

MICHIGAN  
STATE HIGHWAY DEPARTMENT  
G. Donald Kennedy  
State Highway Commissioner

SUMMARY  
ACTIVITIES OF RESEARCH LABORATORY  
LOCATED AT  
MICHIGAN STATE COLLEGE

By  
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Research Laboratory  
Testing and Research Division  
Report No. 37  
August 1, 1942

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The Michigan State Highway Department, over a period of years has realized the value of research and has contributed valuable information to the art and science of highway building. Further evidence of the importance of research in the highway industry is manifested by the establishment of a separate organization, by the administration, for the express purpose of conducting certain research activities of the Department.

The activities of the research organization are devoted to specific problems arising within the several technical divisions of the Highway Department, as well as comprehensive laboratory and field studies carried out on a long range plan.

The research laboratory was established in September 1939, at Michigan State College, East Lansing, by request of the Highway administration upon approval of the State Board of Agriculture and the State Administrative Board. The personnel and equipment of the organization are located in the R. E. Olds Hall of Engineering, on the campus. The college authorities accorded to the Highway Department the facilities and certain space of the Civil Engineering laboratories for pursuance of their research program.

#### The Research Program

The research program is comprised of primary problems pertaining to higher quality concrete and bituminous pavements as well as subgrade investigations and soil stabilization. In regard to concrete pavements, special emphasis is being placed upon such subjects as, scaling, curing,

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design, including slab thickness, spacing of joints, joint design and concrete mix design. The changes in characteristics of binding medium and consequent development of specifications for binding material are being considered in connection with bituminous pavements. Subgrade soil studies involve measurement of subgrade supporting value, relation of characteristics of subgrade soil to supporting value and methods of soil stabilization.

This report presents the purpose, scope and status of each of the nine major projects included in the research program of the research laboratory as well as other activities in which the research organization has taken an active part.

The major research projects are:

1. Structural design of pavement joints
2. Concrete durability studies
3. Concrete pavement design
4. Concrete mix design
5. Bituminous pavements
6. Soil stabilization
7. Snow and ice control
8. Miscellaneous studies
9. The Houghton project

## PROJECT 1

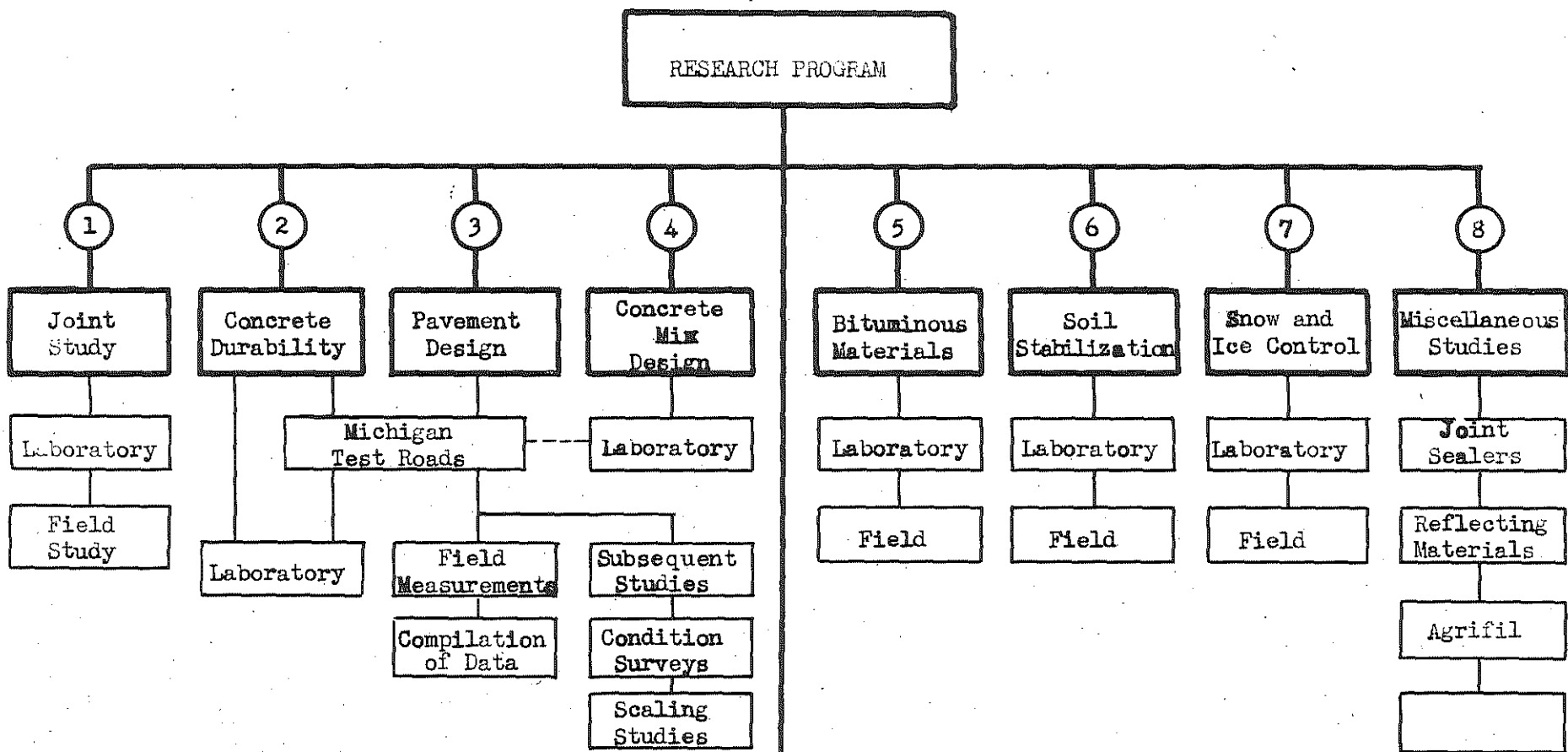
STRUCTURAL DESIGN OF PAVEMENT JOINTS

The evaluation of load transfer devices pertains to the study of the statics; elastic and plastic properties; strength characteristics and stress distribution in transverse joints composed of different types of load transfer devices.

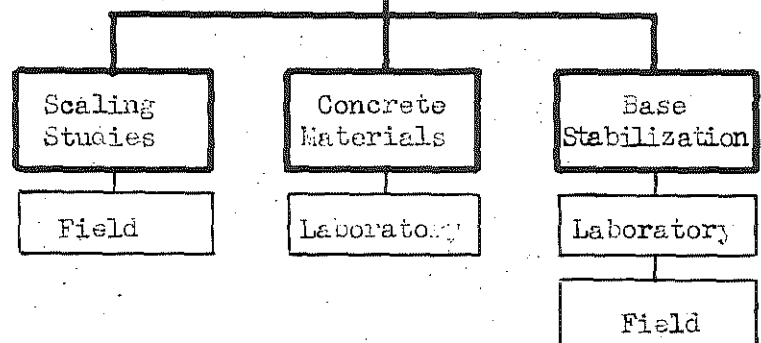
The purpose of the study is to establish criteria for the evaluation of load transfer devices and joint assemblies, to determine proper spacing of same and to obtain data for writing specifications.

The importance of such a study is quite evident. There has been a feeling, for some time, among engineers that as long as expansion joints are required in concrete pavement slabs some type of load transfer device will be required to strengthen the free edges at such joints, especially to maintain the slabs at equal elevation. However, there has been a wide divergence of opinion as to how it should be accomplished and a decided lack of agreement on the fundamental structural requirements at such a joint when load transfer is used.

Load transfer devices have been used experimentally for a number of years but no definite criteria has been established for their use and design. Because there is such a diversity in the design and use of these devices, the situation seems to dictate the necessity for obtaining accurate information regarding other characteristics as individual units in concrete, as well as their characteristics in groups in a concrete slab.



HOUGHTON PROJECT



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The project has been planned to include the four following major studies -

1. Development and construction of a special hydraulic testing machine capable of not only testing joint units but equally adaptable to other tests requiring compressive forces.
2. Shear deflection tests on various types of load transfer devices to determine their mechanical characteristics. Also, shear tests exemplifying load transfer at contraction joints.
3. Completion of data and necessary mathematical calculations incidental to the structural design of pavement slab edges at expansion joints.
4. The establishment of a proposed field installation test for joint unit assemblies and preparation of specifications for load transfer units, and joint unit assemblies.

Development of Hydraulic Testing Machine

Purpose: To design, and construct a compression machine capable of testing the various types of load transfer devices.

Scope: The testing machine was to be designed and constructed with the thought of using it for other laboratory tests involving the need for compressive forces.

Status: This part of the investigation has been completed.

Shear-Deflection Tests

Purpose: To study the characteristics of the various load transfer devices under laboratory shear-deflection tests in order to obtain data necessary for the successful design of expansion joints.

Scope: The study has included seventy individual shear-deflection tests on load transfer devices including the several proprietary makes on

the market as well as special devices. Also, the study includes shear-deflection tests on different types of contraction joints.

Status: This work has been completed.

Structural Design of Pavement Slab Edges at Expansion Joints

Purpose: To develop a definite criteria for determining the proper spacing of load transfer units and to establish stress relationships in concrete slab edges at expansion joints.

Scope: The study will include a review of the work of Westergaard, Teller, Friberg, the previous work of the Michigan State Highway Department, as well as the laboratory studies included in the scope of the joint project.

Status: This work has been completed and written up in preliminary form.

Field Installation Test for Joint Unit Assemblies

Purpose: To establish a field test whereby a joint assembly could be subjected to conditions similar to those encountered in actual concrete construction for the purpose of judging its merits and to determine if it meets specifications.

Scope: The study includes two separate parts; first, the development of a suitable joint assembly test and second, to prepare specifications to include all types of load transfer assemblies.

Status: This work has been completed and is written up in preliminary form.



## PROJECT 2

CONCRETE DURABILITY STUDIES

A survey study of all concrete pavements show that a considerable percent of the surface is scaled in varying degrees. This condition has become more apparent as the use of chemical salts has increased for the removal of ice from pavements. Scaling has been common in most parts of the state, but, on a whole, the concrete is predominantly good. But, even so, the unsightliness of scaled areas and subsequent maintenance and the added possibility of further deterioration is of immediate concern to the highway engineer.

For this reason, a study of scaling, its causes and methods for prevention, has been incorporated into the research program under the title of "Durability of Concrete Pavements".

The durability project includes the following major parts:

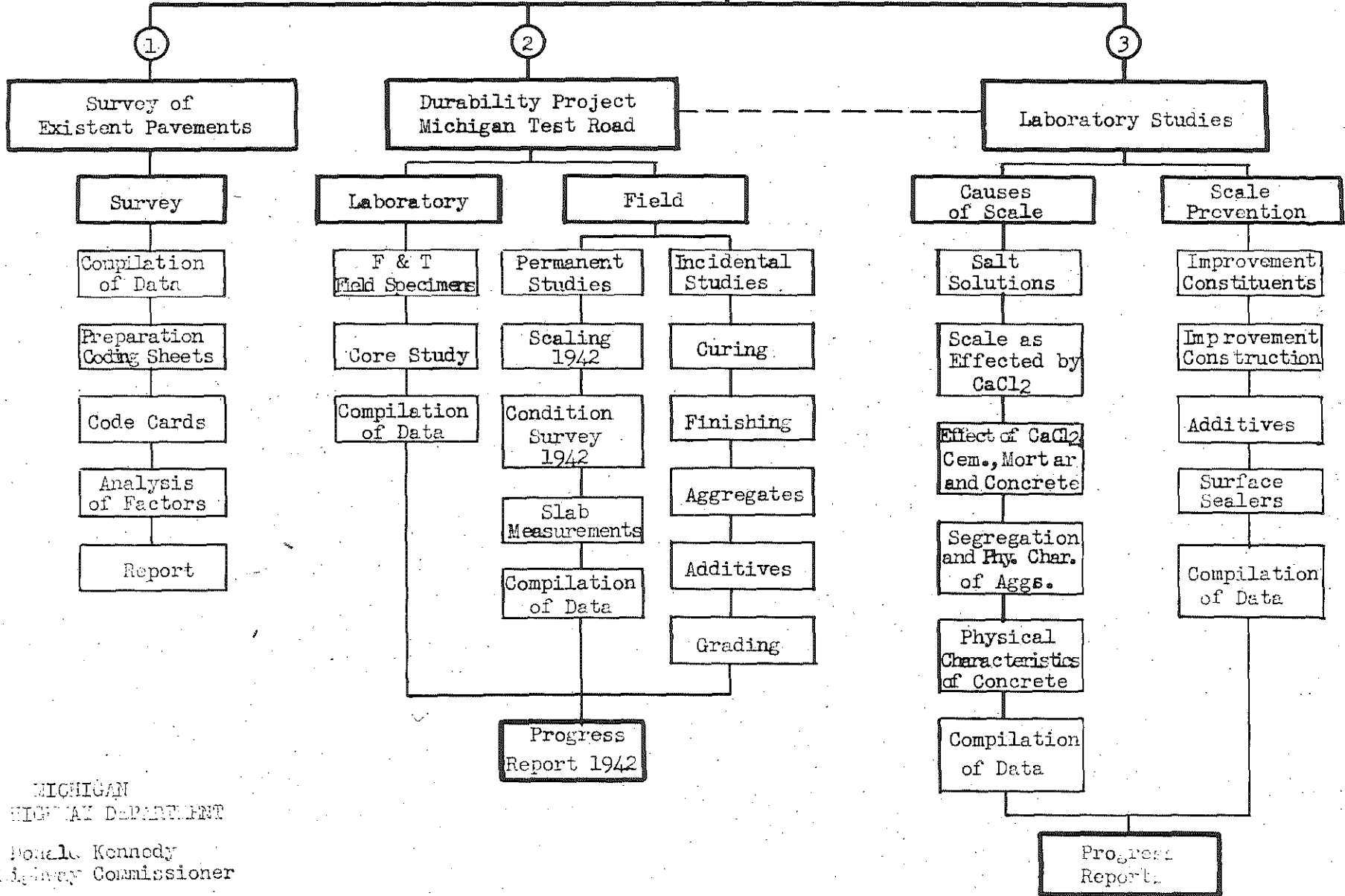
1. Condition survey of existent pavements.
2. Durability project of the Michigan Test Road.
3. Laboratory durability studies.

The major studies outlined above will be discussed separately including their purpose, scope and present status.

Condition Survey of Existent Concrete Pavements

Purpose: To determine by visual observation the amounts and degree of scaling prevalent in concrete roads in Michigan and to correlate this information with the various factors incidental to the construction of the pavement slab.

DURABILITY CONCRETE  
PROJECT NO. 2



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Scope: Survey included all of the concrete pavements on the state trunkline system.

Status: All of the factors and amounts of scaling have been recorded on coding sheets specially prepared for this particular study. It remains to have the data on the coding sheets transferred to cards for punching and the desired information obtained by the manipulation of the cards through the International Business Machines. It is proposed to have this completed as soon as possible.

Durability Project of the Michigan Test Road

Purpose: The performance of concrete under the severity of service cannot be predicated upon laboratory studies. Therefore, the purpose in constructing the durability project was to obtain a field laboratory to obtain accelerated action of chloride salts or ice on concrete pavement and to study the resultant action. Also, to evaluate the effect of variation of factors relative to construction and materials used in highway construction upon the durability of concrete pavements.

Scope: Embodied in the durability project are the following considerations:

1. The grading of aggregates with definite recognition of the material passing 200 mesh.
2. The comparative effect of various types of additives including, physical and chemical varieties as well as cement blends and cements produced with grinding aids.
3. Crushed limestone aggregates with special attention to finer fractions.
4. A study of finishing methods in relation to scaling.

- 5. A study of various curing methods in relation to scaling.
- 6. Accelerated scaling studies.
- 7. Comparative laboratory freezing and thawing tests on field specimens.
- 8. Special laboratory study of pavement cores taken from durability project including freezing and thawing, unit weight, void content, distribution of aggregate.
- 9. Factors incidental to construction which might be contributory to scaling.

Status: The field and laboratory work has been practically completed on all problems except the accelerated scaling studies and the core study, numbers 6 and 8 respectively. It is planned to carry on the scaling studies for a period of years. The core study is now in progress. It is proposed to submit all of the data from the durability project in the form of a progress report. The compilation of data for this progress report has been started.

Laboratory Durability Study

As a part of the general investigation of the durability of concrete pavements in Michigan, laboratory studies have been undertaken to supplement the field study and the durability field project of the Michigan Test Road.

The laboratory program has been divided into two main divisions devoted to the following work -

- 1. The determination of causes of scaling.
- 2. A study of methods to prevent scale.

The above problems pertaining to the laboratory durability study will be discussed in the order given.

1. The determination of Causes of Scaling

Purpose: To make a comprehensive study of the many factors considered to be contributory to scaling for the purpose of obtaining substantial data to enable us to approach the problem of prevention in a logical manner.

Scope: The study of causes of scaling has been divided into three phases; chemical, physical and mechanical. Under chemical causes have been included -

1. Compilation of data pertinent to salt solutions involving a bibliographical study and a field study to determine the probable concentrations of salt solutions on pavements due to ice removal methods.
2. Scale formation on concrete as effected by chloride salts, involving such studies as the chemical reaction of chloride salts on the constituents of concrete and the formation and distribution of chemical products conducive to scaling.
3. The chemical action of chloride salts on neat cements, mortars and concrete under different test conditions.

The physical phase involves two main subjects -

1. The segregation and variation of constituents of concrete, such as bleeding when associated with mix design, physical characteristics of constituents, working of the concrete surface and interfacial relations between the constituents of concrete.
2. Variation in physical characteristics of concrete from top to bottom of slab, involving grading, amount of cement, density, absorption, porosity and coefficient of expansion.

Mechanical factors will be considered to include; frost action, freezing and thawing and traffic conditions.

Status: Parts 1 and 2 of the chemical phase have been temporarily completed pending further results from other phases of the problem. The study of chemical action of chloride salts on neat cement is practically completed and preparation has been made to continue with the study on mortars and concrete.

Studies 1 and 2 of the physical phase have been correlated with construction factors relative to the test road and that part has been completed. However, further laboratory studies are necessary to completely terminate the project.

The mechanical factors remain to be studied.

## 2. Scale Prevention Studies

Purpose: It is a recognized fact that scaling can be materially reduced by additives, and by the proper control of construction practices. Therefore, it is the purpose of this investigation to study the relative merits of the many proposed methods of scale prevention as a part of the whole subject of durability of concrete.

Scope: The scale prevention studies include the following subjects:

1. Improvement of characteristics of constituents of concrete.
2. Improvement of construction practices involving mix design, construction operations and curing methods.
3. The use of admixtures or grinding aids.
4. The use of surface sealers.

Status: These four problems cannot be completely terminated until the durability project has been exhausted in all its phases. However,

enough data has been accumulated, so far, to enable the Research Laboratory to present certain recommendations relevant to the subject.

PROJECT 3

CONCRETE PAVEMENT DESIGN

Purpose: To establish certain fundamental principles in concrete pavement design and to correlate certain laboratory studies with construction methods in order to develop more durable concrete pavements. The facts and relationships obtained shall be used for the improvement of the Michigan State Highway Department design and construction procedure.

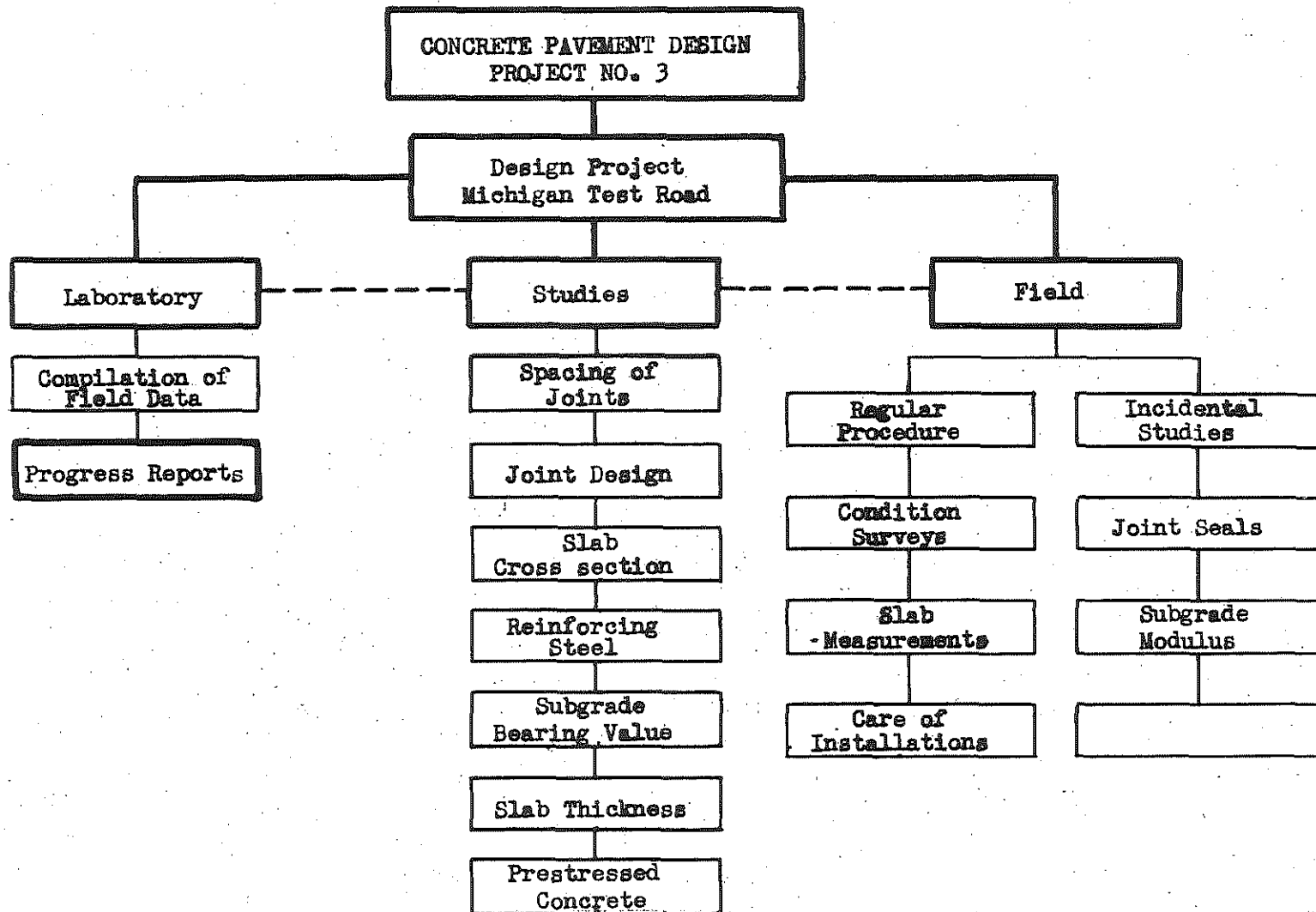
In order to realize the purpose of the project, it was necessary to construct an experimental pavement incorporating the principles and factors incidental to design and construction. This experimental pavement is known as the design project of the Michigan Test Road.

The design project coincides in a general way with the Public Roads Administration's plans and procedure for construction of experimental roads which were submitted to the Department in 1940.

Scope: The important design studies considered with respect to modern practices are:

1. Spacing of expansion and contraction joints.
2. Expansion and contraction joint design.
3. Uniform slab thickness versus balanced cross sections.
4. Amount of reinforcing steel necessary.
5. Relation of pavement cross-section to subgrade supporting value.
6. Pavement cross-section thickness.
7. Prestressing of concrete slabs during curing.





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Included in the scope of the design project were certain incidental construction features, such as -

1. Mechanical versus manual handling of concrete on subgrade.
2. Mechanical versus hand tamping of forms.
3. The use of different types of joint seals.

Importance: There is need, at the present time, of a comprehensive evaluation of modern theories of design and construction. This statement is clearly demonstrated in recent reports of technical writers on the subject.

The value of this study is further enhanced by increased beauty, safety, roadability, economic life and reduction of cost of construction and maintenance.

Furthermore, no study of this type has been carried on since the Bates Road Test in Illinois in 1922-23.

Status: It will take several years time before sufficient data will be accumulated from the design project of the test road to warrant making any definite conclusions relative to the design studies. However, the data will be compiled as received from the field and, no doubt, some definite trends relative to the various factors studied will be noted within a short time. This project is in progress continuously.

PROJECT 4

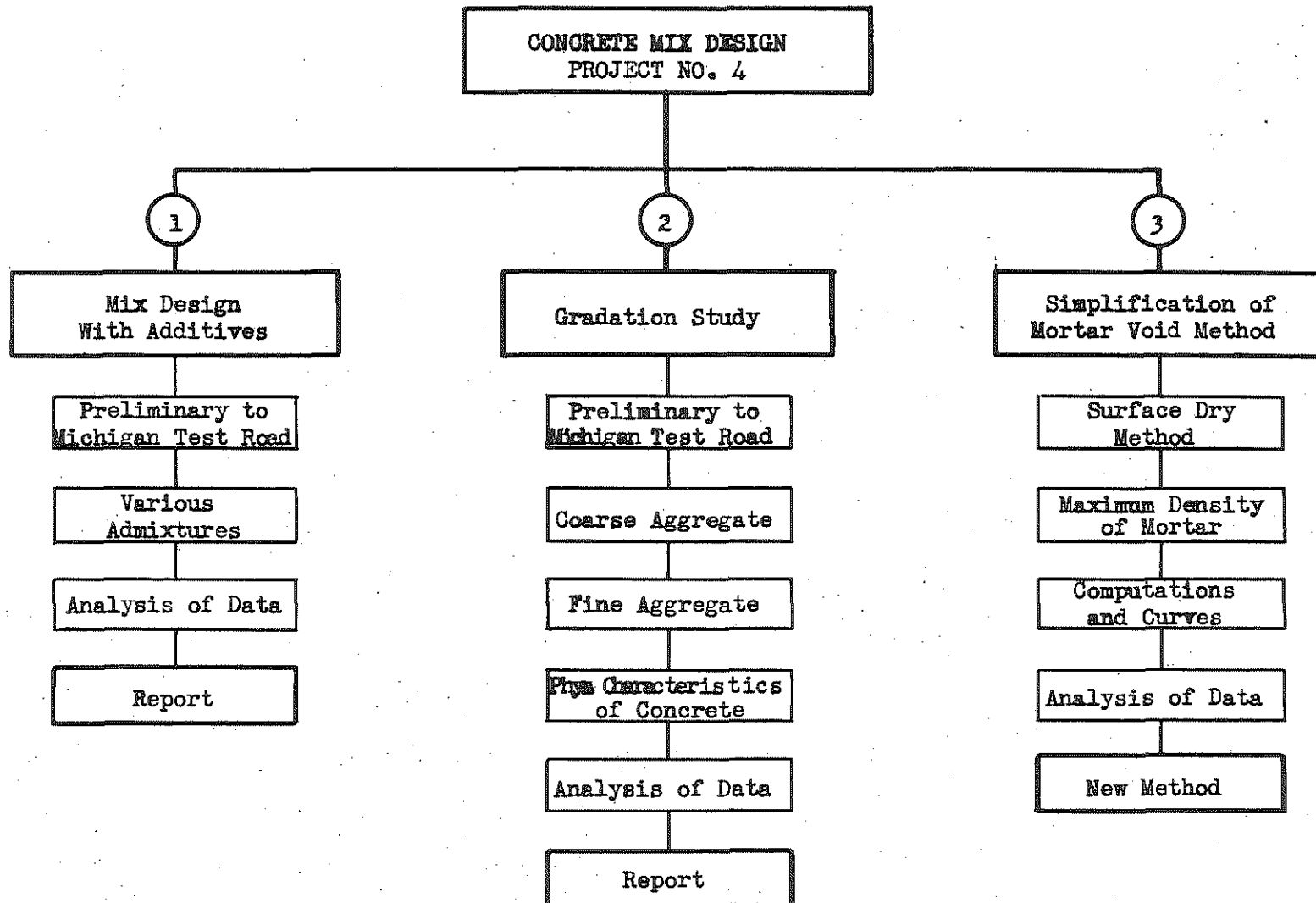
CONCRETE MIX DESIGN

Purpose: The purpose of this study is two-fold. First, to design concrete mixtures according to the mortar void theory, using various additives as preliminary work to the durability project of the Michigan Test Road. Second, an attempt to design a practical and economical concrete mix that would show improvement in resistance to scaling as compared to some of our present day pavements.

Scope: The project is comprised of three main problems, namely:

1. The design of concrete mixtures by mortar void method when additives are to be used in the mixture. A preliminary study to durability project of test road.
2. A gradation study of concrete aggregates and cement as related to scaling and durability of concrete.
3. The simplification of mortar void method of concrete design.

Importance: In one respect, this subject is a part of the durability project, however, it is of such significant importance from another standpoint that it has been set up as a separate project. It is significant that our present specification requirements are not all that they should be with respect to gradation of fine and coarse aggregates, especially where workability and durability are concerned. Also, it is important that we consider several possible changes in gradations and thus open up local material sources for the manufacturing of more

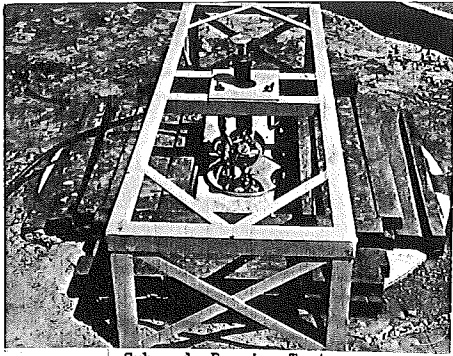


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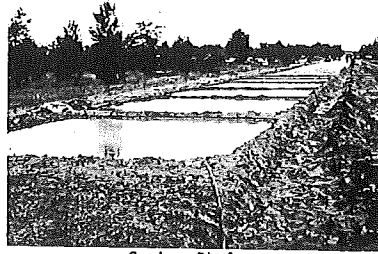
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economical concrete. The mortar void method of concrete design as used by the Department should be thoroughly studied in all its phases and simplified so that it can be understood and applied by all engineers, who are interested in concrete design problems.

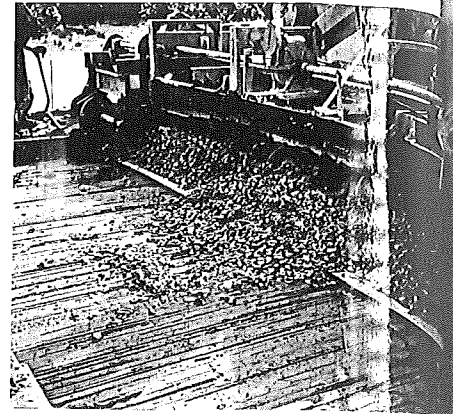
Status: Part one of this project program has been completed. The balance of the project program was dropped because men were not available for assignment to the work. Preliminary report No. 21 has been prepared.



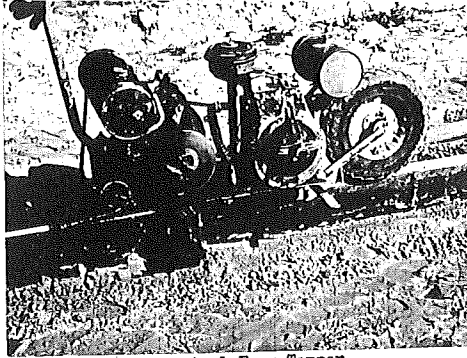
Subgrade Bearing Tests



Curing Study



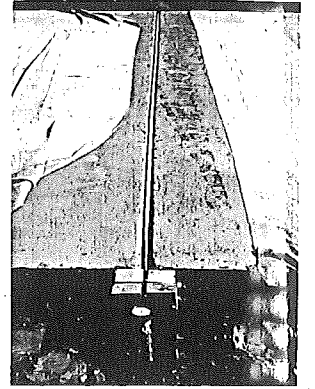
Mechanical Handling of Concrete



Mechanical Form Tamper



Slab Movement Measurements

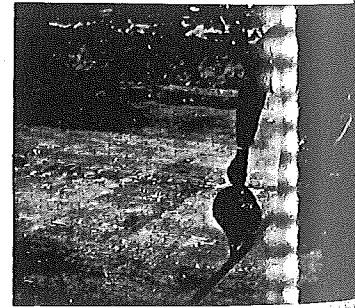


Pavement Slabs Prestressed During Curing

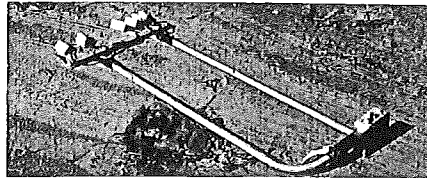


Analysis of Fresh Concrete

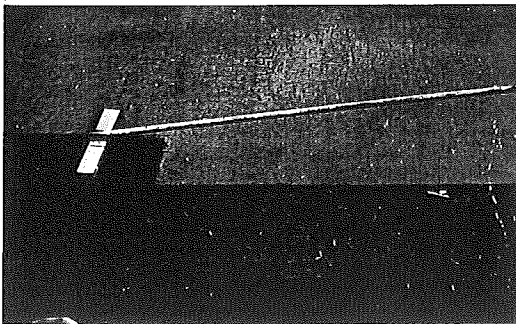
# THE MICHIGAN TEST ROAD



Joint Sealing Study

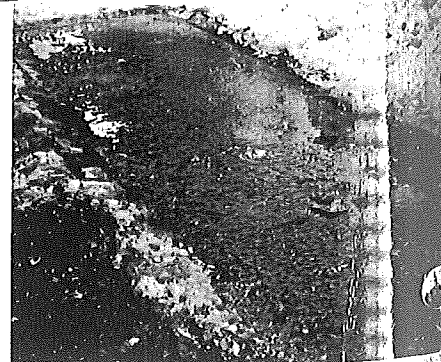


Moisture Cell and Thermocouple Assemblies

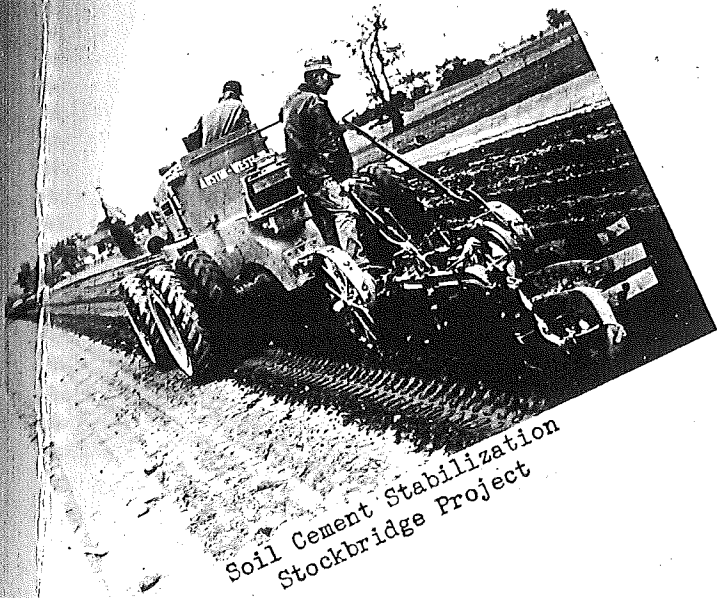


Brooming Operations

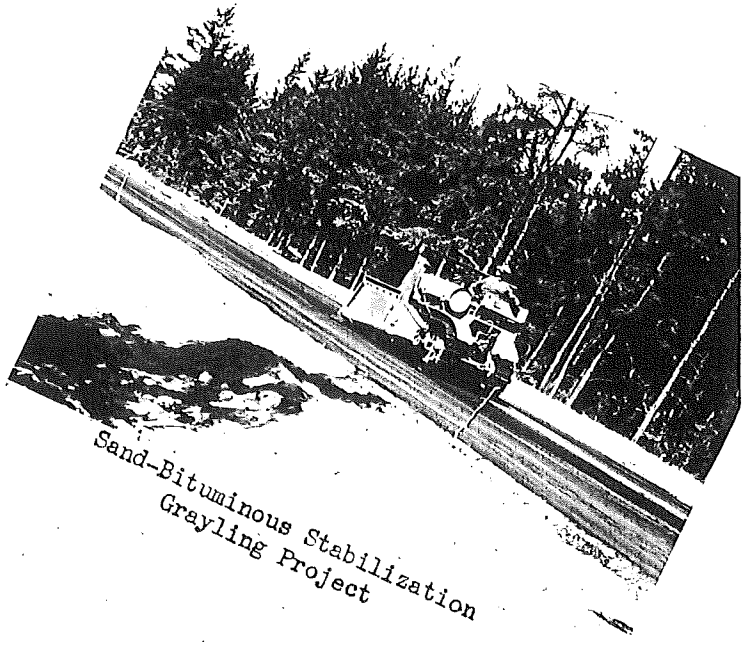
Strain Measurements of Slab



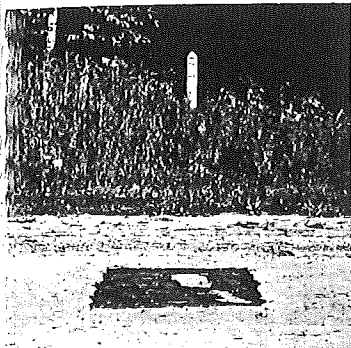
Scaling Studies



Soil Cement Stabilization  
Stockbridge Project

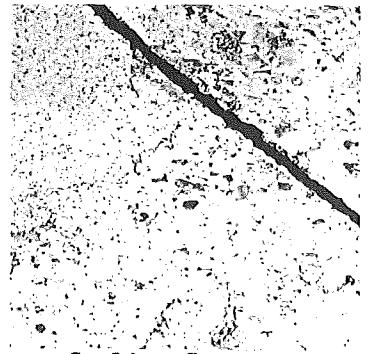


Sand-Bituminous Stabilization  
Grayling Project

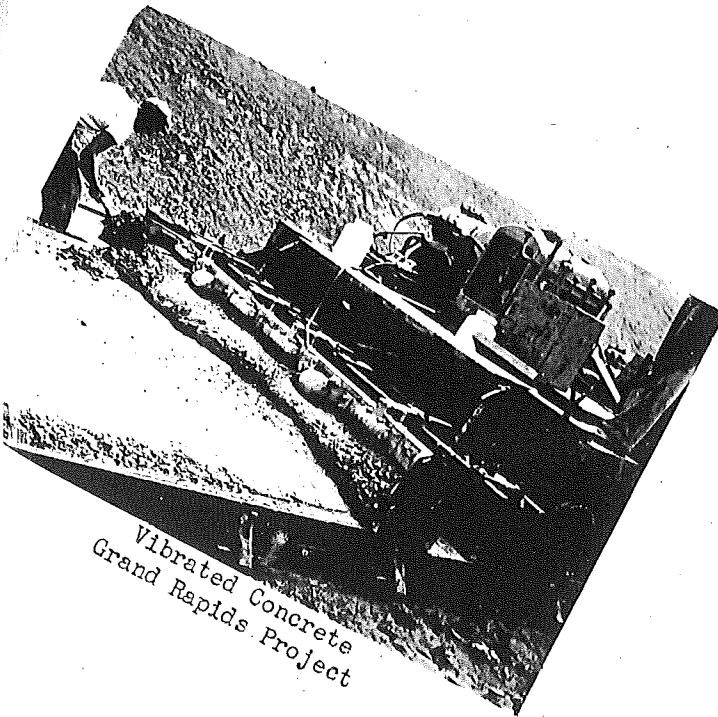


Weathering of Asphaltic  
Oils in Service

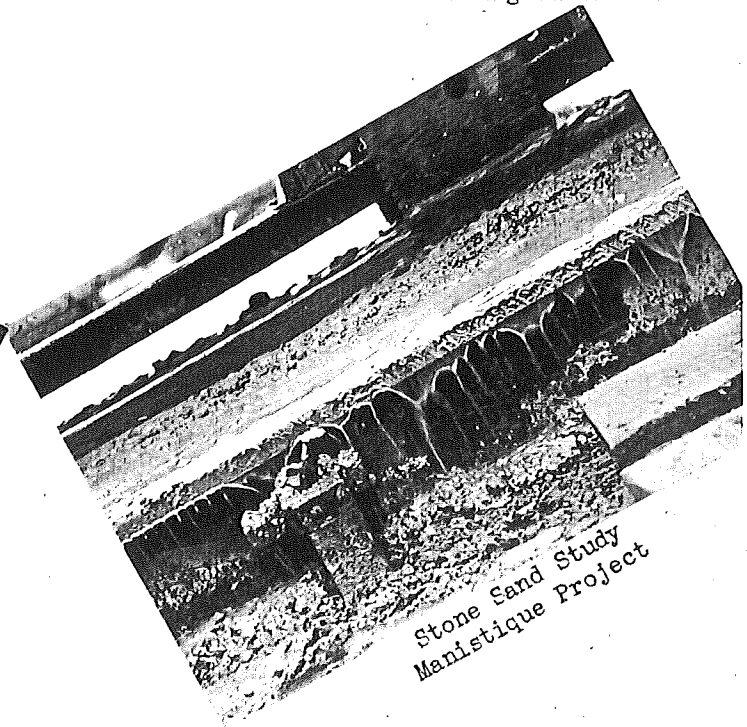
# OTHER FIELD STUDIES



Scaling Survey  
of Existing Pavements



Vibrated Concrete  
Grand Rapids Project



Stone Sand Study  
Manistique Project



## PROJECT 5

BITUMINOUS PAVEMENTS

Purpose: This is a continuation of a bituminous research program initiated in 1933. The purpose being to determine the changes in characteristics of slow curing asphalts before and after weathering with the idea of perfecting a laboratory test whereby it would be possible to distinguish between bituminous materials possessing good or undesirable weathering qualities before they were incorporated in the bituminous mixture.

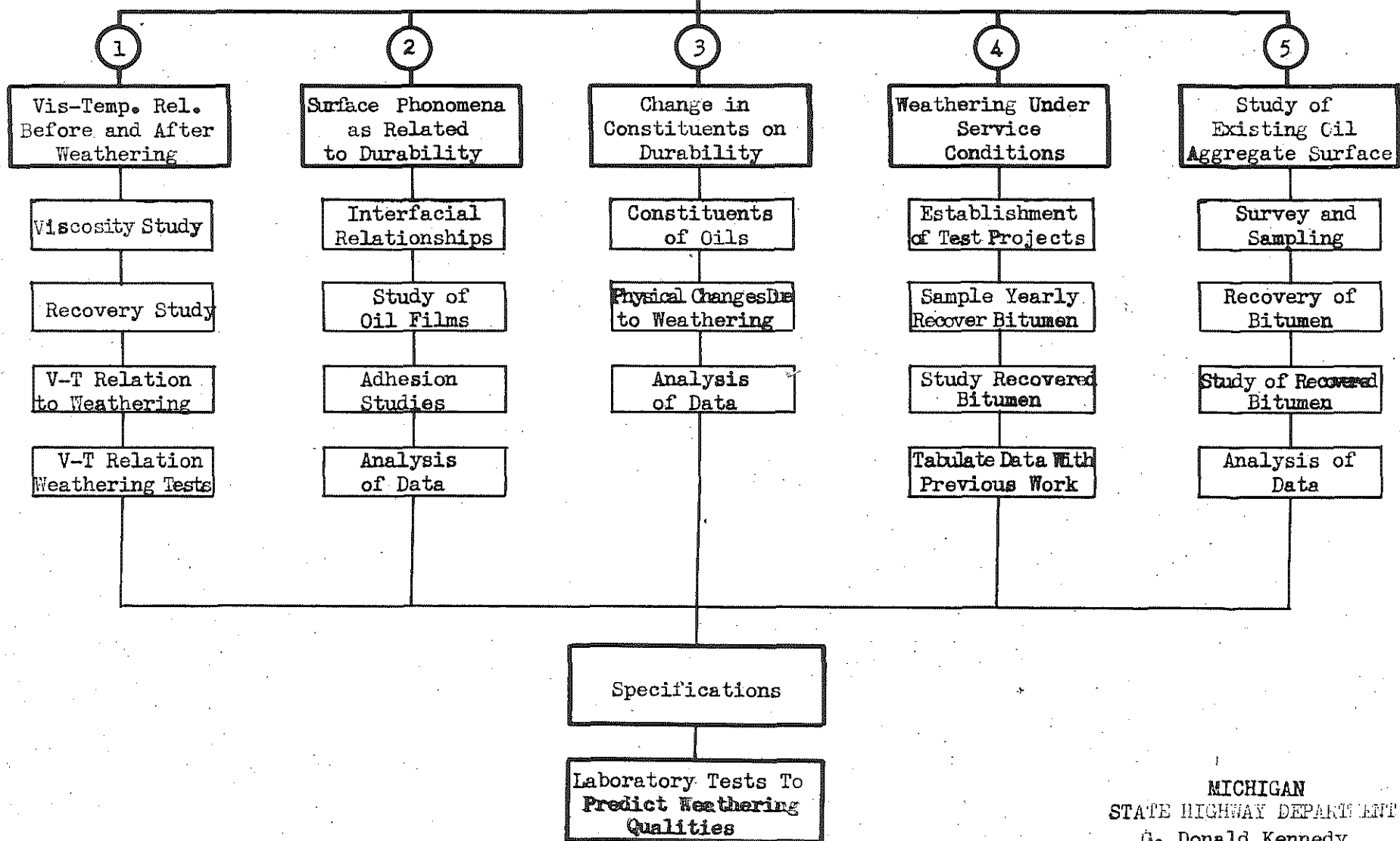
Scope: The scope of the investigation included five important phases of the subject of durability of bituminous materials, namely;

1. The viscosity-temperature relationship of bituminous materials before and after weathering.
2. Physical and chemical surface phenomena is related to durability.
3. Effect of change in constituents upon durability.
4. Changes in characteristics of slow-curing asphalts after weathering under service conditions. This study embraces sixteen test projects established over a period of years from which samples are taken each year for laboratory study.
5. Condition survey of existing bituminous surfaces using slow-curing oils as a binder. Samples were taken from the various surfaces for correlation with laboratory studies. The studies of changes in characteristics of asphaltic cements has not been undertaken.

Importance: The urgent need for continued research in bituminous materials is evident because of the rapid growth of bituminous surfaces



BITUMINOUS MATERIALS  
PROJECT NO. 5



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in Michigan, especially of the oil-aggregate type which produce definite maintenance problems involving stockpiling and repairs. The undesirable variation in characteristics of the bituminous materials from the various refineries, as well as the failure of current specifications to predict service behavior of the bituminous material makes it doubly important that better laboratory control must be devised to insure durable and lasting surfaces.

Status: Parts 1 and 5 of this project have been completed. Only certain phases of parts 2 and 3 have been touched upon. Part 4 is continuous in that each fall a survey is made of the test sections, samples taken, recovery of the bitumen made and subsequent studies conducted on the recovered bitumen.

PROJECT 6

SOIL STABILIZATION

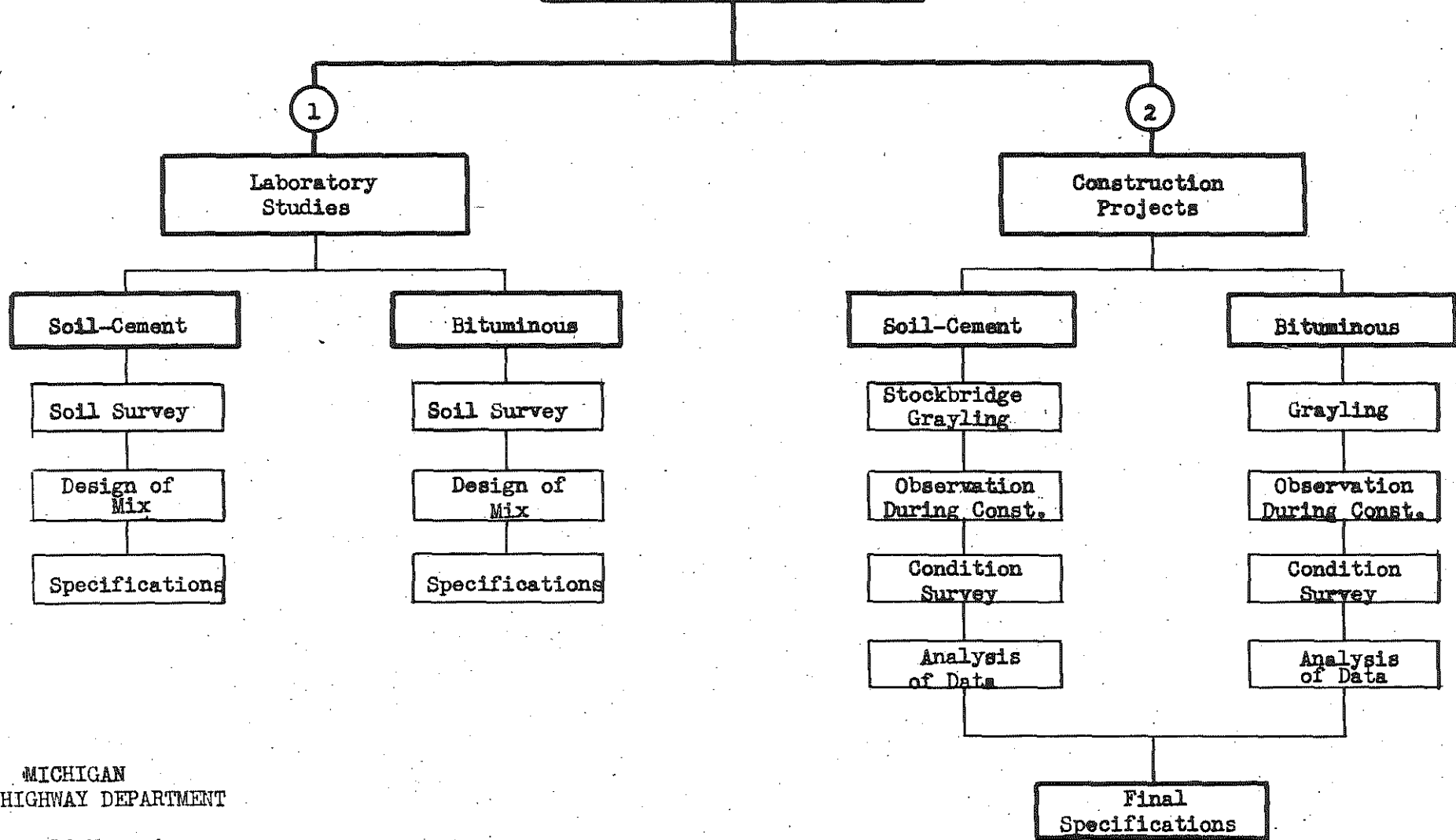
Purpose: To construct soil-cement and bituminous stabilized road surfaces using existing roadway material, new material and Portland cement to produce a low-cost light-traffic surface. The purpose being to determine the feasibility of constructing such roads with existing surfacing materials, or with suitable local materials, and to develop specifications for the use of the Michigan State Highway Department in construction of such types of roads.

Scope: This project included the construction in 1941, of two soil stabilized roadway surfaces as follows:

1. Soil cement construction on M-92, Stockbridge north, length 3.02 miles, project M 53-50, C1.
2. Soil cement construction on M-72, Grayling east, length 1.57 miles, project M 20-20, C2.
3. Bituminous stabilization on M-72, Grayling east, length 4.5 miles, project M 20-20, C2.

Importance: Many types of stabilized roads are being developed and it is important to the Michigan State Highway Department to know which are best suited to Michigan conditions. From an economic standpoint, it is important to know the relative cost of this type of construction as compared to other types of light-traffic surfaces. Also, it is desirable to know if this type of construction is satisfactory for certain localities where prepared aggregates are not available.

SOIL STABILIZATION  
PROJECT NO. 6



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Status: The work outlined under the scope of the project has been completed and specifications based on this work have been prepared. Preliminary reports Nos. 34, 38 and 39 have been prepared.

PROJECT 7

SNOW AND ICE CONTROL

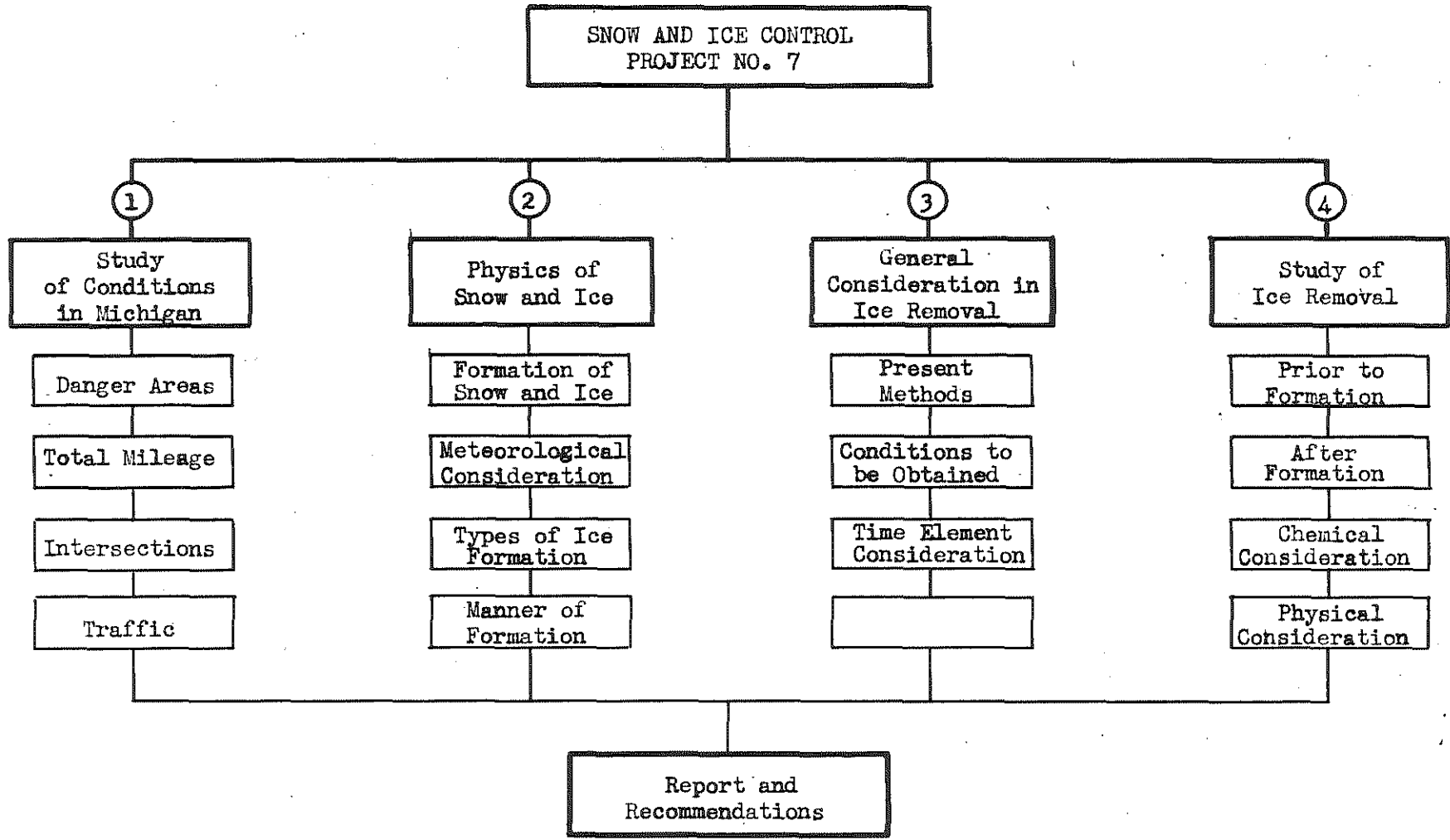
Purpose: The snow and ice problem on highways has reached a state of real importance in highway transportation. Therefore, it is believed that serious consideration should be given to introducing modern methods into removing or preventing ice formation on pavements. It was proposed to attack this problem from a scientific standpoint in an attempt to find out better, modern and economical methods to overcome this serious traffic hazzard.

Scope: This problem is only in the outline form, taking into consideration such phases as -

- 1. Survey of ice conditions in Michigan.
- 2. Physics of snow and ice.
- 3. General considerations in ice removal.
- 4. Comprehensive study of ice removal methods.

Importance: Michigan, because of its unusual topographic location, with respect to the Great Lakes, is subjected to frequent snow and sleet storms which interrupt the normal functions of the Michigan highway system. They also cause many traffic accidents, excessive maintenance costs and reduction in traffic movement. Therefore, any studies which will reveal methods which will improve these conditions should be worthy of consideration by the Department.

Status: This work has not progressed beyond the outline and discussion stage because men have not been available to assign to the work.



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## PROJECT 8

MISCELLANEOUS STUDIES

This project was established to take care of miscellaneous research studies of a special nature requested by administrative officials and division heads of the Highway Department. The investigations being carried on at the present time are -

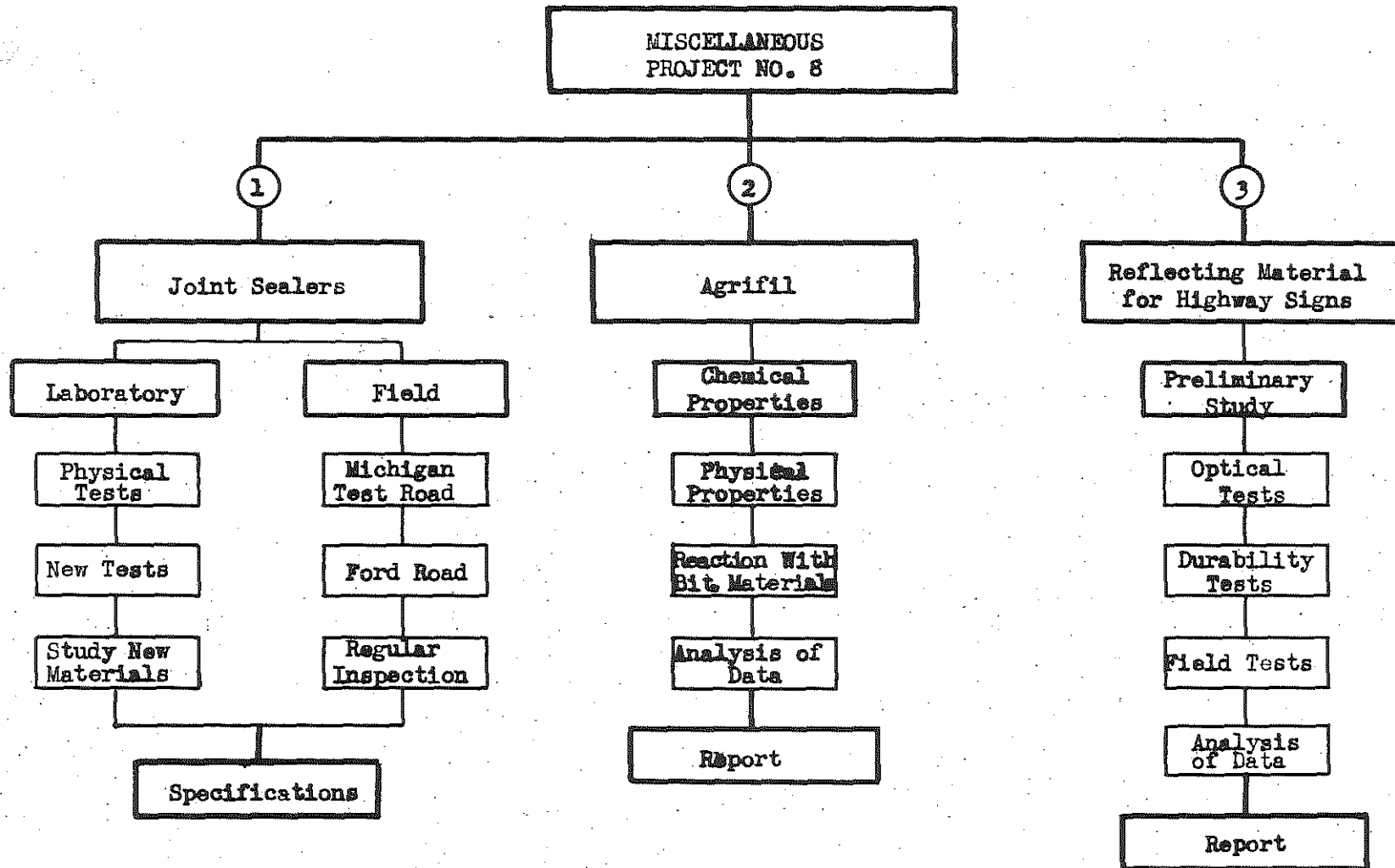
1. A comparative study of reflecting materials for highway signs.
2. Agri-fil and its use as an admixture in bituminous mixtures.
3. Membrane curing materials.

Preliminary work has been completed on study 1, but in order to complete the work, weatherometer tests must be made in Ann Arbor, which will require at least 30 days time. The optical work can be done in East Lansing. This study can be completed with present personnel in approximately 8 weeks.

The study on agri-fil is completed as far as physical and chemical characteristics are concerned. If it is believed desirable to continue the study involving bituminous mixtures in the laboratory.

The study of membrane curing materials is in progress and will continue for an indefinite period of time.





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## PROJECT 9

THE HOUGHTON PROJECT

In March 1941, at the request of Grover C. Dillman, President of the Michigan College of Mining and Technology, State Highway Commissioner G. Donald Kennedy, instructed the Research Division to proceed with the establishment of a cooperate research project between the Michigan College of Mining and Technology and the State Highway Department. The Research Division to assume the responsibility for the general direction of the work.

It was understood that the branch research laboratory would be established at Houghton for the purpose of using the laboratory facilities of the College for convenience in investigating the problems of immediate concern to the construction of highways in the Upper Peninsula.

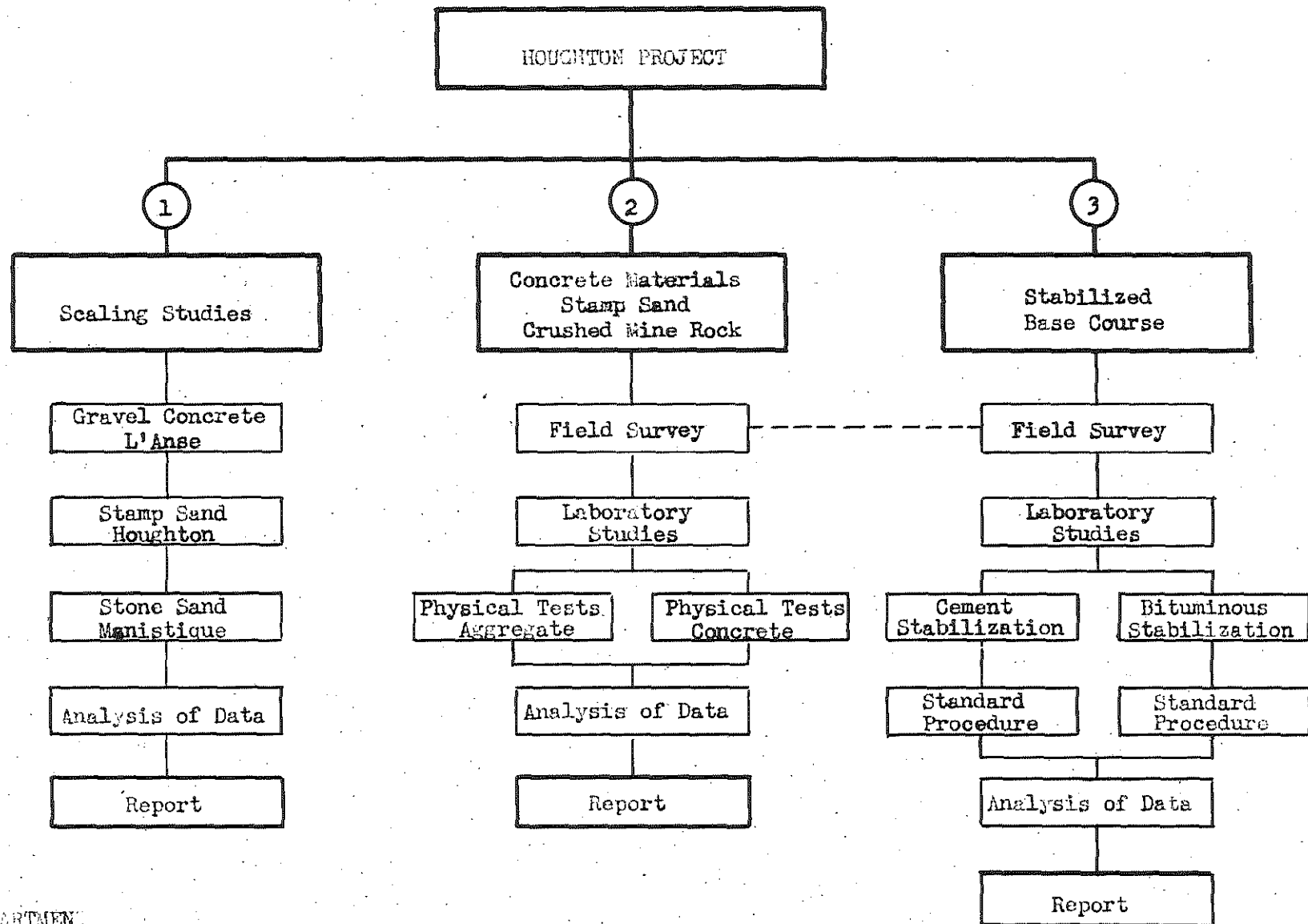
After considerable delay in obtaining and training a man to assume the responsibility for this particular project, the project was started in December 1941 under the following program.

The program was prepared on the basis of suggested projects recommended by the Testing Division and the current activities of the Research Division in the Upper Peninsula.

The research program consists of three major projects as follows:

1. Field scaling studies on concrete pavements.
2. Concrete materials investigation.
3. Stabilized base course investigation.

The major studies listed above will be discussed in the order presented.



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## 1. Field Scaling Studies on Concrete Pavements

Accelerated scaling studies were made on certain concrete pavements to supplement similar scaling studies on the Michigan Test Road as well as laboratory studies being conducted at East Lansing.

The field scaling projects include a comparative study of calcium chloride salt versus natural freezing and thawing, the effect of calcium chloride on concrete containing stamp sand and the effect of calcium chloride on stone sand with and without silica dust and containing Orvus.

### Investigation of Calcium Chloride Salt versus Natural Freezing and Thawing of Water on Concrete Pavement.

Purpose: To conduct comparative scaling studies on a concrete slab not previously treated with calcium chloride to determine in what degree calcium chloride or natural freezing and thawing are inductive to scaling of concrete surfaces.

Scope: Scaling panels similar to those used on the Test Road were installed on US-41, Baraga County near L'Anse. The pavement was constructed in 1941 using Champion sand and gravel.

Status: This work has been completed.

### Investigation of Calcium Chloride on Stamp Sand Fine Aggregate Concrete Pavement.

Purpose: To determine the resistance to scale of concrete pavement containing stamp sand as a fine aggregate.

Scope: Scaling panel was established on pavement surface containing stamp sand. The scaling panel is on US-41 about 8 miles north of Hancock toward Calumet, station 440+00.

Status: Work has been completed.

Investigation of Calcium Chloride on Stone Sand Fine Aggregate Concrete With and Without Silica Dust and Containing Orvus.

Purpose: To determine the relative resistance to scaling of stone sand concrete pavement with and without silica dust as a mineral filler and containing Orvus.

Scope: Sealing panels were installed on stone sand project in the City of Manistique. Project M 75-28, C2. Panels at station 53+00 right (Orvus and silica dust). Station 54+15 left (Orvus only).

Status: This work has been completed.

2. Concrete Materials Investigation

It was proposed to make a comprehensive study of local mine wastes to determine their suitability for use in highway construction. The study includes both stamp sand and crushed mine rock.

Study of Stamp Sand as Fine Aggregate for Concrete

Purpose: To determine the suitability of stamp sand, ground and reground for use in concrete mixtures. This work will entail field and laboratory studies on the aggregate separately and in concrete specimens.

Status: This study is in progress. To date, the work has consisted of collection of samples and running routine laboratory tests on materials from different sources.

Study of Crushed Mine Rock as Coarse Aggregate for Concrete

Purpose: To determine the suitability of crushed mine rock for use as coarse aggregate in concrete mixtures. This work will entail field and laboratory studies on the aggregate separately and in concrete specimens.

Status: This study is in progress in conjunction with the stamp sand investigation.

4. Stabilized Base Course Investigation

Purpose: A study to determine the suitability of stamp sand for bituminous or portland cement stabilized base courses. The project will consist of two parts:

- 1. Bituminous stabilization studies.
- 2. Cement stabilization studies.

It was proposed to conduct laboratory studies on these materials for the purpose of developing proper mix design and prepare specifications for base or surface construction.

Status: This phase of the program has not been started.

MISCELLANEOUS ACTIVITIES

In keeping with the functions and the policies of the research organization and the principles set forth in the Memorandum of Agreement between the Michigan State Highway Department and Michigan State College, the research organization has had the opportunity during the past three years to participate in several activities of an educational and cooperative nature. These activities will be discussed briefly as follows:

Soils School at Michigan State College

In March 1941, an Engineering Conference in soils for engineers was held at Michigan State College. This soils school was organized in cooperation with the Civil Engineering Department, at Michigan State College for the purpose of giving practicing engineers, and especially engineers of the Highway Department an opportunity to become better acquainted with the subject of soils as related to modern highway engineering practices. The school consisted of lectures, discussions and demonstrations. Proceedings of the conference have been published.

Conference with Officials and Representatives of the Portland Cement Association and Cement Manufacturers and members of the Michigan State Highway Department.

This conference was held for the express purpose of explaining to the group, the scope and principles relative to concrete pavement construction contained in the Michigan Test Road, as well as to discuss and exemplify the work of the Highway Department in their attempt to solve

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the scaling problem. The conference was held on the Campus in the Engineering Building. Members of the Engineering staff of the college were invited to attend.

#### Central Snow Conference

The Central Snow Conference is an international organization composed of a group of men interested in snow and snow problems. At the first meeting of the central Snow Conference which was held at Michigan in December 1941, the research laboratory of the Highway Department was asked to cooperate in preparing a progress report relative to standards, techniques and methods of application of knowledge of the character of snow in relation to highway transportation.

The proceedings of this conference were published in 1942.

#### Farmer's Week Activities

The research laboratory has participated in two Michigan State College Farmer's Week programs by preparing extensive exhibits to acquaint the visitors with the research activities of the Highway Department and how they are eventually benefited by the fruit of such efforts.

#### Student Interests

The research program is of such a nature that it has been possible to handle part-time employment for students either through the N.Y.A. or through Civil Service of the State.

The facilities of the research laboratory have always been available to students interested in research problems. Several students in the Engineering Division have taken advantage of these facilities.



College Personnel

The Engineering Division, as well as other departments on the Michigan State College Campus such as Chemistry, Physics, Soils, Geology and Forestry have been familiarized with the work of the research organization and gave even cooperated in problems of mutual interest.

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REPORTS AND ARTICLES

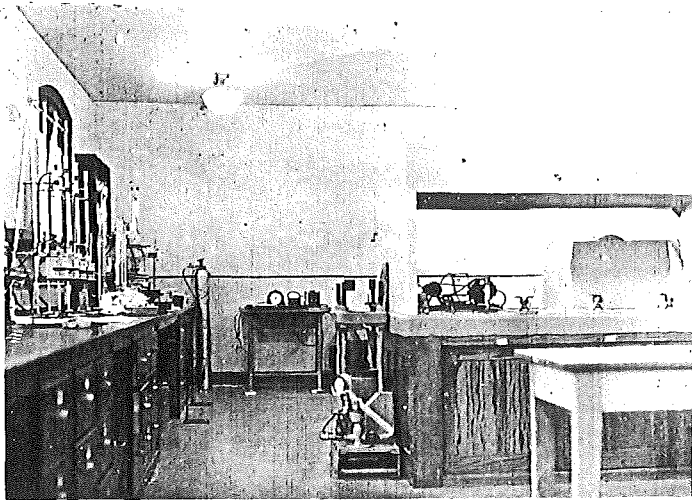
The reports prepared by the research laboratory have been summarized in the following pages. The summary represents the final reports which have been completed by the research laboratory and submitted to individuals or organizations both inside or outside of the Highway Department during the last three years.

Copies of these reports are on file in the research laboratory.

<u>No.</u>	<u>Date</u>	<u>Title</u>
1	7-40	Research Activities of the Michigan State Highway Department.
2	10-40	Field Study of Joint Sealers.
3	11-40	Michigan Test Road.
4	12-40	Investigational Concrete Pavement in Michigan.
5	12-40	Load Transfer at Concrete Pavement Joints.
6	12-40	Changes in Characteristics of Slow Curing Asphaltic Oils.
7	1-41	Activities of Research Division.
8	1-41	Summary, Michigan Test Road.
9	1-41	Value of Concrete Spreader in Concrete Pavement Construction.
10	1-41	Pavement Joints and Their Functions.
11	2-41	Concrete Durability Studies.
12	2-41	Construction of Michigan Test Road.
13	3-41	Natural Conditions Affecting Performance of Soils.
14	5-41	Fundamental Principles and factors Embodied in Michigan Test Road.
15	5-41	Report on Manufactured Stone Sand and Its Use in Concrete Mixtures.

<u>No.</u>	<u>Date</u>	<u>Title</u>
16	5-41	Report on Claims Presented by W.L. Thon Company, Projects F 18-20, C4 and F 67-37, C6.
17	7-41	Proposed Specifications for Slow Curing Liquid Asphalt.
18	7-41	Construction and Subsequent Studies of Concrete Durability Project, Michigan Test Road.
19	8-41	The Library-Laboratory Research.
20	8-41	Movie Script of Michigan Test Road.
21	9-41	Pamphlet on Michigan Test Road.
22	11-41	Research Activities of Michigan State Highway Department.
23	12-41	General Observations on Concrete Scaling.
24	12-41	Comments on Concrete Scaling Studies.
25	2-42	Effect of Various Axle Loadings on Highway Pavements.
26	2-42	Selected Bibliography on Airport Construction for National Defense.
26-A	3-42	The Design and Construction of Flight Strips.
27	4-42	Summary of Research Projects.
28	4-42	Agrifill as a mineral filler for Bituminous Mixtures.
29	4-42	Construction of Experimental Soil-Cement Stabilization Road Surface, Stockbridge.
30	4-42	Curing of Concrete by Calcium Chloride Integral Mixed.
31	5-42	Grayling Cement and Bituminous Soil Stabilization Projects.

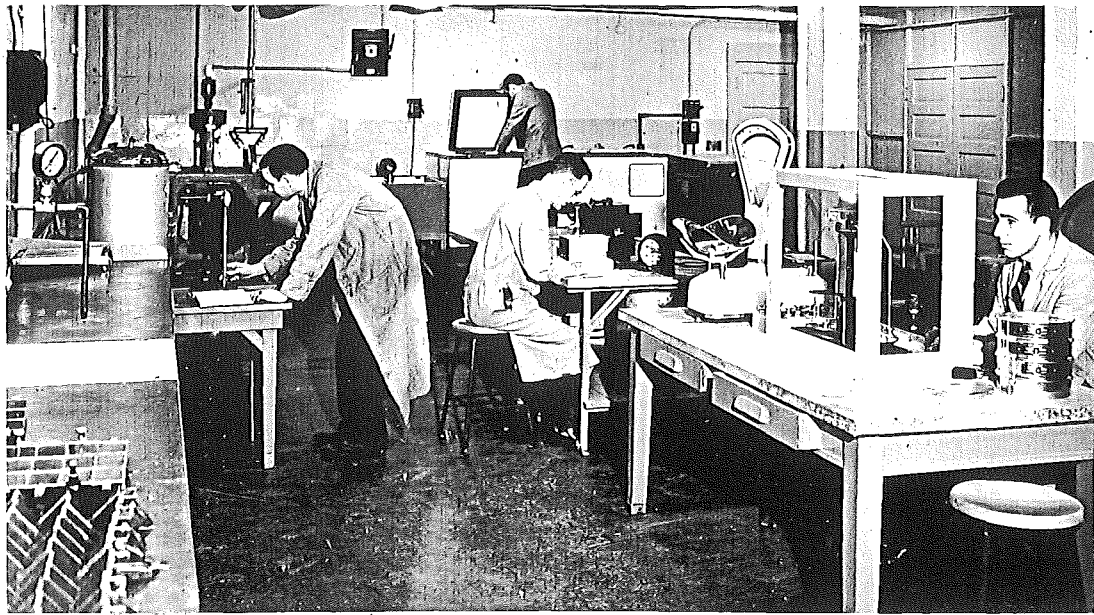
<u>No.</u>	<u>Date</u>	<u>Title</u>
32	6-42	Limestone Dust in Mortar.
33	7-42	Research Laboratory Report for Biennium 1940-42.
34	7-42	Progress Report on Houghton Project, December 1941 - July 1942.



Bituminous and Chemical Laboratory

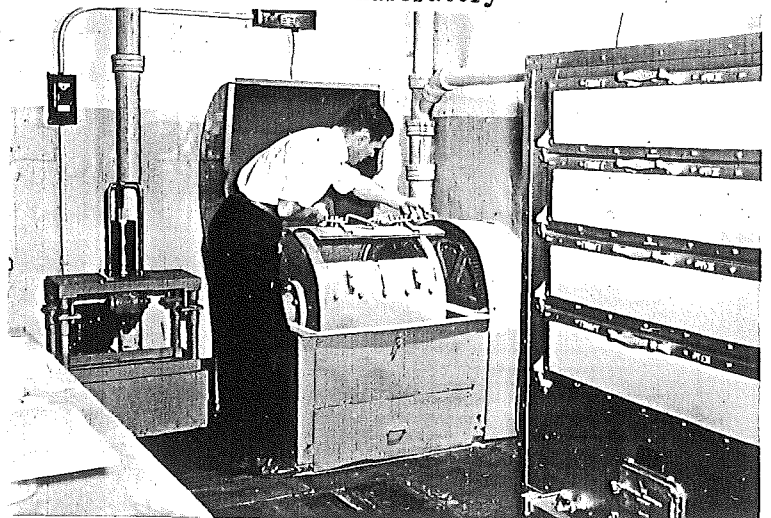
# LABORATORY FACILITIES

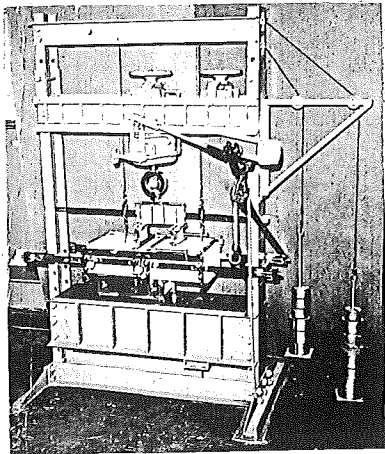
ENGINEERING BUILDING  
MICHIGAN STATE COLLEGE



General Research Laboratory

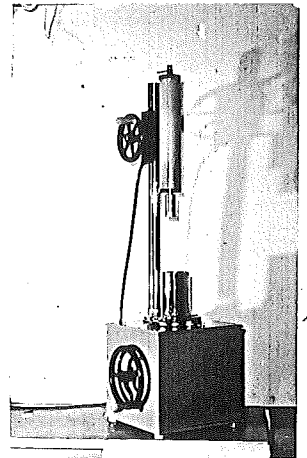
Soils Laboratory



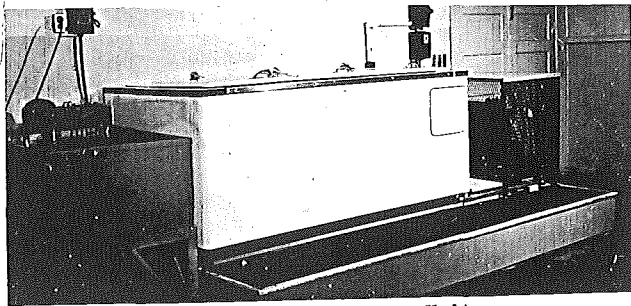


Hydraulic Testing Machine

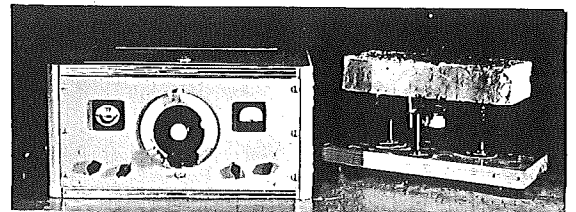
# MODERN RESEARCH LABORATORY EQUIPMENT



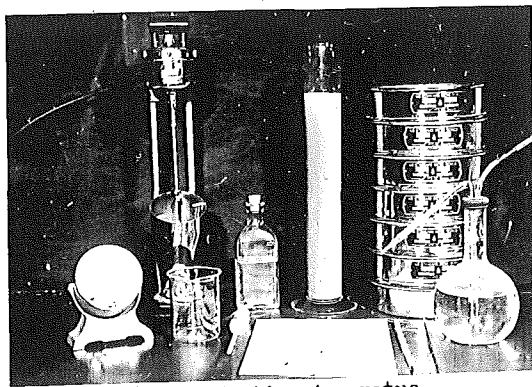
Proctor Apparatus for Soil Testing



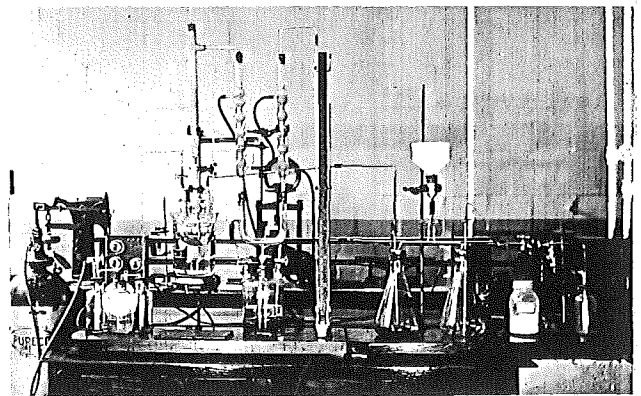
Freezing and Thawing Unit



Sonic Apparatus to Determine Young's Modulus

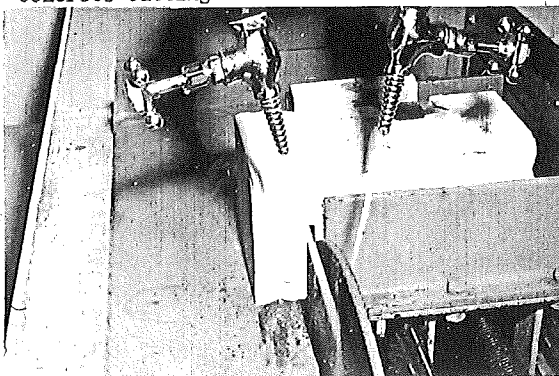


Soil Testing Apparatus



Bituminous Recovery Apparatus

Concrete Cutting Saw



Treadometer

