

THE  
MICHIGAN STATE HIGHWAY  
RESEARCH LABORATORY

----- its facilities -----

functions ----- and

activities

MICHIGAN  
STATE HIGHWAY DEPARTMENT  
Charles M. Ziegler  
State Highway Commissioner

Testing and Research Division  
Report No. 132 - June 1, 1949

ADMINISTRATION

## MICHIGAN STATE HIGHWAY DEPARTMENT

Charles M. Ziegler	State Highway Commissioner
Harry T. Ward	Chief Deputy Commissioner
Harry C. Coons	Deputy Commissioner Chief Engineer

## TESTING AND RESEARCH DIVISION

W. W. McLaughlin	Testing and Research Engineer
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## RESEARCH LABORATORY

E. A. Finney	Assistant Testing and Research Engineer in charge of Research
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FOREWORD

This summary of information concerning the Research Laboratory of the Michigan State Highway Department has been prepared primarily to acquaint the personnel of the Department with the operation of the organization, and the nature and scope of the work being performed by it.

In addition, the summary may serve as a progress report to the State Highway Administration and also as a reference for people outside of the highway organization who have an interest in highway research.

The information contained in this report includes the history of the organization and its location, facilities, personnel, functions, objectives, activities and accomplishments since its establishment in 1939.

TABLE OF CONTENTS

I.	HIGHWAY RESEARCH . . . . .	3
II.	HISTORY . . . . .	4
III.	LOCATION . . . . .	6
IV.	FACILITIES . . . . .	7
V.	PERSONNEL . . . . .	8
VI.	FUNCTIONS . . . . .	9
VII.	OBJECTIVES . . . . .	10
VIII.	CURRENT RESEARCH PROGRAM . . . . .	11
IX.	RESEARCH ACTIVITIES . . . . .	13
X.	OTHER RELATED ACTIVITIES . . . . .	34
XI.	GENERAL ACCOMPLISHMENTS . . . . .	38
XII.	BIBLIOGRAPHICAL INFORMATION . . . . .	39
XIII.	APPENDIX A SUMMARY OF COMPLETED PROJECTS . . . . .	48
XIV.	APPENDIX B SUMMARY OF RESEARCH PROJECTS BY SUBJECT MATTER . . . . .	52

HIGHWAY RESEARCH

Research plays an important part in the art and technique of highway building. Highway technology, and the benefits in highway service which the public derives therefrom, advances through research. In a technical organization such as a highway department, research has a considerable bearing not only on construction but even on the general policy of the department.

The specific objective of highway research is to raise the standards of the highway system's service by improving its physical facilities and increasing the efficiency of its operating methods. This it may accomplish by bringing into use new or improved things which will prolong the economic life of highway structures, provide greater comfort, safety and usefulness to highway users at reduced operating costs, and also to reduce operation, construction and maintenance expenditures in order that additional funds can continually be made available for producing better highway service to the public.

Highway administration carries much greater responsibility today than at any previous period and, therefore, it must be provided with facilities to keep pace with technological advances. The highway administrator is dependent largely upon the work of his technical staff to secure information on the various problems which confront him.

## HISTORY

From the creation of the Highway Department in 1905 until 1919, research consisted of special studies conducted by Department Officers. The studies for the most part included experimental road sections constructed primarily for the purpose of acquiring information to be used in the preparation of specifications and for improving construction methods.

In 1919 a Testing Laboratory was established at Ann Arbor for the purpose of testing materials used in construction and to perform investigations related to materials and methods of testing. The research work of the laboratory supplemented the special research projects related to construction and maintenance practice which were continually increasing in number and scope.

The volume of research work had increased to such a point by 1924 that a new Division of Investigation and Research was created by the Administration for the purpose of carrying on studies pertaining to roads already built and for investigating conditions under which new roads were to be constructed.

In 1927 the Division of Investigation and Research was changed to the Division of Research and Statistics responsible for the collection and preparation of all data having a bearing on highway problems and to investigate those problems of particular importance to Michigan. The Laboratory at Ann Arbor continued to operate independently on matters of testing and research.

Between 1927 and 1933 the Statistical section of the Division of Research and Statistics was divorced from Research and the Division of

Research continued as a separate unit investigating problems related primarily to construction, maintenance and allied operations in conjunction with the Laboratory at Ann Arbor.

In 1933 the activities of the Research Division and those of the Testing Laboratory were combined under one head to form a new Department unit designated the Research and Testing Division under the direction of the Research and Testing Engineer with offices in Lansing. The laboratory research work at Ann Arbor and field studies of a research nature were correlated under the supervision of a Research Consultant.

A separate Research Organization known as the Research Division was created in 1939 by the Highway Administration and was established at Michigan State College by mutual agreement between the State Board of Agriculture, the State Administrative Board and the State Highway Commissioner. This new Division was organized to carry on the research work formerly done by the various Divisions within the Department and was charged with the responsibility of creating and executing a program of highway research best suited to the needs of the Department.

In April, 1942, the Research Division and the Testing Division were combined, thereby forming the present Testing and Research Division. The merger of the two divisions under the Testing and Research Engineer in Lansing effected only an administrative change. The Research Division then became the present Research Laboratory, and its research activities continued without interruption under the immediate supervision of the Assistant Testing and Research Engineer in charge of Research.

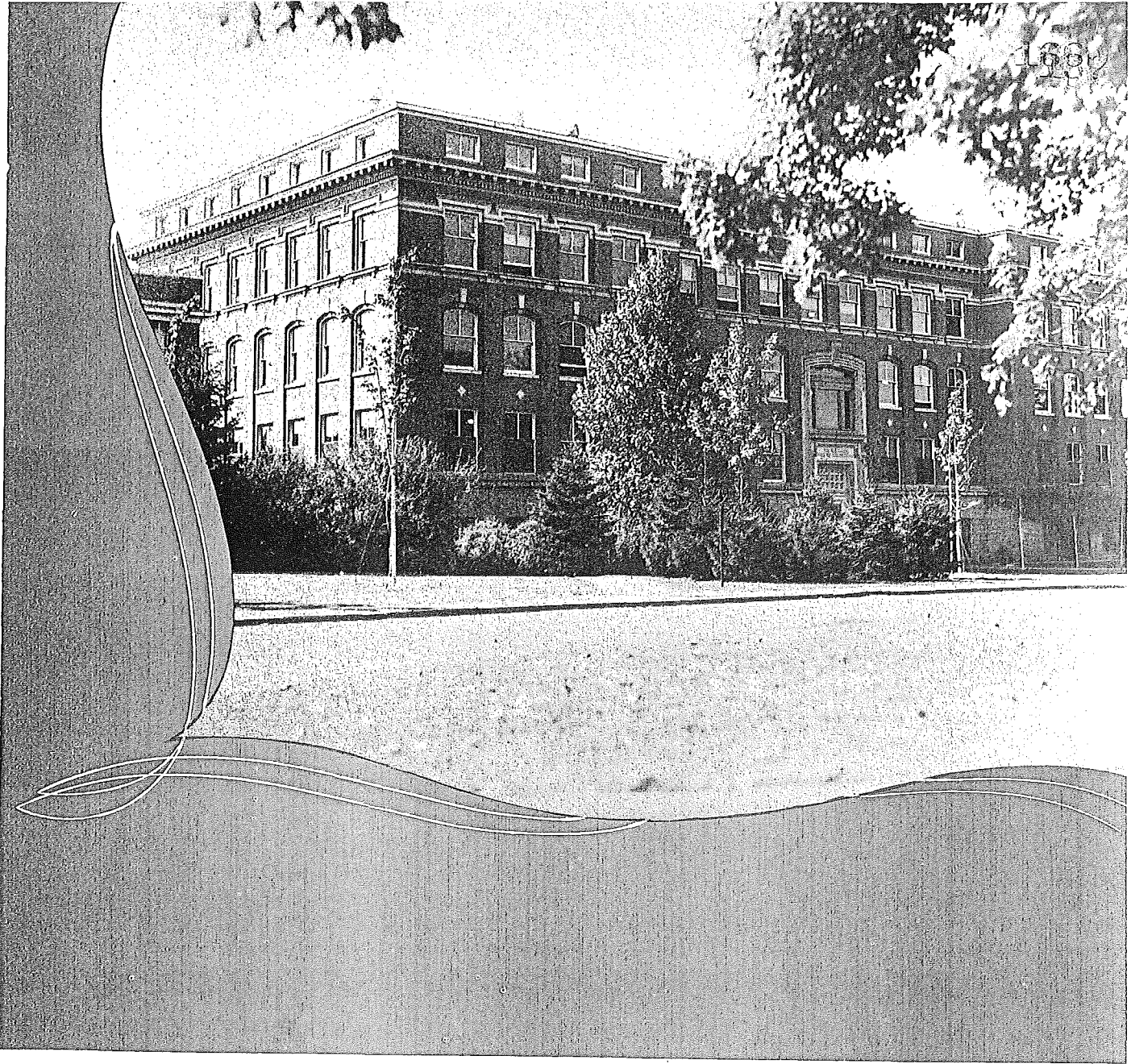
## LOCATION

The Research Laboratory is located in Olds Hall of Engineering on the Campus of Michigan State College in East Lansing. The College authorities accorded to the Highway Department its facilities and certain space in the building and of the Civil Engineering Laboratories for carrying on its research activities.

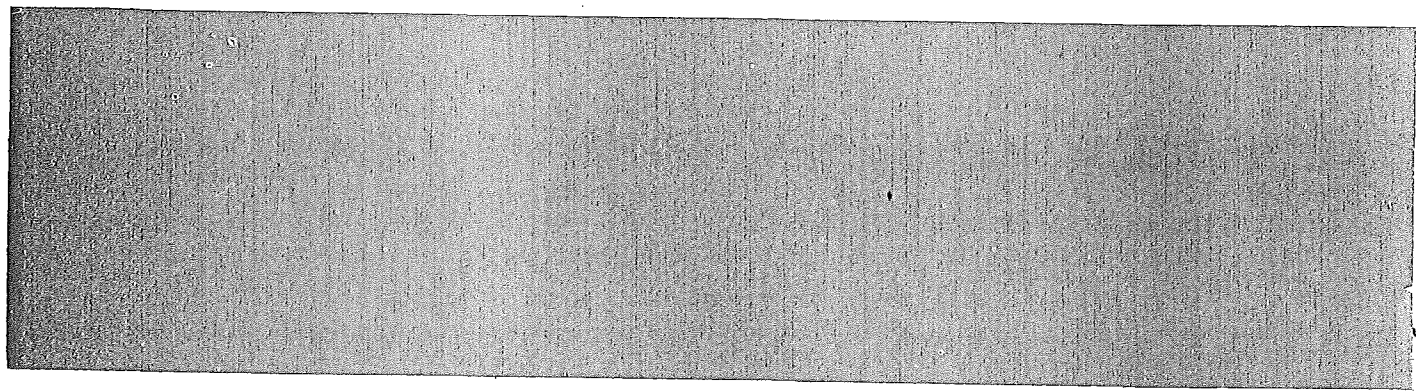
The location of the Research Laboratory on the Campus of Michigan State College has many advantages. The College environment is ideal for the promotion and pursuance of scientific investigations. Through mutual confidence and coordination of effort there will result a correlation of new data and new knowledge to give added impetus to the advancement of highway engineering.

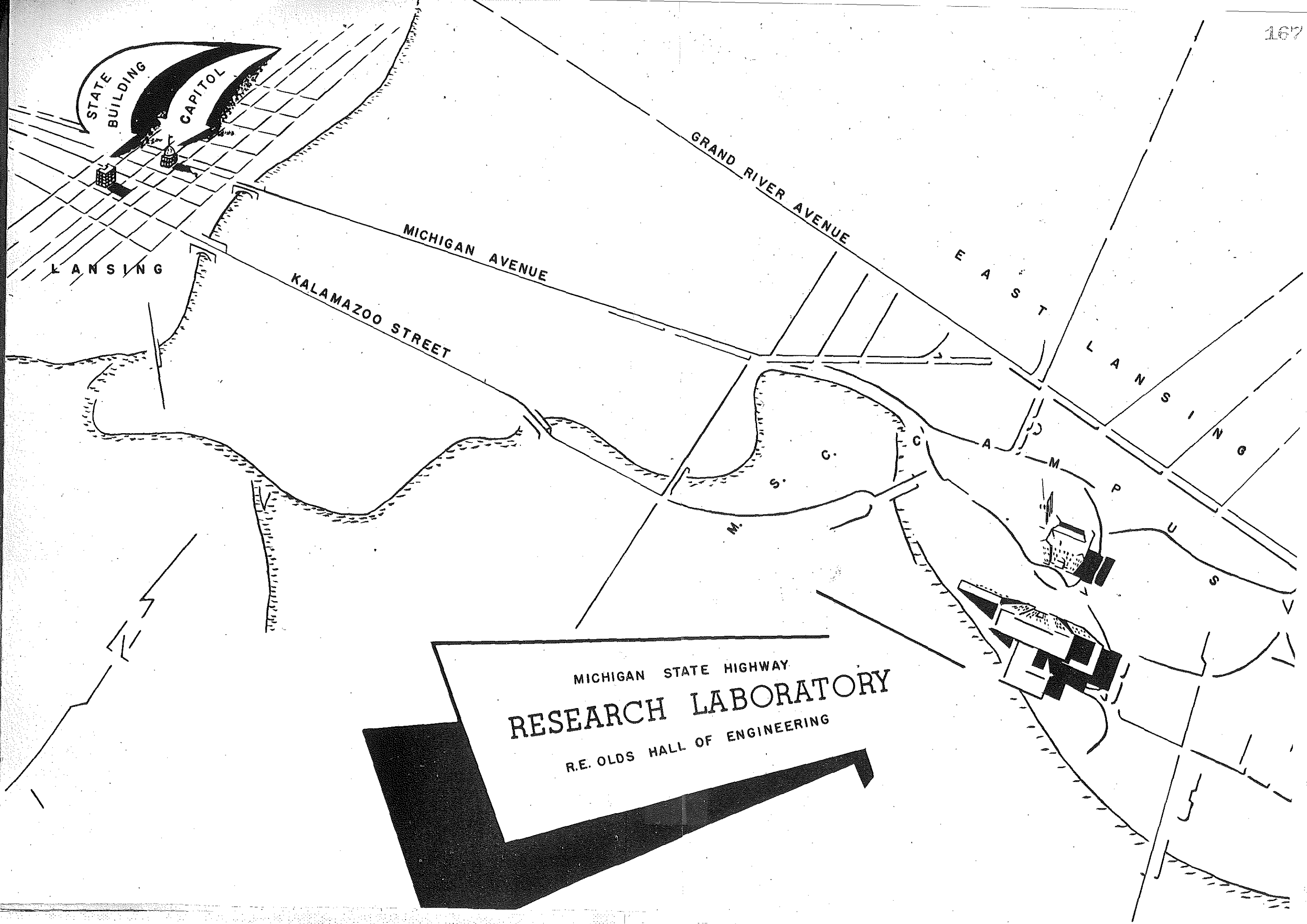
The proximity of the laboratory to Lansing not only facilitates the performance of routine administrative functions, but also makes it readily accessible at all times to the Staff and other personnel of the Department.



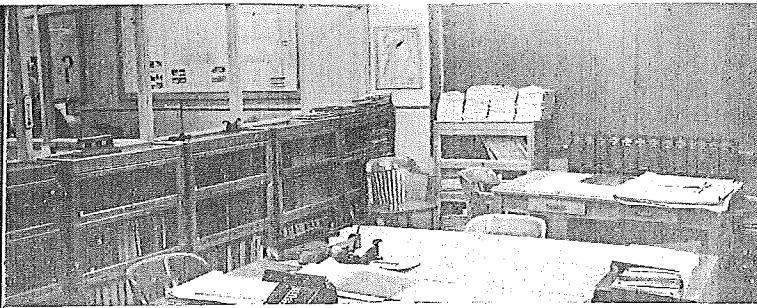


*The* R. E. OLDS HALL *of* ENGINEERING

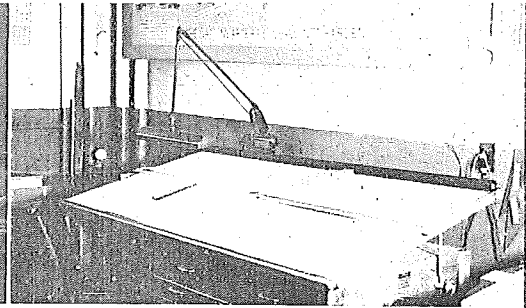




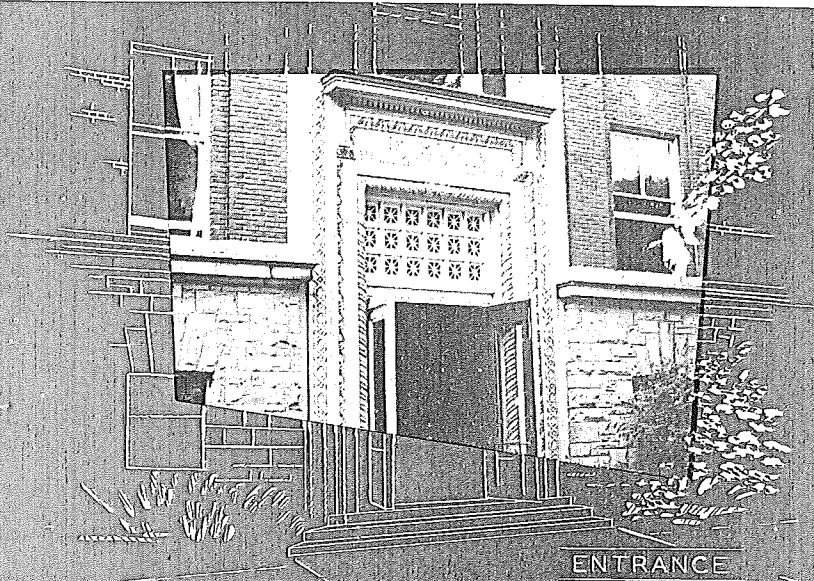
MICHIGAN STATE HIGHWAY  
**RESEARCH LABORATORY**  
 R.E. OLDS HALL OF ENGINEERING



FRONT OFFICE

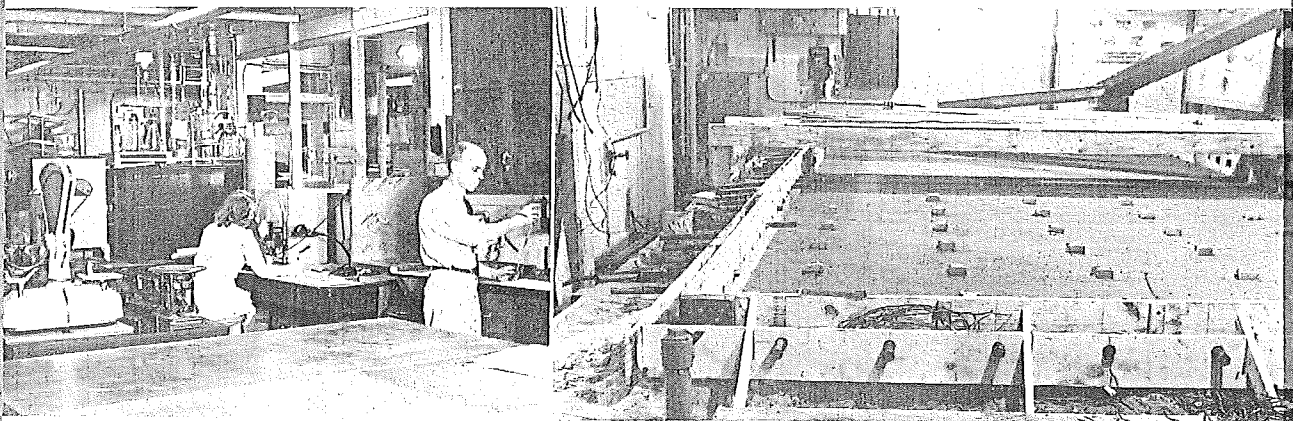


GRAPHIC PRESENTATION OFFICE



OFFICES *and* LABORATORY FACILITIES

GENERAL RESEARCH LABORATORIES



FACILITIES

The general administrative office of the Research Laboratory is located in Room 3, Olds Hall of Engineering. At the present time laboratory activities are carried on in two large basement rooms. The laboratory is fully equipped to conduct research work on problems related to cement, concrete, soils, aggregates, bituminous materials and those of a general chemical nature. In addition, the laboratory has a well-equipped work shop, a photographic dark room, a moist room and drafting room. A small library of specialized books is being created on subjects related to highway problems.

The laboratory has many pieces of special equipment which it has made or purchased for work of a specific nature. This includes a hydraulic compression machine, fast freezing refrigerator unit, sonic apparatus, petrographic microscope and associated equipment, electric soil compaction machine, soil vibrometer, Koppers absolute viscometer, bituminous recovery apparatus, photometer, electric strain indicator, special electrical bridges, and equipment for measuring electrical phenomena.

Other facilities are offered by the College, including the main library and the several specialized departmental libraries. The College maintenance shops, as well as those of the Mechanical Engineering Department, are available for repair work and developing new scientific equipment. The staff of the Schools of Science at the College is available for consultation on matters of mutual interest and their laboratories and equipment may be used with special permission. The College campus and adjacent farm lands also are available for special field studies.

The Research organization also maintains a small field laboratory at the Michigan Test Road on M-115 for facilitating field studies and seasonal observations in conjunction with this nationally known experimental pavement project.

## PERSONNEL

Direct administrative responsibility of the Research Laboratory is vested in the Assistant Testing and Research Engineer in charge of Research, who acts under the authority of the Testing and Research Engineer, administrative head of the Testing and Research Division.

The personnel of the present full-time research staff includes Civil Engineers, Chemical Engineers, and Chemists possessing considerable practical research experience and scholastic achievement. Their duties are to carry on independent research, to guide and supervise the laboratory assistants and, in general, organize and direct the work of the Research Laboratory.

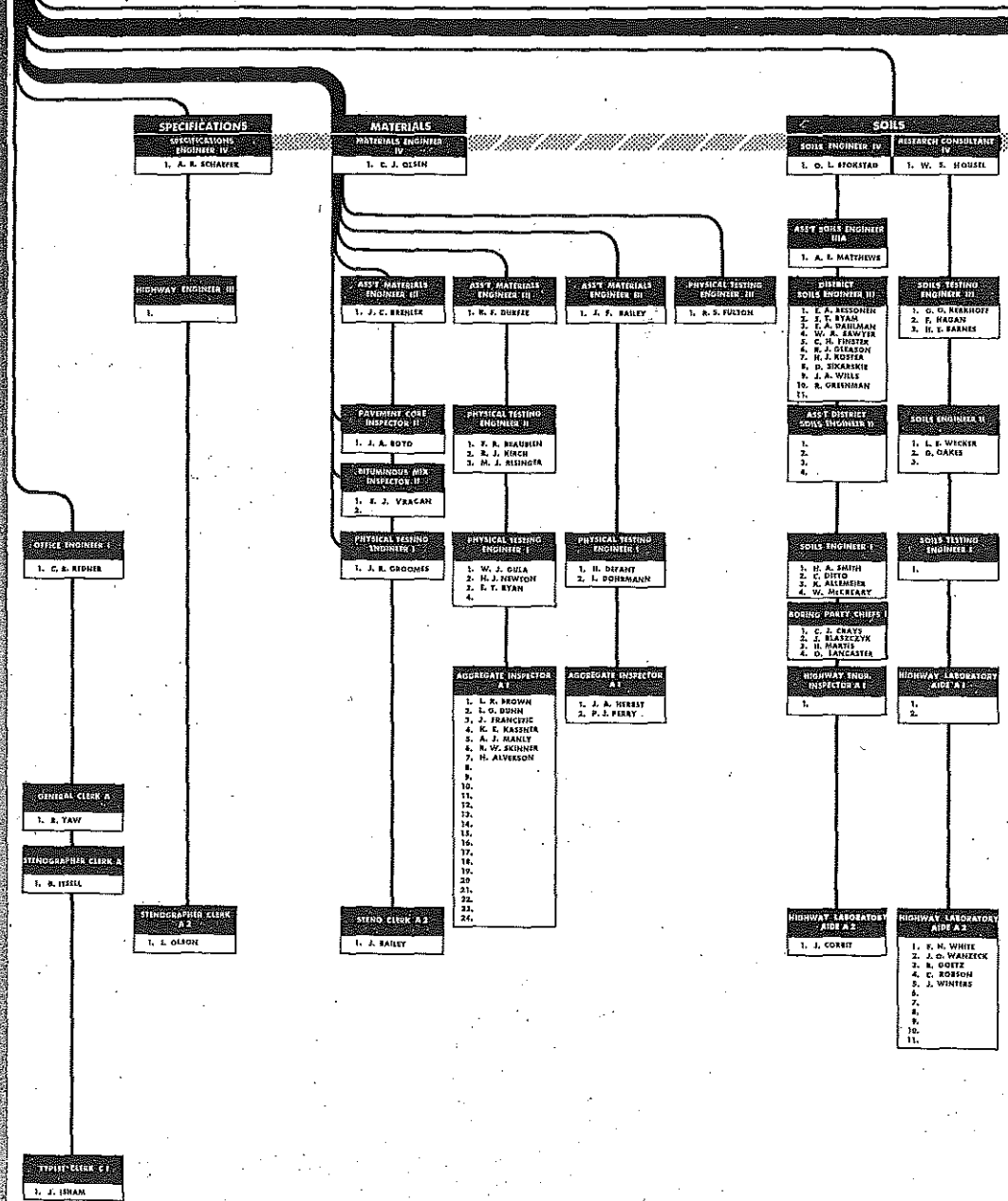
Laboratory assistants consist of full-time Department employees and part-time Michigan State College undergraduate and graduate students who need financial assistance and are interested in obtaining practical laboratory research experience. At present there are six full-time laboratory assistants, and normally the number of part-time student assistants varies from ten to twenty. The student assistants are usually chosen for their special attributes in relation to scientific training, research ability and laboratory experience.

# TESTING & RESEARCH DIVISION

W. W. McLAUGHLIN  
TESTING & RESEARCH ENGR. VI

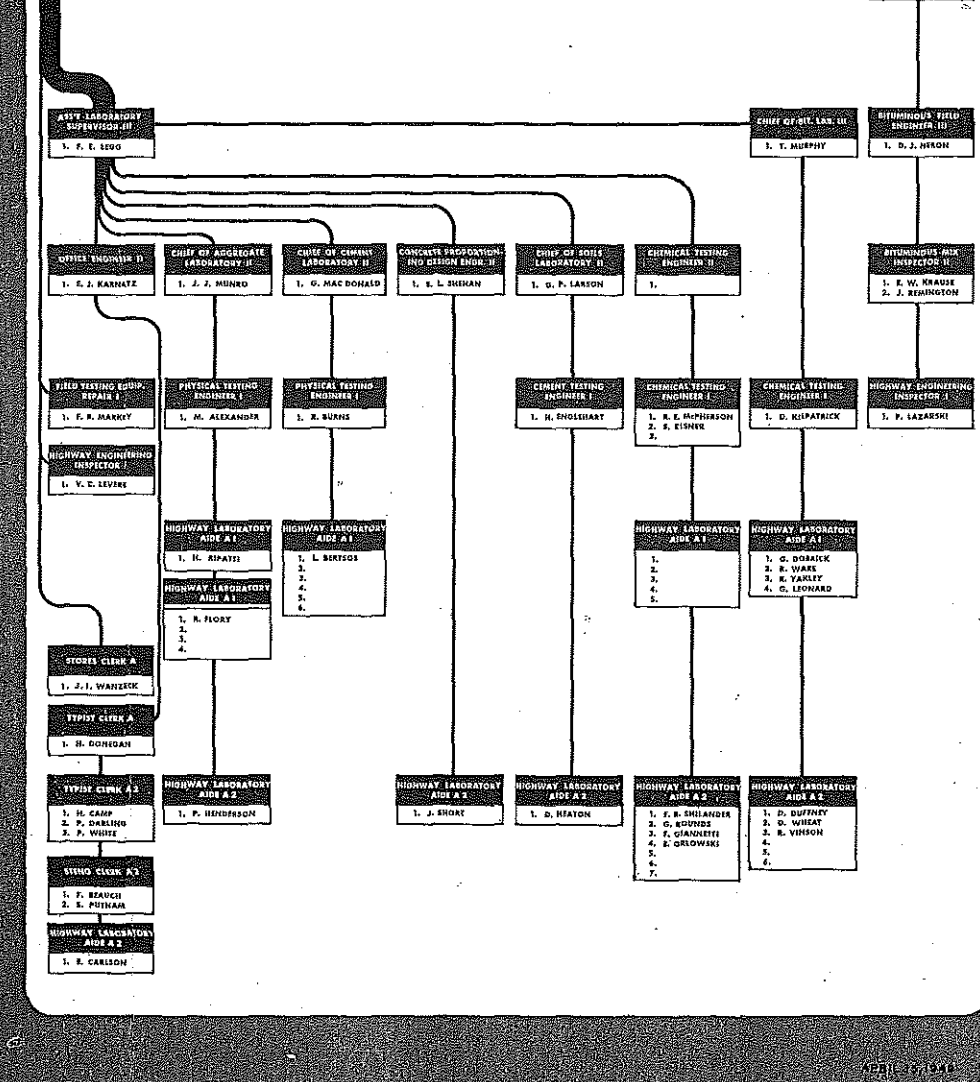
## MATERIAL TESTING

H. R. STE  
ASST. TESTING & RESEARCH ENGR. V



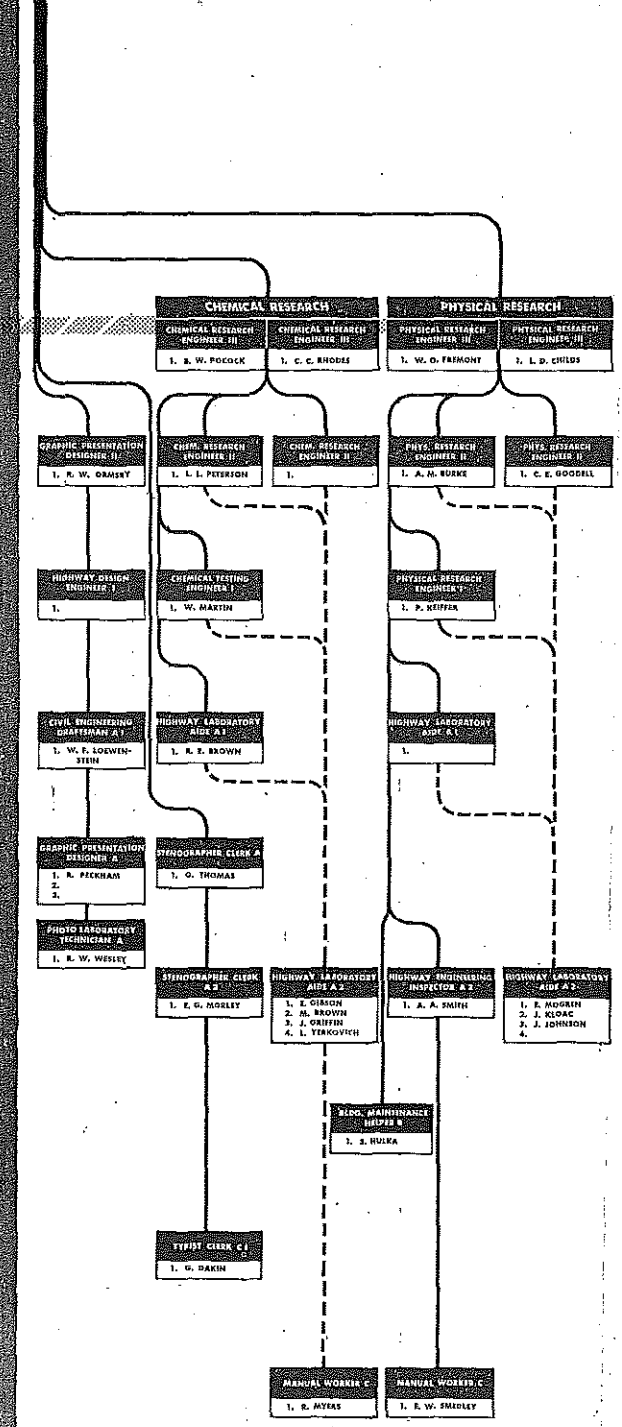
## TESTING LABORATORY

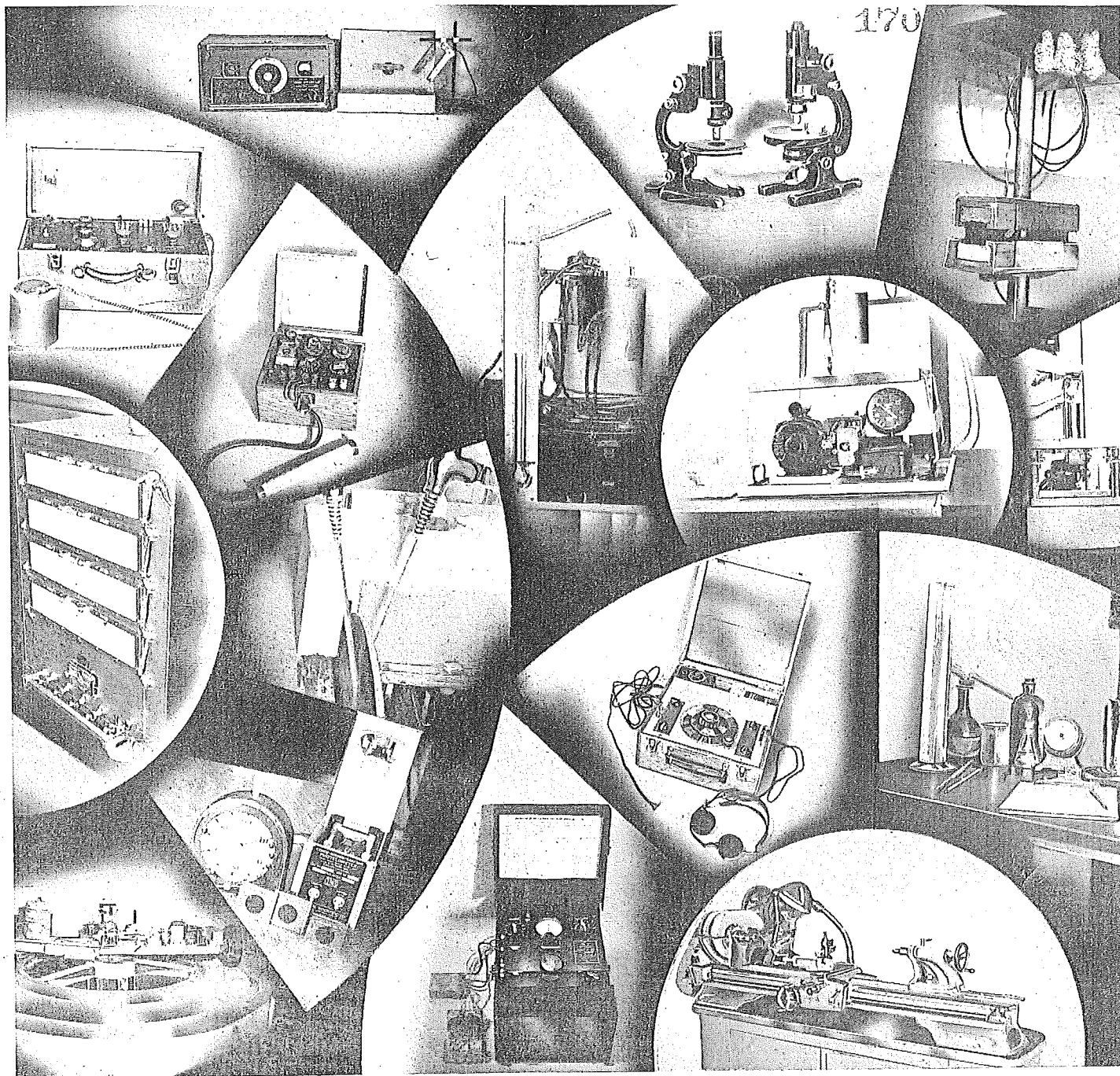
J. L. STEIN  
LABORATORY SUPERVISOR IV



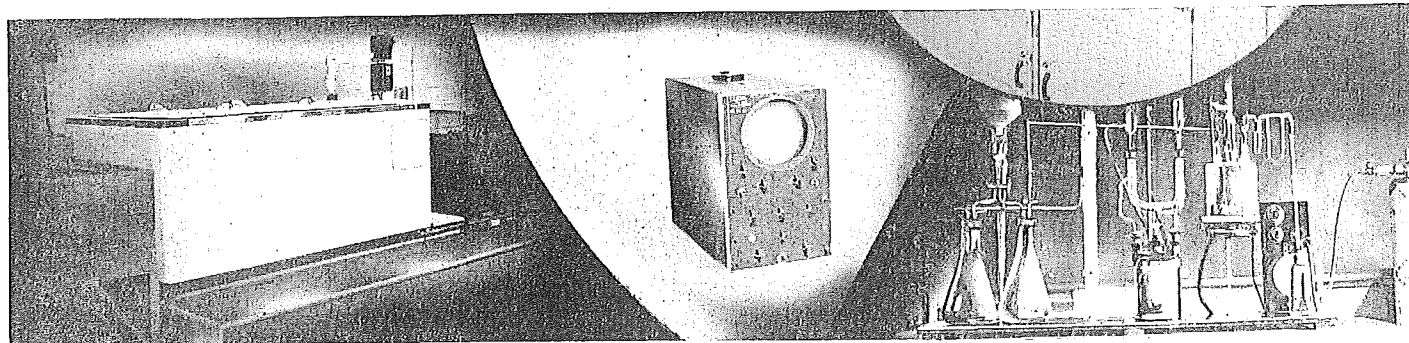
## RESEARCH LABORATORY

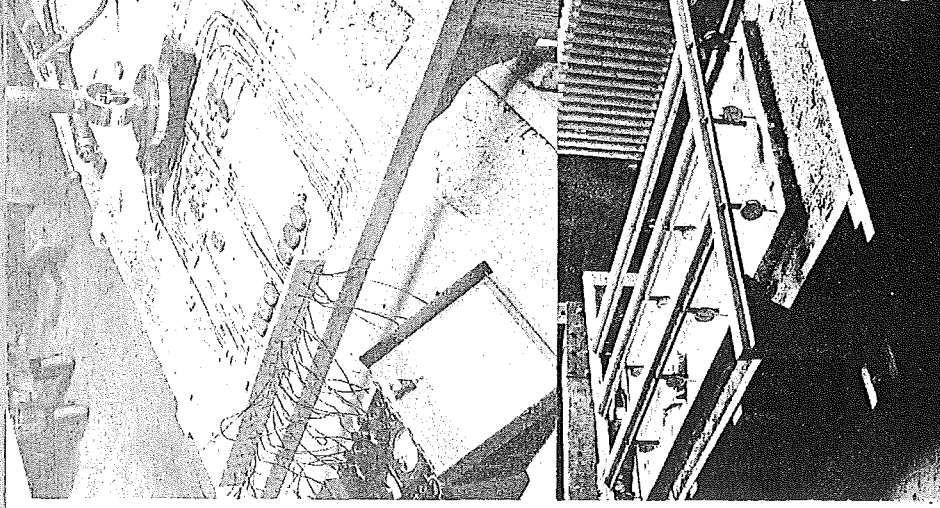
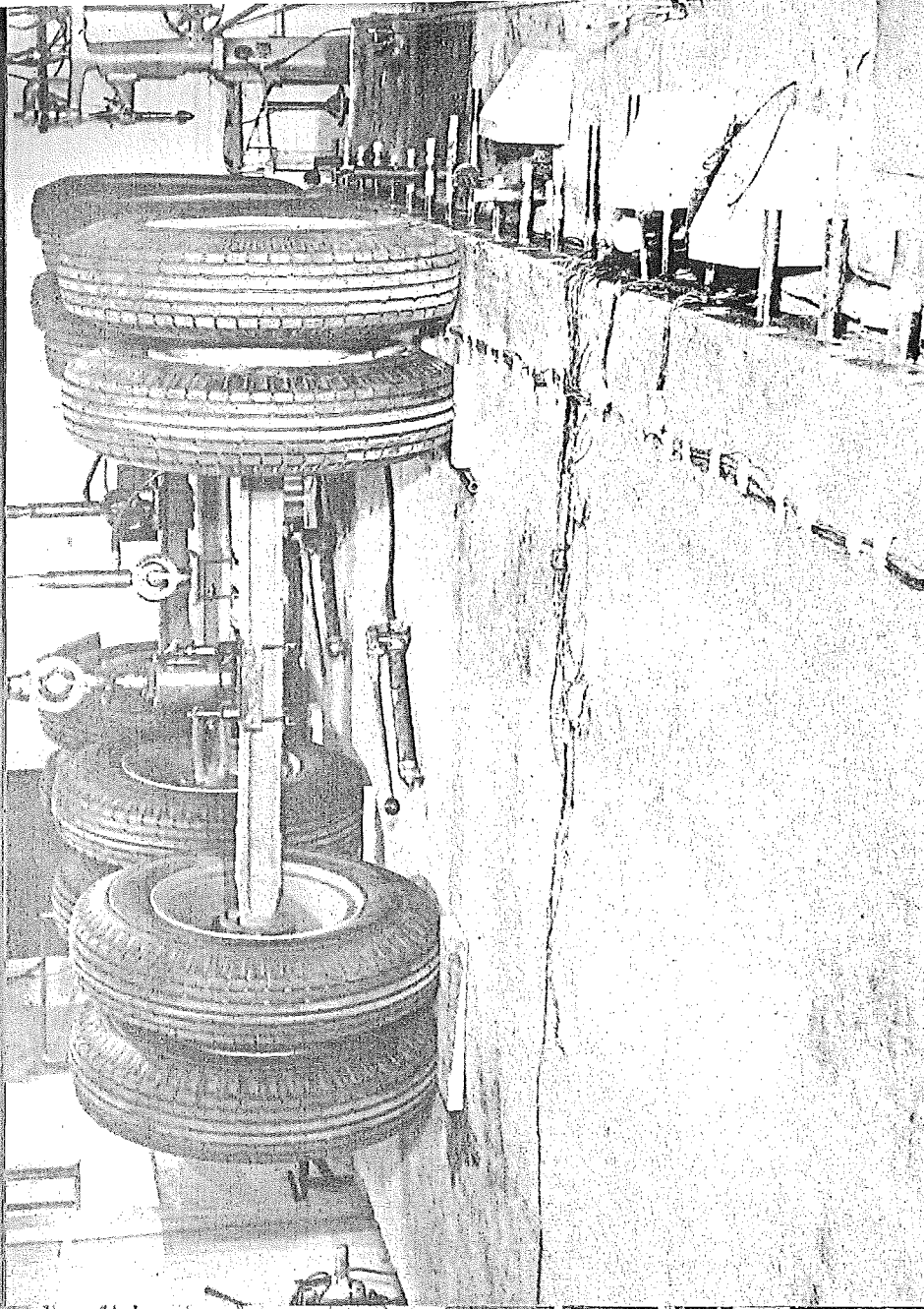
E. A. FINNEY  
ASST. TESTING & RESEARCH ENGR. V





LABORATORY EQUIPMENT





LOADING STUDIES *on* MODEL *and* FULL SCALE SLAB



FUNCTIONS

The functions of the Research Laboratory are manifold, diversified, and of vital importance to the development of all phases of highway work. These functions may be broadly outlined as follows:

1. To visualize the problems of highway technology, to determine which of the many phases involve further research, to formulate and execute a definite program of research.
2. To perform experimental and developmental researches directed toward the solution of technical problems arising in the various divisions of the Department, or to the development of new procedures and methods and the improvement of existing ones.
3. To participate in theoretical researches directed toward the solution of certain major problems of interest in the general field of highway engineering.
4. To engage in cooperative research programs with educational institutions, agencies of the federal government and certain manufacturers on problems of mutual interest.
5. To provide specifications and standards for materials, make specialized analyses and research tests on new materials, and render assistance in regard to construction difficulties.
6. To accumulate, analyze and distribute to the Department technical and research information from outside sources pertaining to highway problems.
7. To prepare technical reports for members of the Department outside of the Research Organization.
8. Through membership take part in committee work of the various technical organizations and thereby represent the Department in their activities.
9. To act in an advisory capacity to the Department on problems of a technical nature or on matters of policy in regard to design, construction and maintenance practices.

## OBJECTIVES

Organization of research within the Department is directed toward the accomplishment of the following objectives:

1. Achievement of a sound research organization in terms of administration, staff and facilities for the conduct of a research program commensurate with the growth and responsibilities of the Department.

2. Encouragement of those now actively engaged in research and provision of opportunities in research work for interested and capable employees of the Department not now doing research.

3. Promotion of cooperation in research within the Department, and between the Department and educational institutions, agencies of the federal government and industry, in order to secure concentration of effort, minimize duplication and stimulate progress.

4. Formulation of comprehensive projects of research and the development of effective means of utilizing the scientific and technical resources of both the State and the Nation for dealing with these projects.

5. Effective cooperation with the Highway Research Board's newly created Correlation Service which has recently been established. With this new functional responsibility the Highway Research Board plans greater emphasis on highway research in the future with the thought of utilizing all available research agencies and facilities to develop an integrated national program of highway research.

CURRENT RESEARCH PROGRAM

When the Research Laboratory was organized in 1939, a research program consisting of eight major projects was established. During the past nine years it has been necessary to expand the scope of the original research program greatly in order to keep pace with the rapid advancement in highway technology, and also to handle the many problems submitted to the laboratory by the administration and various divisions of the Department.

The investigations which comprise the current research program are listed below:

A. Aggregates

- 47 A-7 Evaluation of Aggregate Sources
- 47 A-8 Material Surveys
- 47 A-9 Effect of Heat on Physical Characteristics of Aggregates

B. Cement and Concrete

- 39 B-11 Concrete Durability Investigation
- 42 B-13 Air Entraining Concrete in Bridge, Plainwell FB2 of 3-8-1, C1
- 42 B-14(2) Curing of Concrete Pavements
- 42 B-16 Effect of Low Temperatures on Concrete Containing Admixtures
- 45 B-18 Preserving and Reconditioning of Concrete Structures
- 46 B-19 Concrete Failure, FL5-11, C2, US-131
- 47 B-21 Control of Autogenous Volume Changes in Concrete

C. Bituminous Materials

- 36 C-1 Changes in Characteristics of Slow Curing Oils
- 47 C-5 Use of Inhibitors to Control Weathering of Bituminous Materials

D. Bituminous Mixtures

- 46 D-13 Experimental Bituminous Surface Treatments
- 46 D-14 Bituminous-Rubber Mixtures for Pavement Surfaces.

E. Soil

- 36 E-5 Soil Stabilization
- 43 E-9 Turf Growth on Highway Shoulders
- 44 E-10 Soil Action Under Bridge Piers
- 45 E-11 Design and Construction of Pavement Foundations
- 47 E-12 Chemical Stabilization of Granular Materials

Current Research Program - Continued

F. Structural

- 39 F-1 Evaluation of Load Transfer Devices
- 39 F-7 Concrete Pavement Design
- 39 F-7(5) Grand Rapids Experimental Project, F41-34, C6
- 43 F-6 Structural Failure, F40-11, C2 and F5-15, C2
- 47 F-13 Slab Action Under Dynamic Loads
- 47 F-14 Distribution of Stresses in Bridge Structures
- 47 F-15 Pavement Roughness Investigation
- 47 F-16 Longitudinal Cracking on Project 17-43, C2
- 47 F-17 Effectiveness of Spiral Shear Developers
- 49 F-19 Multi Plate Investigation

G. Miscellaneous

- 36 G-3(7) Snow and Ice Removal by Radiant Heat
- 36 G-4 Joint Seal Investigation
- 39 G-14(2) Reflector Button Investigation
- 46 G-33 Guard Rail Expansion Take-up and Anchorage Design
- 47 G-36 Use of Glass Beads for Reflectorized Center Stripe
- 47 G-38 Skidding Properties of Pavement Surfaces
- 47 G-40 Comparative Cost Study between Reflector Buttons and Reflectorized Material
- 48 G-43 An Investigation of Rust Inhibitives for Chloride Salts Used in Ice and Dust Control

RESEARCH ACTIVITIES

The activities of the Research Laboratory are devoted primarily to problems pertaining to the improvement of highway materials, construction, maintenance and operation. There is presented in the following text a brief synopsis of each of the major problems listed under the organization's research program. Figures in parenthesis identify reports which have been completed on each Research project.

A. AGGREGATES

Michigan has a good supply of satisfactory road building aggregates. Due to glaciation, gravel deposits are widely deposited throughout the State. Suitable limestone aggregates are produced economically in certain locations. There are instances, however, when performance surveys indicate that certain sources do not supply satisfactory materials for road construction purposes. The Research Laboratory has the facilities to investigate these conditions and other aggregate problems submitted to it. Two outstanding aggregate investigations on the program are listed below.

47 A-7, Evaluation of Aggregate Sources

The purpose of this investigation is to evaluate the aggregates from current sources in Michigan on the basis of durability, physical properties and service record; and to correlate these properties with geological factors in order that the existence and probable qualities of potential sources may be predicted and to insure that only the better materials will be used in highway construction.

47 A-8, Material Surveys

It is proposed to investigate the several well-known methods of geophysical exploration for the purpose of obtaining engineering information on soils and granular materials and to develop techniques and methods for doing this work. Information from such a study will have many applications in relation to design

policies and for providing information on material sources for foundation and pavement construction.

47 A-9, Effect of Heat on Physical Properties of Aggregates

A study is in progress to determine the effect of high temperatures or heat shock on the subsequent durability of limestone and natural aggregates used in bituminous resurfacing mixtures. Report (124).

B. CEMENT AND CONCRETE

Investigations related to cement and concrete are classified under this section of research activities. They consist of problems involving factors affecting concrete performance and may include concrete design, the chemical and physical properties of concrete mixtures and their components, construction practices and detailed performance surveys associated with pavement failures. Current research projects included under this category are:

39 B-11, Concrete Durability Investigation

This investigation has been established on a long range basis and is devoted to the improvement of concrete durability, especially in relation to scaling and disintegration. The most significant result of this research to date has been the application of the principle of air entrainment to construction practices in Michigan for the purpose of producing more durable concrete pavements. The investigation includes several associated research projects. Report (11).

Michigan Test Road, Durability Project F 18-20, C3, 39 B-11 (2): This section of the nationally known experimental pavement was constructed in 1940 to evaluate the effect of variation of factors relative to construction and materials upon the durability of concrete pavements. This project has been completely described

in Departmental Bulletin titled "Michigan Test Road." Reports (3) (8) (12) (14) (18) (20) (21) (25) (31) (39) (41) (48) (64) (79).

Manistique Stone Sand Project, M 75-28, C2, 39 B-11 (4): On the basis of results from scaling studies conducted on the Michigan Test Road, further experimentation was carried on with the use of admixtures in stone sand concrete mixtures. In the construction of a concrete pavement using limestone aggregates in the City of Manistique, both an air-entraining agent and silica dust were added to the concrete mixture. The purpose of this work was to determine whether the admixtures would improve the objectionable characteristics of stone sand in concrete, such as excessive bleeding, difficult finishing and subsequent scaling due to chloride salts. It was found that air-entraining agents corrected most of the undesirable properties of stone sand concrete. Report (36).

Air-Entraining Concrete Study, 39 B-11 (7): Since air-entraining concrete is a comparatively new product in the highway industry, there is always the need to improve the product and to determine its physical characteristics under different construction conditions. A continuous study of these factors is being carried on by the Laboratory. Reports (48) (54) (63) (75) (79) (112).

Muskegon Experimental Project, 39 B-11 (8): This experimental pavement was constructed in 1938 on M-126 in Muskegon Heights - Construction Project M 61-27, C5. Embodied in the construction of the project are several construction features for the purpose of determining methods to eliminate scale and to evaluate practices concerning the spacing and construction of transverse joints. Although this project was constructed before the establishment of the Research Laboratory, it has become one of the many such projects taken over by the Laboratory for periodic examination. Report (78).

Use of Admixture H.P. 7, 39 B-11 (10): A concrete admixture known as H.P. 7, and produced by the Master Builders of Cleveland, has been added to two pavement projects in Michigan for the purpose of studying its effectiveness in producing scale resistant concrete. The projects are M 71-24, C1 at Rogers City and M82-110, C1 on Belleville Road, US-112 South, both of which are under surveillance by the Research Laboratory.

42 B-13, Bridge Project FB-2 of 3-8-1, C1 at Plainwell

An air-entraining admixture (Orvus) was added to the concrete which was used for constructing the sidewalks on this bridge project for the purpose of scale prevention. This project is also under observation by the Research Laboratory. (131)

42 B-14 (2), Curing of Concrete Pavements

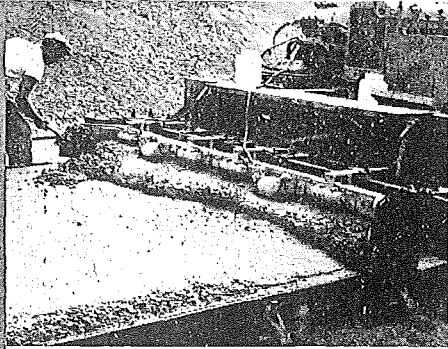
This is a cooperative project between the Highway Research Laboratory and the Engineering Experiment Station at Michigan State College. The project has a twofold purpose: (1) to establish the basic principles involved in curing of Portland cement concrete, and (2) to compare membrane curing with other methods on the basis of efficiency, practicability and cost. Report (118)

The work entails a comprehensive laboratory study where variables occurring in actual construction practice may be controlled. These studies will be supplemented by observation of experimental pavement sections in the field.

42 B-16, Effect of Low Temperatures on Concrete Containing Admixtures

This project was set up to study the effect of cold weather practices on the durability and characteristics of concrete containing air-entraining agents with and without the addition of calcium chloride. Certain field studies related to this subject were finished during the construction of the Detroit Industrial Expressway - Research Project 39 B-11 (10). There remains to be done a certain amount of laboratory work under controlled conditions before





AIR-ENTRAINING  
CONCRETE



ASPHALT LATEX  
JOINT SEAL



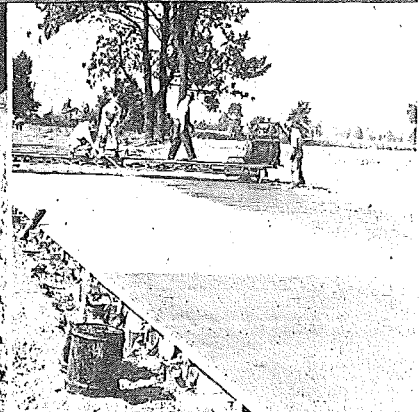
STONE-SAND  
CONCRETE



WARPING



JOINT MOVEMENT



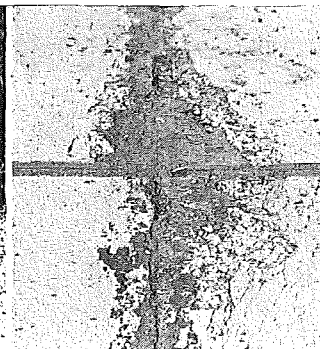
MEMBRANE CURING

## CONCRETE PAVEMENT STUDIES

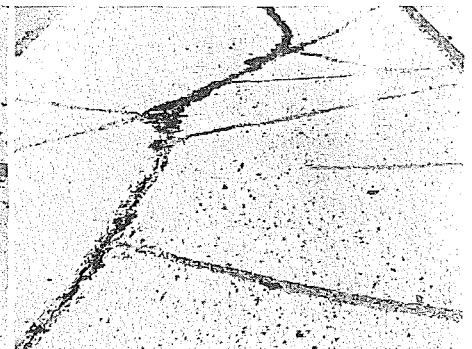
SCALING



DISINTEGRATION



CRACKING





this project can be successfully completed.

45 B-18, Preserving and Reconditioning of Concrete Structures

This project covers two important problems of vital interest to the Department: (1) the application of surface treatments to concrete bridge structures for protective or aesthetic purposes, and (2) the restoration of any concrete which shows evidence of disintegration due to weathering or other causes, especially in relation to bridge structures.

It is proposed to investigate in cooperation with the Bridge Division the various methods and proprietary materials now on the market as to their relative merit for reconditioning purposes, and to determine the economic justification and practicability of such treatments with the view of making recommendations and providing specifications for such bridge maintenance practices in the future.

The first part of this investigation has been completed. Report (87) (110).

46 B-19, Concrete Failure, Project F 15-11, G2, U.S. 131, Emmet County Line, South

This concrete pavement project has developed abnormal deterioration as manifested by excessive deep scaling of the surface. It has been necessary to resurface certain portions of the pavement. Before this was done, an investigation was made to determine the contributing causes of such a phenomenon.

The investigation will be directed along two lines: (1) a study of materials used in this project, and (2) a review of construction conditions and practices with regard to their possible effect on the durability of the finished pavement.

47 B-21, Control of Autogenous Volume Changes in Concrete

This project has been established with the primary objective of eliminating cracking in long concrete pavement slabs, as related to the Department's current design practice, by an attempt to control the inherent shrinkage of Portland Cement concrete during the early hardening period. The first attempts directed toward the

solution of this problem will be in the trial of special admixtures and the use of expanding cements. The idea is not new, since the principle has been under study for some time by European research agencies.

### C. BITUMINOUS MATERIALS

Every year large quantities of bituminous materials are used in Michigan for different types of road surfaces. Several different kinds of bituminous materials are required for this work. The Research Laboratory has initiated studies in this field for the purpose of continually improving specifications covering the requirements of current products, and to seek methods of improving the weathering characteristics of current materials as a means of attaining more durable bituminous surfaces.

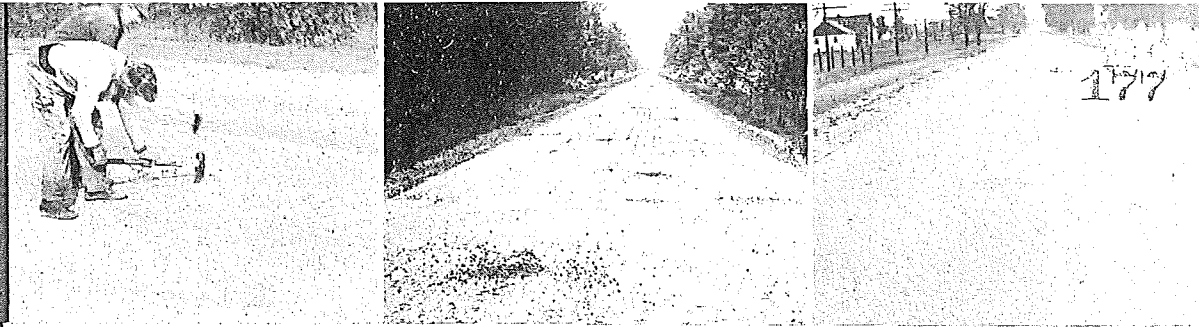
#### 36 C-1, Changes in Characteristics of Slow Curing Oils

The purpose of this investigation is to determine the characteristics of slow curing asphaltic oils 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 are incorporated in the bituminous mixture. This project was started under former Research and Testing Division.

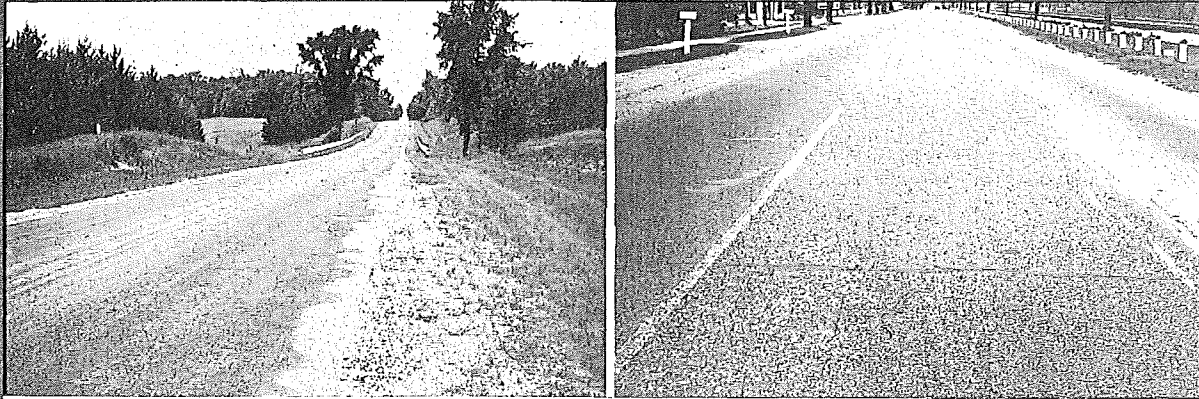
The investigation has included a comprehensive laboratory study of the physical properties of slow curing asphaltic oils before and after accelerated weathering tests. In conjunction with the laboratory investigations, a field study embracing sixteen oil aggregate test projects has been established from which samples are taken each year for laboratory analyses. Reports (6) (17) (69) (89R).

#### 47 C-5, Use of Inhibitors to Control Weathering of Bituminous Materials

This study has been established on the basis of results from investigation



O I L   A G G R E G A T E   S U R F A C E



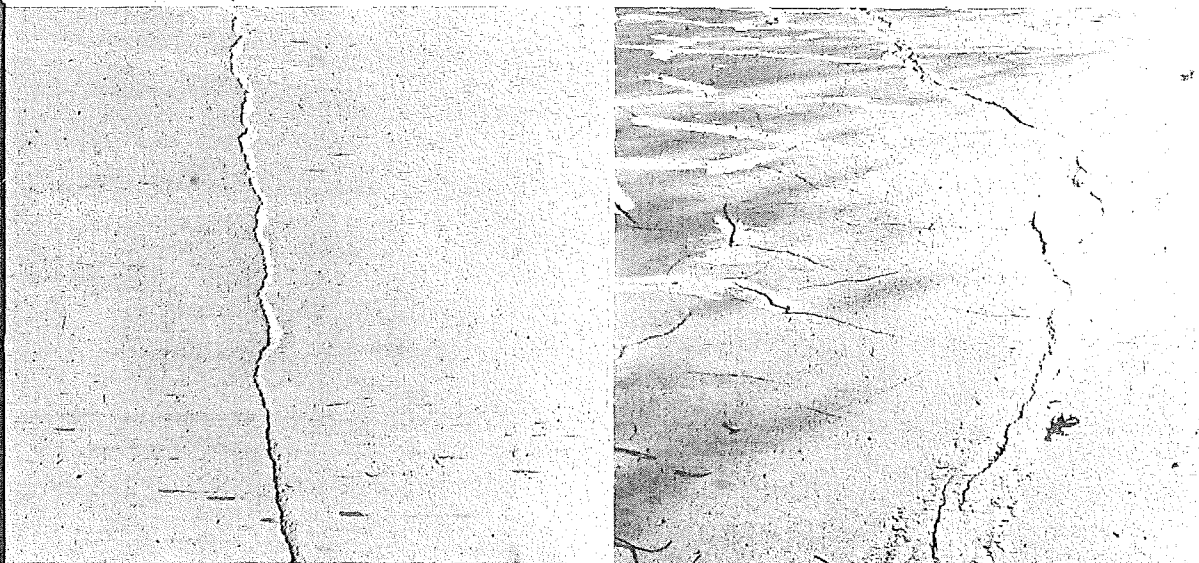
G R A V E L   B A S E S

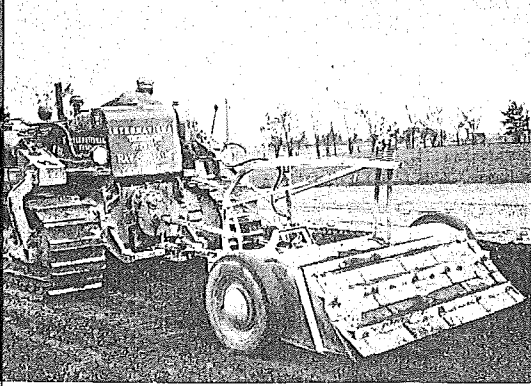
R E S U R F A C I N G

C O N C R E T E   P A V E M E N T

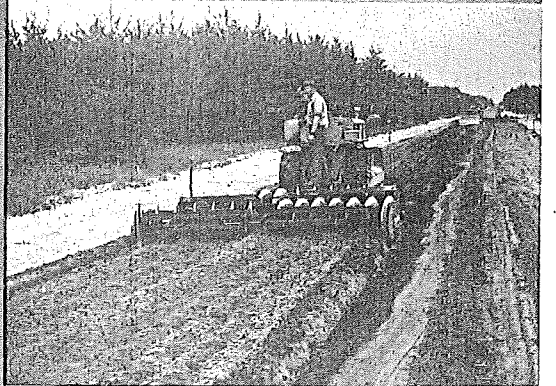
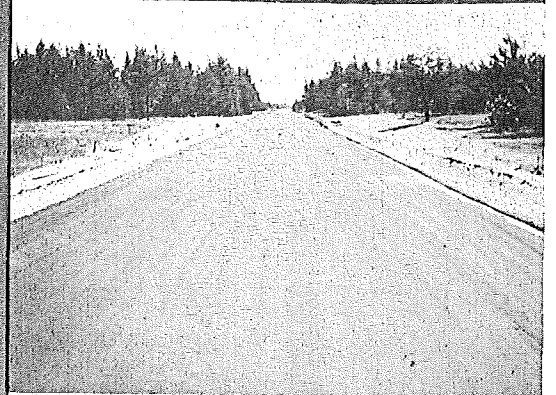
## BITUMINOUS CONSTRUCTION

S T U D Y   O F   B A S E   C O U R S E   D E S I G N   T O   P R E V E N T   C R A C K I N G



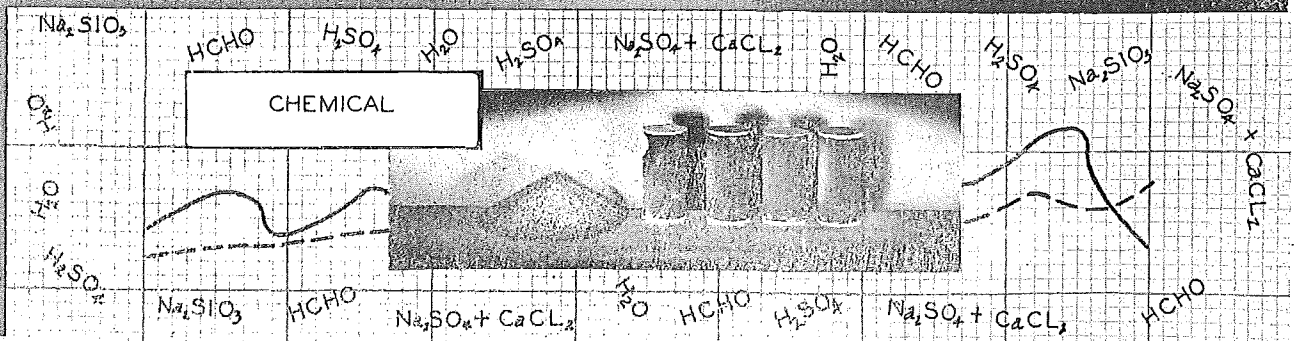


CEMENT



BITUMINOUS

## SOIL STABILIZATION



36 C-1. Its purpose is to determine an economic means of retarding the normal aging of bituminous products by means of chemical inhibitors. This practice is successfully used today on lubricating oils and has been found to work in laboratory experimentation with asphalts.

D. BITUMINOUS MIXTURES

It is recognized that long range research on different types of bituminous pavements and bituminous mixtures is essential in order that continued improvement in quality and durability be attained to meet prevailing traffic and climatic conditions. Research work devoted to that end is incorporated in the program of the Research Laboratory.

46 D-13, Experimental Bituminous Surface Treatments

During the past years several experimental bituminous resurfacing projects have been constructed in which certain factors are varied; for example, the aggregates, the bituminous materials or construction procedure. All investigational work of this kind has been assembled under one investigational heading with the objective of periodically collecting and disseminating worthwhile information to the Department. Also a complete record of the work will be preserved for future reference. Three projects of an experimental nature are included in this investigation at the present time. Report (88).

46 D-14, Bituminous-Rubber Mixtures for Pavement Surfaces

This investigation is in the embryo stage and will be eventually developed to cover a comprehensive study of the use of rubber admixtures in bituminous road mixtures for improving the serviceability of certain types of highway surfaces.

E. SOILS

The laboratory endeavors to study in detail the many problems concerning highway construction in which soil as a material is involved. Such studies

include soil stabilization for low-cost roads; construction of highway sub-grades, subbases, backfills, embankments, and shoulders; and load bearing values and displacement of soils.

#### 36 E-5, Soil Stabilization

Several soil stabilized road projects have been constructed in Michigan. It is important that the Department should know whether this type of construction is suitable to Michigan conditions, and the relative cost of this type of construction compared to other types of light-traffic surfaces. It is important also to know whether this type of construction is satisfactory for certain localities where prepared aggregates for other types of stabilized surfaces are not available. With these facts in mind two experimental projects were constructed in 1941 employing both cement and bituminous materials as binding agents for the express purpose of determining the feasibility of constructing such roads using natural soil in place, and to develop specifications for use in conjunction with future construction of this nature. Two soil stabilization experimental projects are now under periodic observation.

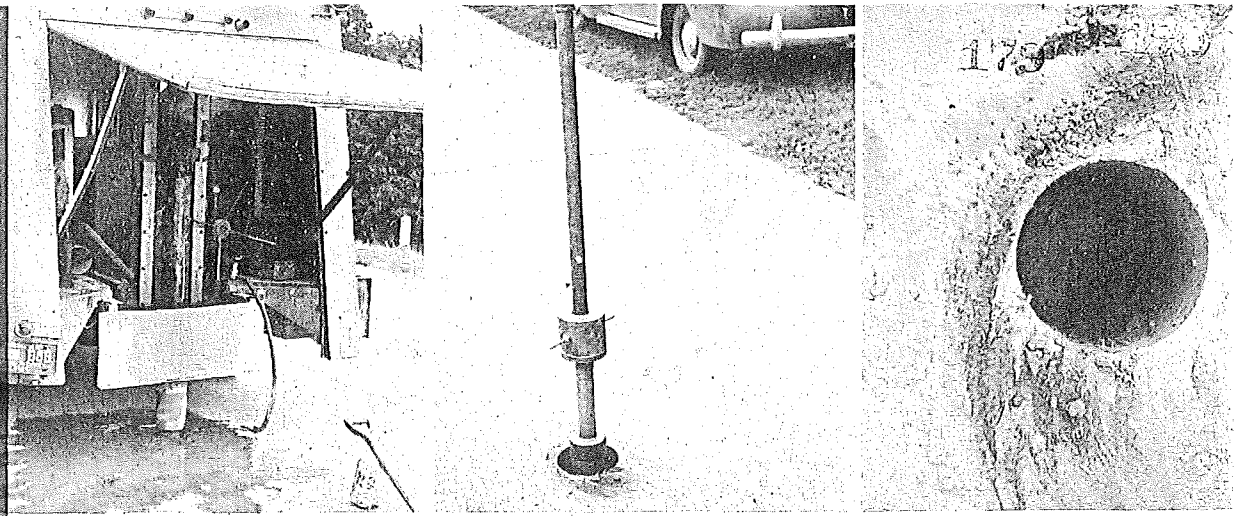
Reports (30) (32) (82).

1. Bituminous versus Cement Stabilization, Project M 20-20, C2, on M-72 Grayling East
2. Soil-Cement Stabilization, Project M 33-50, C1, on M-92, Stockbridge north

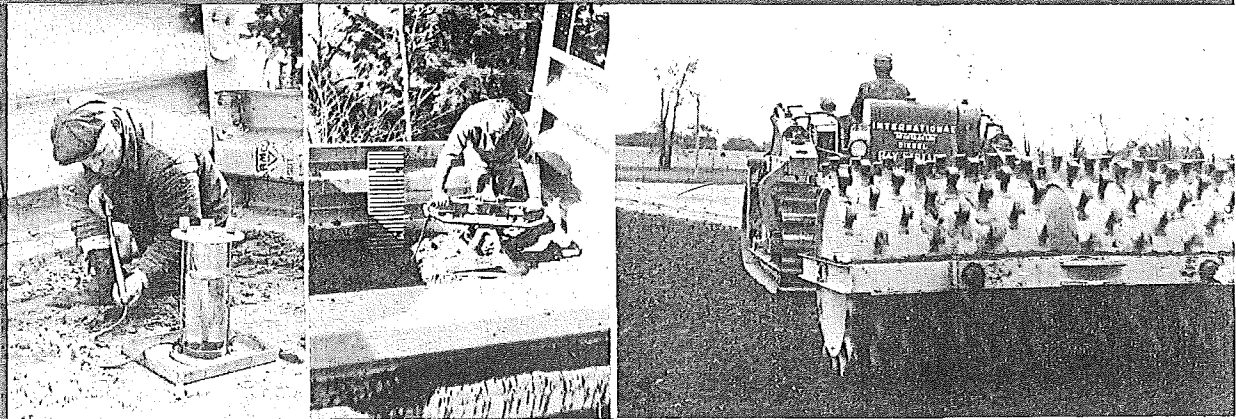
#### 42 E-9, Turf Growth on Highway Shoulders

A cooperative investigation has been established between the Research Laboratory and the Soil Department of the College to study, under controlled conditions, the growth of turf on compacted soil material similar to that used in highway shoulder construction. The study has for its purpose the de-





S A M P L I N G   P A V E M E N T   S U B B A S E



G R A N U L A R

T Y P E

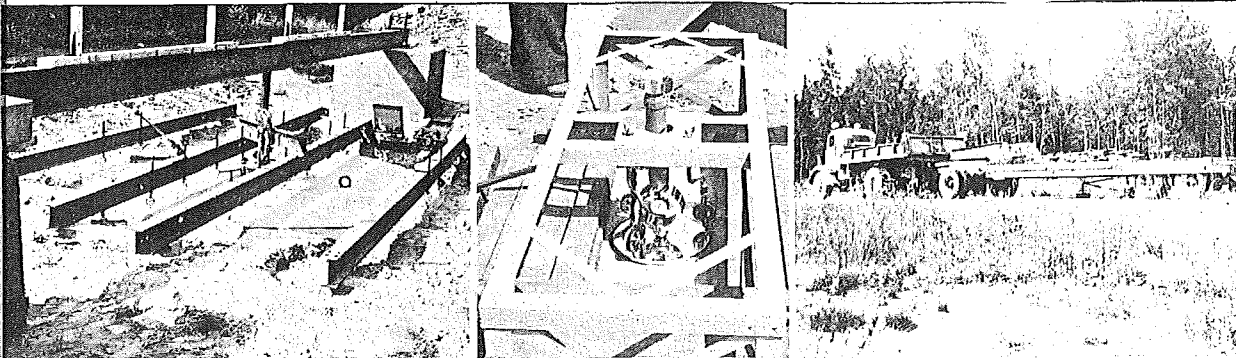
B A C K F I L L

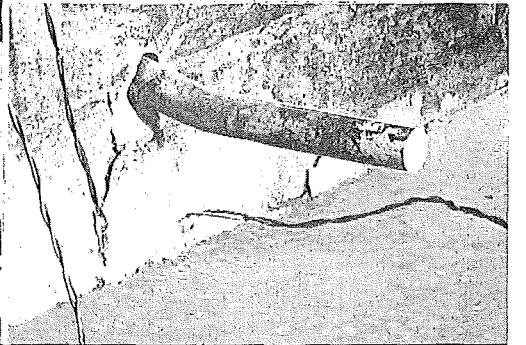
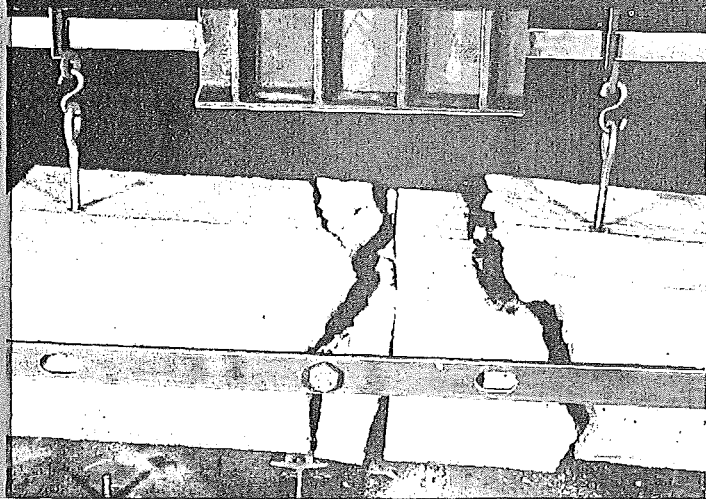
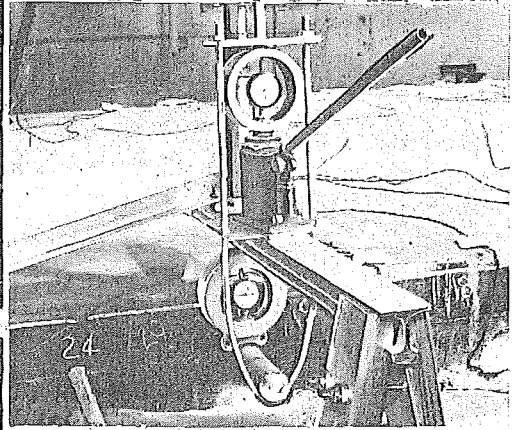
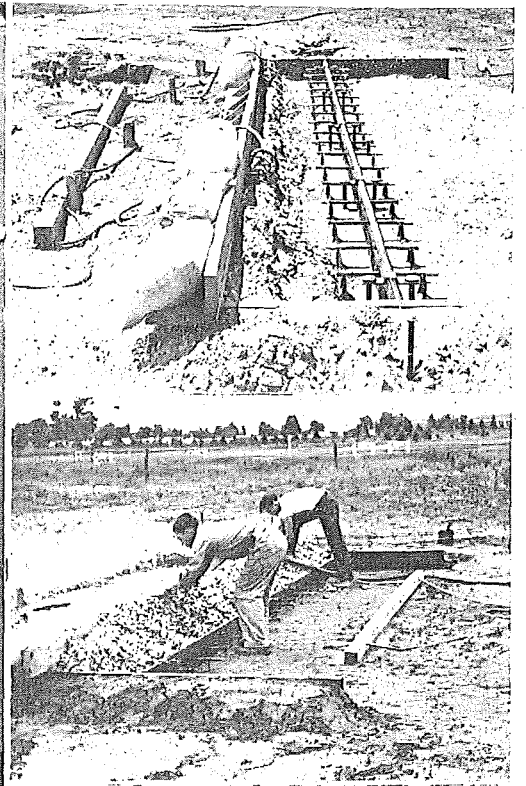
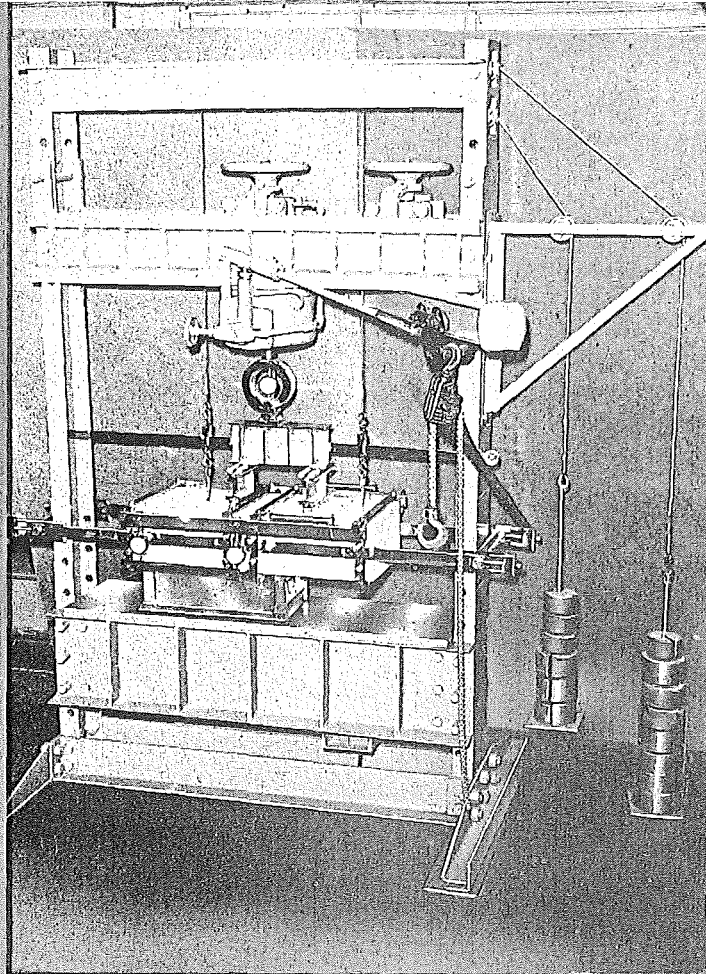
E M B A N K M E N T

C O M P A C T I O N

## PAVEMENT FOUNDATION STUDIES

S U B G R A D E   B E A R I N G   V A L U E





EVALUATION *of* LOAD TRANSFER DEVICES

velopment of shoulder conditions which will assure adequate stability for the support of traffic and, at the same time, provide proper soil characteristics to encourage durable turf growth under abnormal conditions from which specifications may be prepared for this type of construction.

The work naturally divides into two major studies: (1) a study of grass culture on compacted soils under controlled conditions, and (2) a field evaluation of grass growth on existent highway shoulders, including a correlation of available information from various experimental shoulder studies started previously by different agencies within the Department. Report (106).

#### 44 E-10, Soil Action Under Bridge Piers on D.I.E.

A cooperative project with the Soils Laboratory at Ann Arbor was established at the request of the Bridge Division to determine the magnitude of upward soil pressures under bridge structures on the Detroit Industrial Expressway created by lateral flow tendencies of the soil. Heavy concrete members were cast between bridge piers to resist the soil movement and support the pavement slab. The soil pressure against the bottom of the concrete subbase slab was determined in two ways; (1) Goldbeck pressure cells at the interface of soil and concrete, and (2) by SR-4 electrical strain gages attached to the reinforcing members in the concrete slab. The two methods serve as a check on each other. Report (67.)

#### 45 E-11, Design and Construction of Pavement Foundations

Realizing the need of a comprehensive evaluation of methods of design and construction of pavement foundations, a cooperative investigation was established between the Research Laboratory and the Engineering Experiment Station at Michigan State College to study foundation behavior and to develop specifications for foundation design and construction which will provide adequate support for the pavement surface under Michigan climatic conditions and

future traffic loadings. This work also includes the consolidation of granular backfills at bridge structures. Reports (93) (107) (109).

#### 47 E-12, Chemical Stabilization of Granular Materials

This investigation has been established to study methods of both surface and subsurface stabilization of granular soils by the use of chemicals. There are several such materials now recommended for use.

#### F. STRUCTURAL

A large number of research projects have been developed by the laboratory concerned with the design, construction, maintenance and durability of highway structures. Projects in this category include the collection and interpretation of performance survey data; theoretical considerations in relation to pavement design; developing information on pavement design, including such items as load transfer, pavement thickness, joint spacing, traffic loads and subgrade bearing values; investigation of specific pavement failures; and conducting experimental work associated with test roads.

#### 39 F-1, Evaluation of Load Transfer Devices

This investigation pertains to the study of the strength characteristics and stress distribution in transverse joints constructed with different types of load transfer devices. Its main purpose is to establish criteria for the evaluation of load transfer devices and to determine their proper spacing in order to prepare the necessary specifications. The project includes the development of a suitable test procedure for determining the shear-deflection relationship in adjacent slabs for different load transfer devices.

Information obtained to date from this investigation has been incorporated in the Department's new design for joints in concrete pavements. Reports (5) (10) (68R) (104).

43 F-6, Structural Failure, F 40-11, C2 and F 5-15, C2, Kalkaska to Mancelona

Shortly after this pavement was constructed it began to show signs of undergoing abnormal stress, manifested by crushing at the joints and the appearance of longitudinal cracks. Consequently, an investigation was set up to study the phenomenon taking place, and to determine the essential factors contributing to the failure so that similar conditions may be avoided in future construction.

39 F-7, Concrete Pavement Design

This is one of the Research Laboratory's outstanding long range investigations dedicated to the improvement of concrete pavement design and construction. The investigation comprises numerous separate studies whose objectives are directed toward a common goal. The most important study in this respect is the Design Project of the Michigan Test Road which was constructed in 1940.

Theoretical Considerations, 39 F-7 (1): In conjunction with laboratory and field experimentation, it is necessary to supplement and correlate the findings by means of theoretical analysis. In this way it will be possible to develop sound engineering design and construction information for future highway work. Reports (62) (66) (68R).

Michigan Test Road, Design Project, 39 F-7 (2): This section of the test road, projects F 18-20, C4 and F 67-37; C6, was constructed in 1940 on M-115 in Clare and Osceola Counties in cooperation with the Public Roads Administration. The pavement is under constant observation, and various measurements and operations are made several times a year. A primary purpose of this project is to establish certain fundamental structural features in concrete pavement

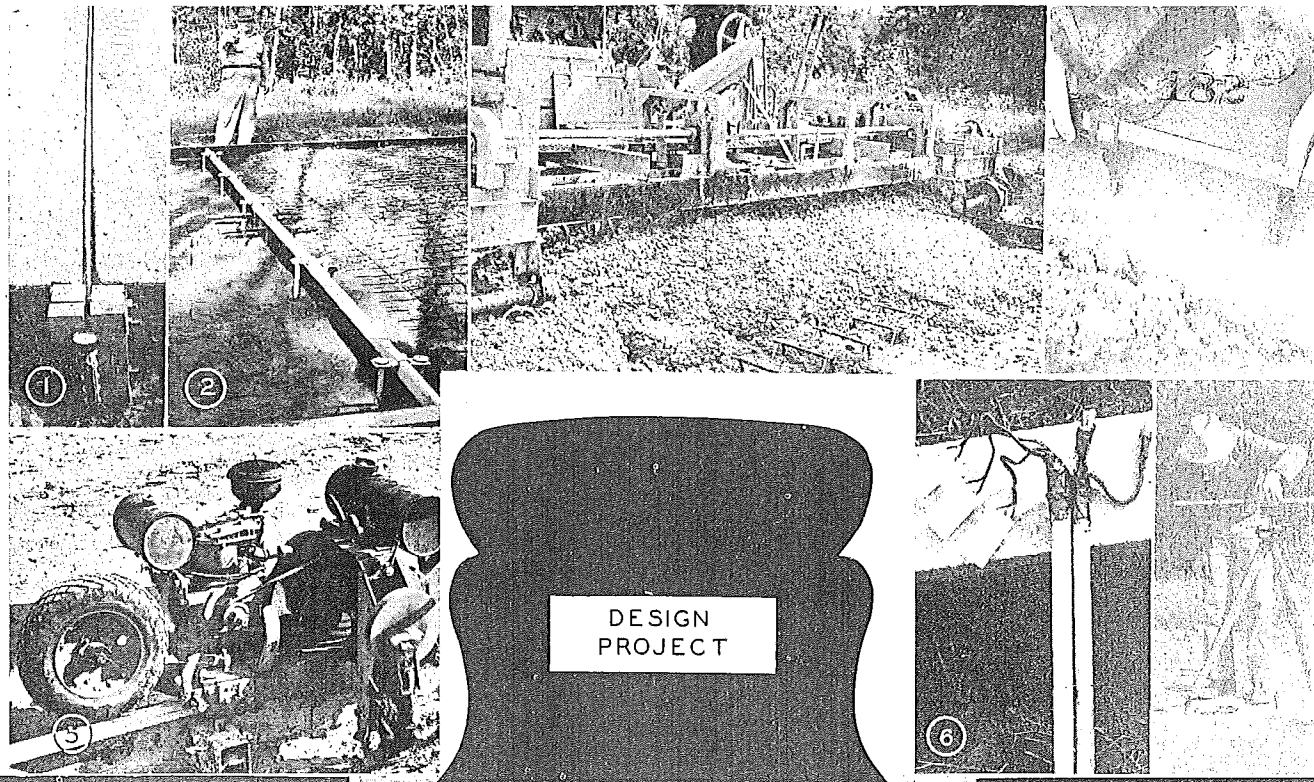
design, among which are; (1) the design and spacing of expansion and contraction joints, (2) pavement cross section, (3) use of steel reinforcement, (4) subgrade bearing capacity, and (5) pavement thickness. A five year history of the project is now being made ready for publication. Reports (3) (4) (8) (9) (12) (14) (16) (20) (21) (41) (59) (64).

Evaluation of Subgrade Modulus, 39 F-7 (3); When applying the Westergaard analysis to concrete pavement design, the modulus of subgrade reaction "K", or subgrade bearing value, must be known with reasonable accuracy. The primary purpose of this study is twofold: (1) to determine subgrade modulus for varying conditions of soil and subbase thickness, and (2) to develop a test method for determining the subgrade modulus adaptable to field and laboratory use. Data developed to date has been employed in design recommendations for post war construction. Report (68R).

Grand Rapids Experimental Project, 39 F-7 (5): When concrete pavement project F 41-34, C6, located on M-114, east belt Grand Rapids, was constructed in 1941, certain experimental construction features were tried out on the job. They were (1) the use of low consistency concrete with mechanical and vibratory methods of placement and consolidation, (2) vibration with air-entraining agents, (3) single lane construction, (4) short contraction joint spacing with no load transfer features, (5) grooved and sealed contractions joints, (6) asphalt-latex joint seal material, and (7) no steel mesh reinforcement.

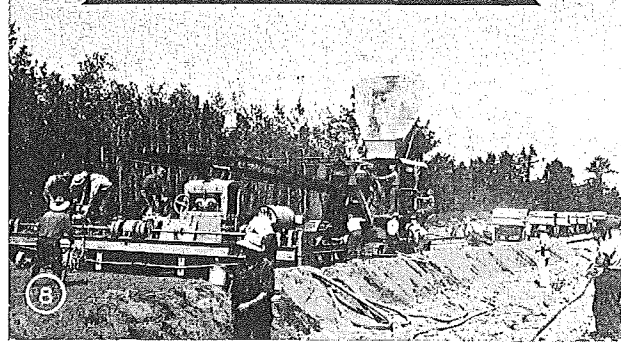
This project is under observation to determine the influence of these factors on the ultimate performance of the pavement.

Evaluation of Existent Concrete Pavements, 39 F-7 (6): Reconnaissance work covering performance of existent concrete pavements is considered in this investigation in order to develop information on pavement design and the many factors



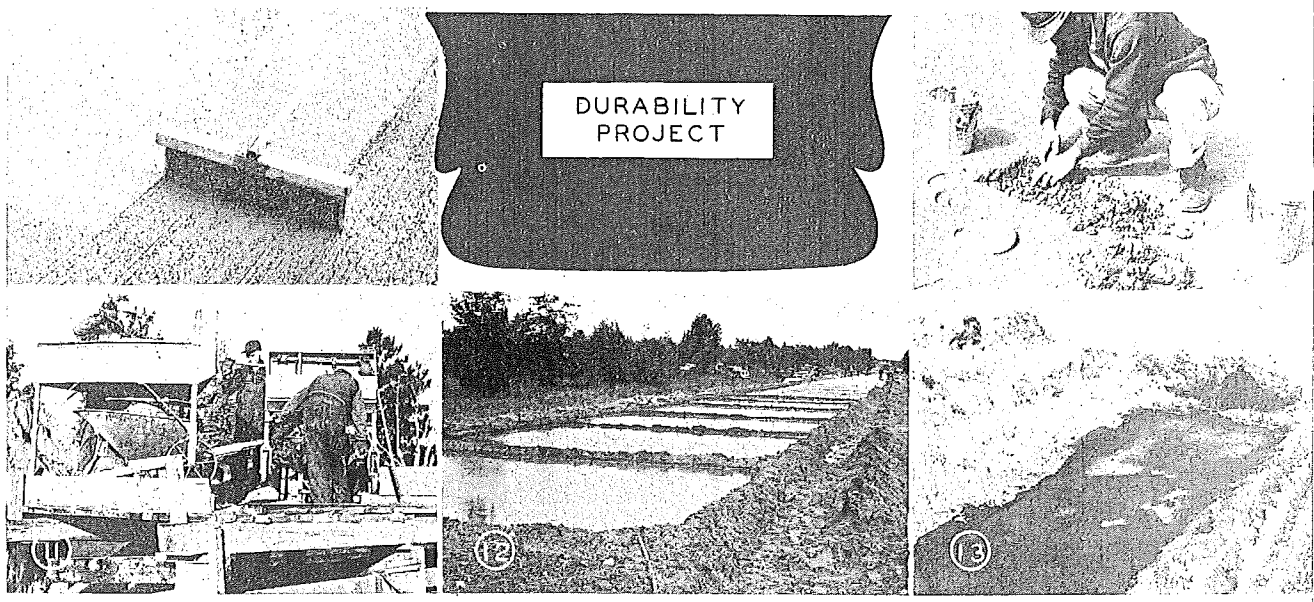
DESIGN PROJECT

- (ABOVE).
- ① STRESS CURING
  - ② JOINT CONSTRUCTION
  - ③ MECHANICAL SPREADER
  - ④ JOINT WIDTH MOVEMENT
  - ⑤ FORM TAMPER
  - ⑥ MOISTURE & TEMPERATURE
  - ⑦ SLAB MOVEMENT

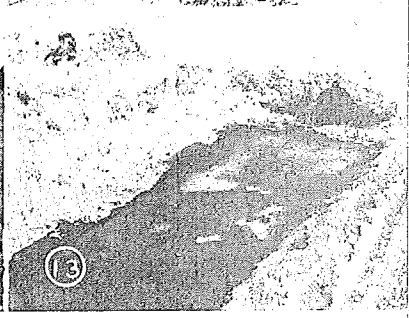
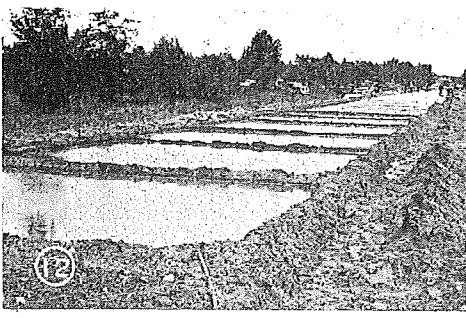
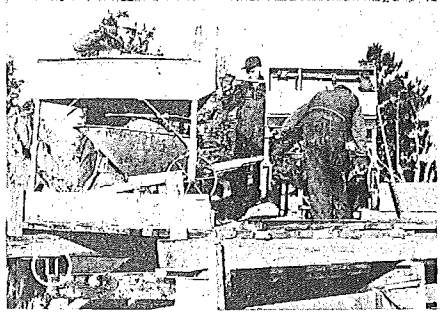


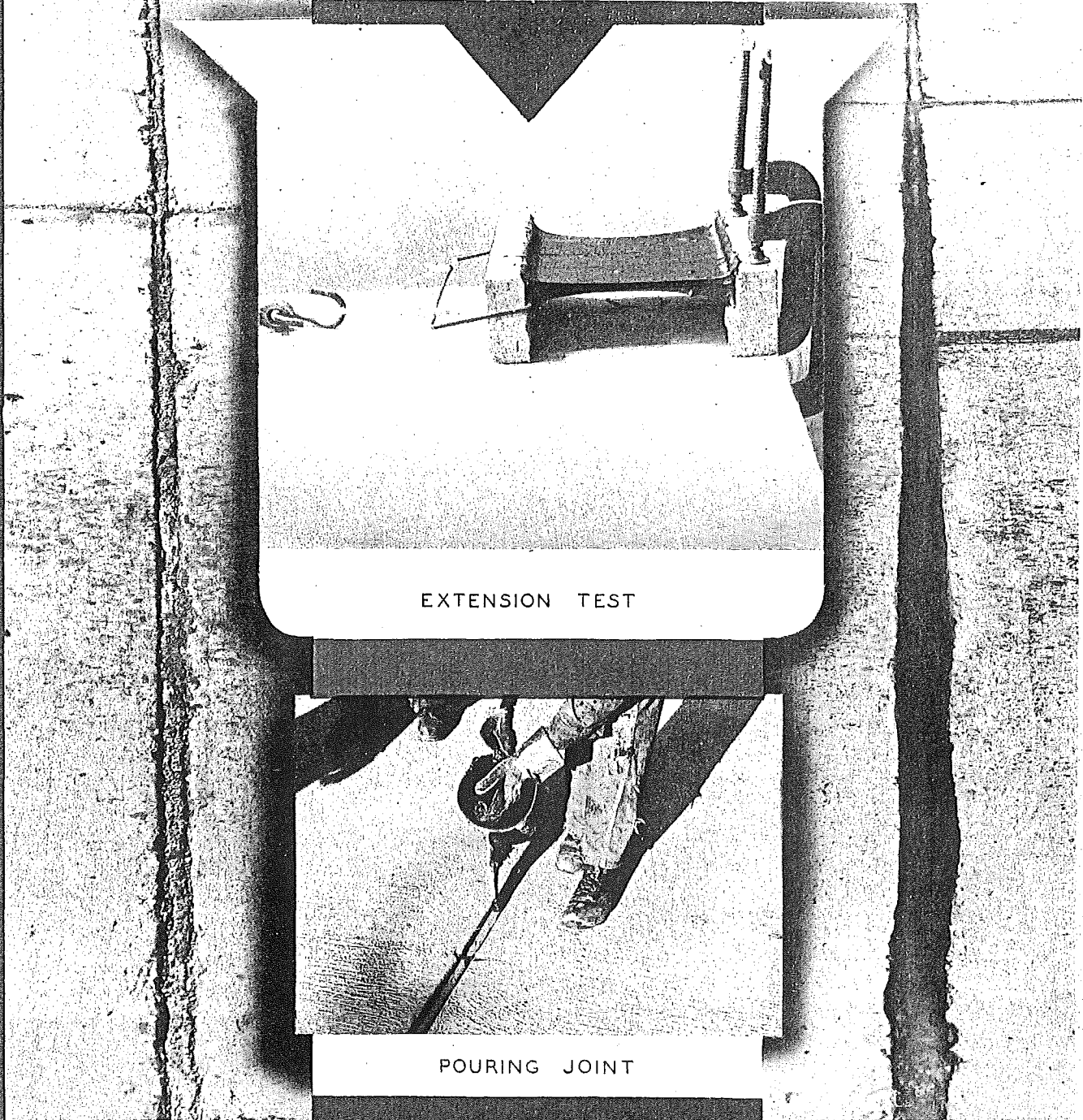
- (CENTER)  
(BELOW)
- ⑧ GENERAL VIEW
  - ⑨ BROOMING
  - ⑩ CONCRETE ANALYSIS
  - ⑪ ADMIXTURE
  - ⑫ CURING METHODS
  - ⑬ SCALING

# The MICHIGAN TEST ROAD



DURABILITY PROJECT





EXTENSION TEST



POURING JOINT

OLD JOINT SEAL

NEW JOINT SEAL

# JOINT SEAL INVESTIGATION



affecting pavement performance. Studies under this investigation include such subjects as reinforcement, blowups, joint spacing, subbase, materials and construction features. Report (73).

Physical Characteristics of Concrete at Early Ages, 39 F-7 (8): This project was established to develop information on the physical characteristics of concrete, especially at ages under 24 hours. This information is very important in relation to pavement design and practically no information of its kind is available, especially in connection with air-entrained concrete.

Concrete Base Course Design, 39 F-7 (9): This work constitutes a study of current design standards for concrete base course construction as a supplement to design recommendations for post war pavement construction with the objective of reducing transverse cracking in the bituminous surface course to a minimum.

Wheel Load Frequencies, 39 F-7 (11): In connection with the Department's investigation on concrete pavement design, a study is in progress to determine the axle load frequency on various routes of the trunk line system. This information will be used to revise pavement thickness requirements in respect to modern and anticipated future traffic conditions. Axle load values and associated traffic information will be obtained by loadometer and traffic classifications surveys. The Maintenance and Planning and Traffic Division are participating in the work.

Grand Ledge Experimental Project, 39 F-7 (12): In connection with the construction on Project F 23-8 on M-43 between Grand Ledge and Mulliken, in 1946, several field studies have been established as a supplement to similar studies

on the Michigan Test Road. The studies include measurements to determine volume changes and warping of the partially and fully restrained 100 foot concrete slabs, the practicability of using membrane curing compounds with white pigments, bituminous joint seal operations, subbase construction, and wood material as a joint filler. Periodic observations will be made during each year.

Pavements and Bridges Constructed with State Cement, 39 F-7 (13): This project consists primarily of preparing a summary of concrete structures, both pavements and bridges, in which State cement was used in their construction. These structures will eventually be examined and a record will be made of their physical condition.

Performance of Pavements of Post War Design, 39 F-7 (14): Performance surveys will be made periodically of a certain number of pavements which were constructed in accordance with the new post war design. It is proposed by this study to correlate transverse cracking and other physical defects with construction factors in order to develop information whereby it may be possible to overcome similar conditions on future construction.

#### 47 F-13, Slab Action Under Dynamic Loading

This investigation consists of measuring strains and deflections in concrete pavement induced by various types of heavy motor transport vehicles in motion. From these measurements it will be possible to obtain information necessary (1) to establish the adequacy of our present motor vehicle laws governing load limits, (2) to furnish reliable data essential to future highway design, (3) to check and supplement existing data obtained from static tests and theoretical analysis, and (4) to determine highway capacity loadings for different types of road surfaces.

This investigation is pending the purchase of suitable electronic measuring equipment.

47 F-14, Stress Distribution in Highway Bridges

This investigation will consist of measuring strain values in critical bridge members produced by dynamic loads simulating modern traffic conditions. The work will produce necessary strain and deflection data which will be correlated with theoretical values to accomplish efficiency and economy in design of highway bridges. The information will be used also to check the adequacy of present load specifications in relation to heavy motor transport units in order to minimize overstress in future bridge construction. The investigation is not active due to lack of appropriate electronic equipment.

47 F-15 Pavement Roughness Investigation

It is the purpose of this investigation to develop suitable equipment to measure the roughness characteristics of highway surfaces and to correlate the roughness factor with construction practices in order to continually improve highway service.

47 F-16 Longitudinal Cracking on Project F 17-42, C2

An investigation is in progress to determine the cause of the unusual amount of longitudinal cracking which has developed on construction project F 17-42, C2 located on M-28 in the Upper Peninsula. The project starts at US 2. Report (129)

47 F-17 Effectiveness of Spiral Shear Developers

Stress computations indicate that for certain ranges of span the spiral shear developer offers economy of design. The problem is to verify this conclusion by field measurements on specific structures. The specific purpose of this study is to obtain deflection and strain data from a bridge incorporating the spiral shear developer, and to compare these measurements with the computed values which formed the basis for design. The Bridge Division is participating in the project.

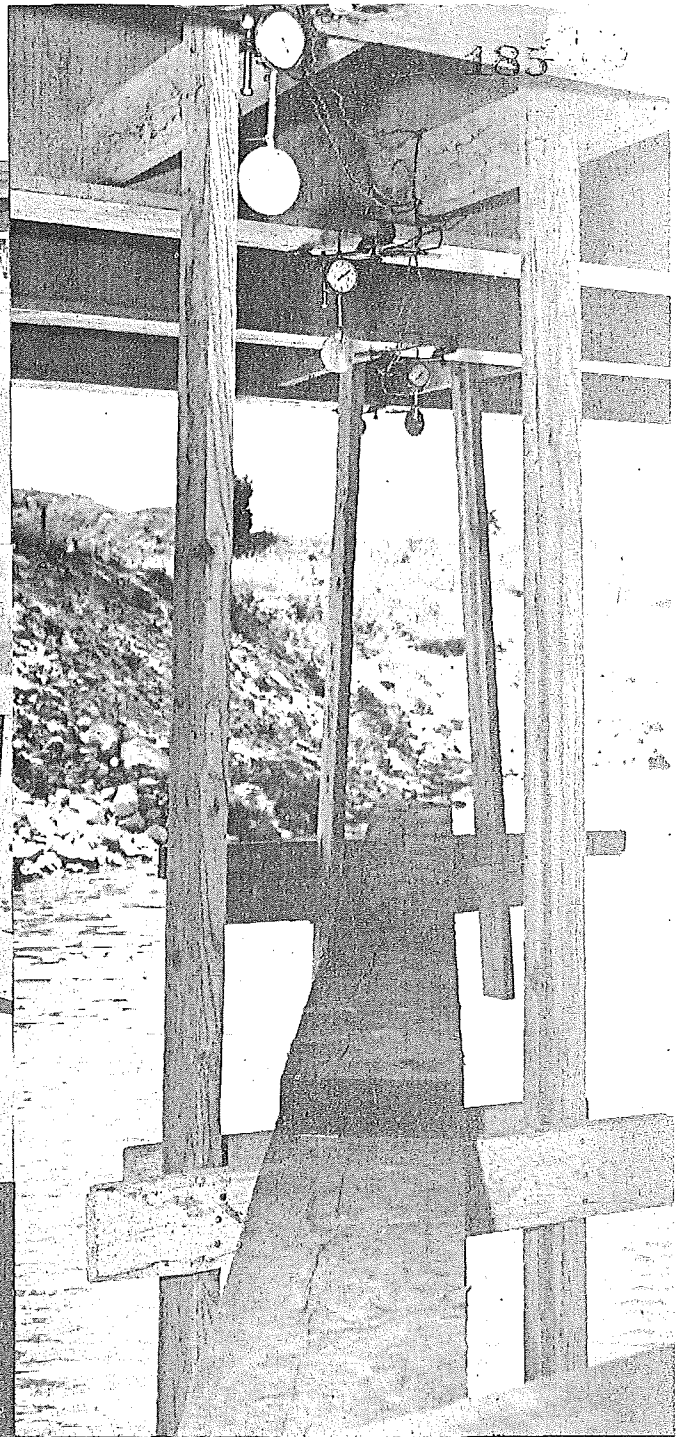
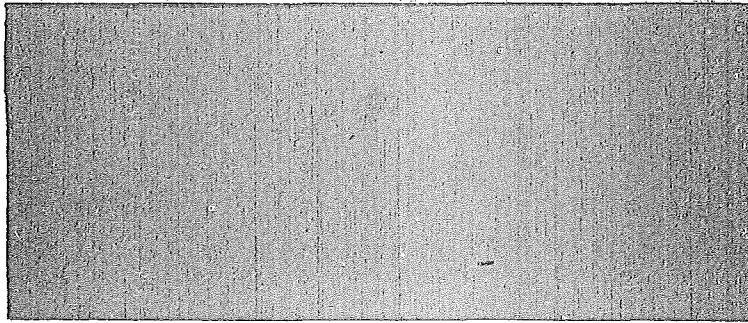
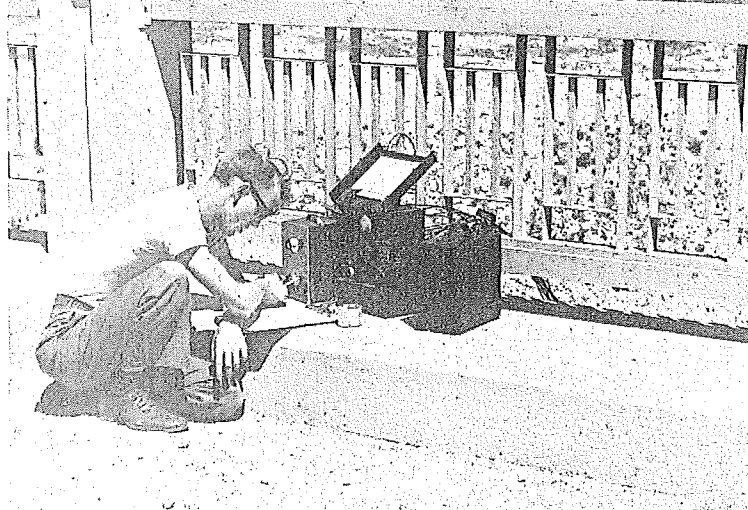
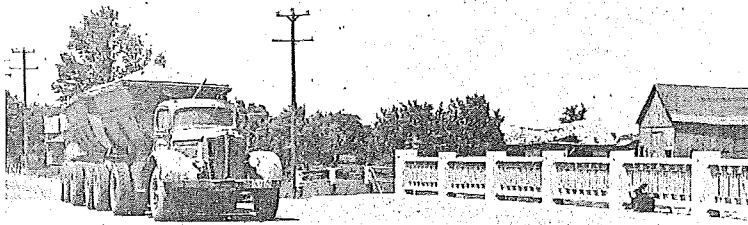
#### 49 F-19 Multi-Plate Investigation

It is the purpose of this investigation to conduct laboratory tests on various corrugated structural plate sections to determine their relative stability under different static load conditions. Hundreds of corrugated metal pipe and arch installations throughout the United States have proved, on the whole, highly satisfactory. Occasionally, however, failures have occurred. These structures are generally designed by highly empirical methods based on past experience but the variables are so numerous that engineers find it difficult to apply the data from one successful installation to another. Height of fill, character and water content of soil, both above and below the pipe, method of back filling, gage and diameter of pipe and whether or not it is installed in a trench - all these factors vitally affect the safety of the design. Recently, two new variables have been introduced which render somewhat questionable the use of existing installations as the criteria of design. The manufacturers are now using 1 3/4" and 2" depth of corrugation in place of the 1 1/2" formerly prevailing, and second, an entirely new shape of corrugation known as the "box type" has been designed and put in competition with the standard type.

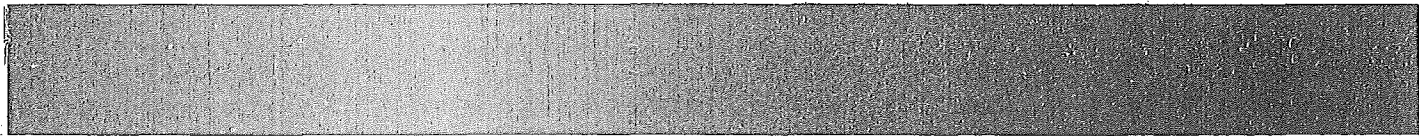
From the above statements, it is obvious that the contemplated laboratory tests will throw light on very few of the uncertainties which have arisen. We do hope, however, to find answers to the following questions.

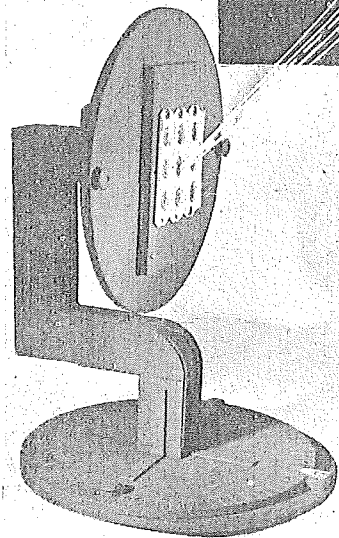
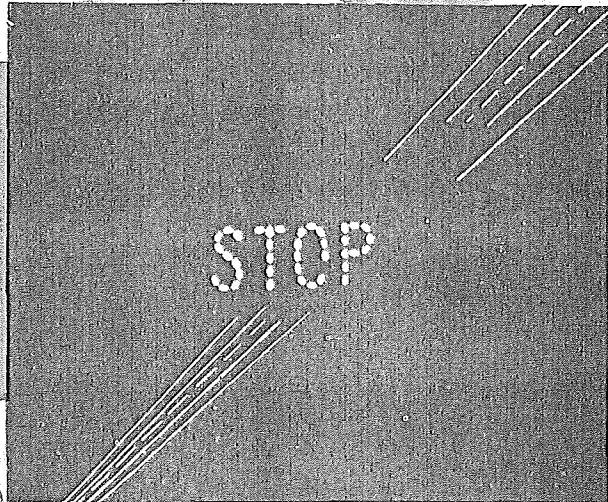
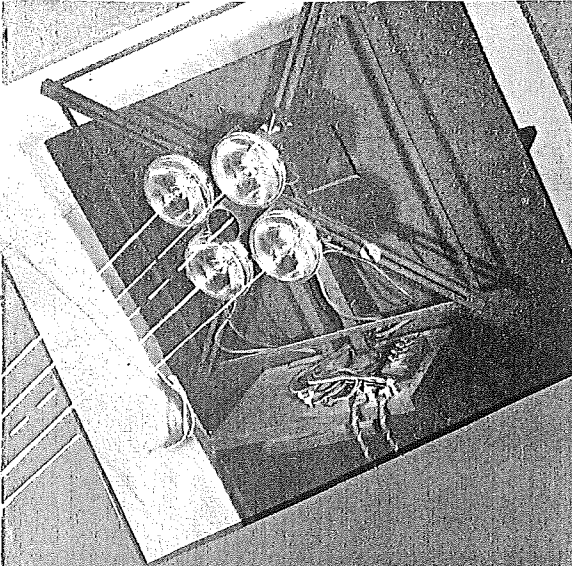
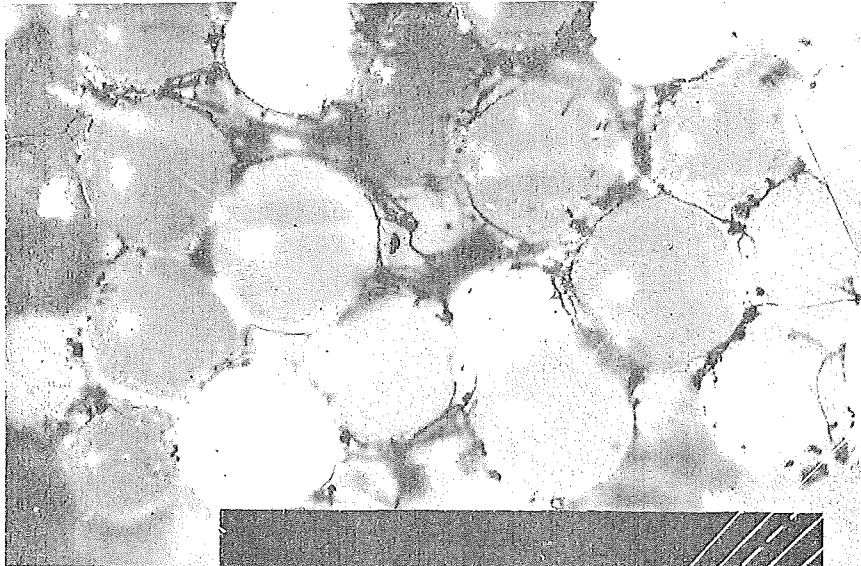
1. Can designs for pipes and arches be made on the basis of section modulus irrespective of depth or type of corrugation as at present manufactured?
2. Do the present methods of making the seams fully develop the metal, both in bending and direct stress or any combination of stress?

The investigation is a cooperative project between the Highway Department, the Public Roads Administration, and the following fabricators of metal plates: Armco Drainage and Metal Products Company, Republic Steel Corporation and United Steel Fabricators, Inc. The Bridge Division is participating in the project.

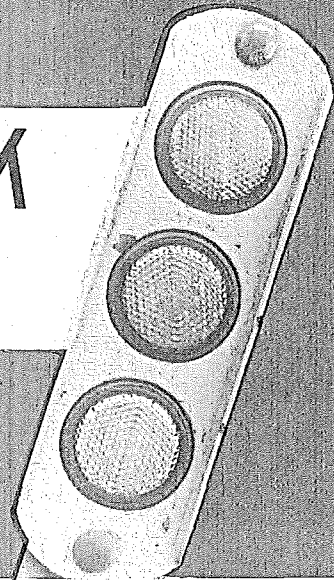


## BRIDGE DESIGN STUDIES





# BATTLE CREEK STURGIS



EVALUATION *of* REFLECTORIZED MATERIALS

G. MISCELLANEOUS

The Research Laboratory handles a large number of miscellaneous studies each year which do not necessarily come under any one of the foregoing sections. They may be projects extremely important and long range in scope, or they may be very short, undertaken primarily to check certain new materials for conformance to specifications, or to provide answers to certain definite problems confronting the administration.

36 G-3 Snow Removal and Ice Control

The snow and ice problem on highways is one of great importance. Studies which will reveal methods to improve winter driving conditions in Michigan are highly desirable. The investigation will include studies of such subjects as Snow and Ice Conditions in Michigan, Physics of Snow and Ice, Snow Removal Methods, and Ice Removal Methods. This project is essentially a continuation of the work done on the subject by the Department and by the Engineering Experiment Station at Michigan State College.

36 G-3 (7) Snow Removal by Radiant Heating

The heating of concrete pavement areas for the purpose of removing ice and snow has been successfully accomplished by passing hot water or steam through pipes embedded in concrete slabs. It is proposed in the investigation to determine the practicability of accomplishing the same purpose by passing an electric current through a resistance grid embedded in the surface. If successful and economical, the method would be ideal for snow and ice control at intersections and traffic interchanges in metropolitan areas. The Road Division is participating in the project. Report (120) (130)

36 G-4 Bituminous Joint Seal Investigation

There has been a long range investigation pertaining to the evaluation and development of suitable joint sealers and fillers, and the preparation of specifica-

tions for the materials and their application in construction. This investigation was started by the former Research and Testing Division and later assumed by the Research Laboratory. Several outstanding studies are associated with the project.

Field Joint Seal Studies, 36 G-4 (3): Several test installations of asphalt-rubber joint sealing compounds have been made for comparative study under field conditions. Reports (49) (53) (81) (83) (94).

Joint Seal Bond Studies, 36 G-4 (4): Studies are in progress to improve the bonding characteristics of the bituminous-rubber joint seal compounds when applied to joints on both new and old pavements.

Development of Asphaltic-Synthetic Latex Joint Seal Compound, 36 G-4 (5): Since natural latices have been hard to procure due to war time conditions, synthetic latices as a substitute have been employed in the investigation to develop a suitable and economical joint seal material. Due to the popular use of commercial hot-poured type of bituminous-rubber joint seal compound, this project has become inactive.

Investigation of Hot-Poured Asphalt -Rubber Joint Sealing Compounds, 36 G-4 (6): This investigation has been established to study the characteristics and performance of the new hot-poured type asphalt-rubber joint seal compounds for the purpose of improving specifications and to instruct the contractors and highway personnel as to its proper use on the job. Report (101) (103).

Joint Fillers, 36 G-4 (7): Materials offered for use as expansion joint fillers are investigated to determine their efficiency in performing their intended function. Such materials include cork, wood, fiber and rubber. Report (98)

39 G-14 (2) Reflector Button Investigation

The purpose of this study is to develop specifications for plastic reflector buttons for traffic control signs and highway delineators.



39 G-15 Guard Rail Post Preservation Investigation

An investigation of wood preservatives and their application to guard rail posts has been undertaken. Consideration has been given to the use of cedar as compared with other species of wood, and also to methods of painting the posts after treatment.

41 G-18 Highway Construction Cost Study

This study was established to develop information on the actual cost of various operations relative to highway construction. Such information is highly desirable in connection with the establishment of new design policies, to check construction and maintenance costs, and for tax rate consideration.

46 G-33 Guard Rail Expansion Take-Up and Anchor Design

This investigation has a twofold purpose: (1) a study of expansion take-ups to determine if they are economically justified for the conditions under which they are installed and operate, and (2) to acquire data on anchor design in relation to construction conditions and cable pull. These questions have been of concern to the Design Division for some time.

47 G-36 Use of Glass Beads for Reflectorized Center Stripe

A comprehensive study of reflectorized pavement marking was undertaken by the Research Laboratory with the ultimate object of developing improved specifications for materials and methods of application. The scope of the investigation includes four main objectives: (1) to determine the degree of transparency and optimum size gradation of the glass spheres necessary for maximum reflectibility and wear resistance throughout the life of the marking; (2) to find what types of paint or binder are necessary for maximum durability and reflection; (3) to establish the optimum coverage of spheres and binder per unit area from the standpoint of both efficiency and economy; and (4) to find the

best method or methods of application of the materials.

The Planning and Traffic and Maintenance Divisions are cooperating in the project.

47 G-37 Application of Liquid Chlorides as a Dust Palliative

The project concerns the application of liquid chloride to gravel surfaces in such a manner as to minimize the persistence of pools of liquid on the surface and the loss of material to the roadsides. Mechanical methods as well as wetting agents will be considered in the study.

47 G-38 Skidding Properties of Pavement Surfaces

The safety of a motor vehicle is bound up with its potential stopping distance which ultimately depends upon the adhesion available between the vehicle tires and the road surface. The friction properties of the road surface are subject to great variation. It is the purpose of this investigation to measure the skidding properties of various types of road surfaces on the State trunkline system in relation to such factors as materials used, age of surface, amount of traffic, and construction features. A knowledge of these skidding properties is of importance to those responsible for the construction and maintenance of the highways.

48 G-40 Comparative Cost Study of Different Types of Reflectorized Signs.

The purpose of this study is to accumulate factual information on the relative cost of different types of reflectorized traffic control signs. Such information will be useful in establishing policies on highway signs.

48 G-41 Investigation of Slippery Conditions on US 2 in Upper Peninsula

A study is in progress to determine the cause and extent of the unusual slippery when wet condition of the concrete pavement on certain sections of US 2 between St. Ignace and Rapids River. The investigation was prompted by the fact that in recent years a large number of accidents have been reported by State Police

as having occurred due to skidding on the concrete surface especially during rains or when pavement is wet. The Maintenance Division is cooperating in this work. Report (117)

48 G-42 Investigation of Hydron Form Lining

The purpose of this project is to investigate the possible benefits of using absorptive form lining in the construction of highway bridges, grade crossings, and other structures. Some of the advantages claimed for it are: (1) increased strength and durability of the concrete surface, even when air-entraining agents are used; and (2) the removal of entrapped air bubbles at the form face, thus providing a smoother surface and corresponding reduction in finishing cost. Tests by the U.S. Army Engineers and the Bureau of Reclamation apparently substantiate these claims. Report (127)

48 G-43 An Investigation of Rust Inhibitives for Chloride Salts Used in Ice and Dust Control

This investigation is concerned with the problem of reducing the corrosive effect of chloride salts on metal parts of vehicles. The work will include both calcium and sodium chloride salts in brine or solid form as used in ice and dust control. It will cover different types of rust inhibitors, their relative efficiency, economy, use and limitations. Special consideration will be given to such factors as packaging, handling and distribution in the field and effect on persons and materials other than steel. Motorists will benefit materially from the successful solution of this problem through prevention of considerable annual damage to motor vehicles.

## OTHER RELATED ACTIVITIES

In addition to carrying on an extensive research program, the Research Laboratory is ideally situated to take part in other work of significance to the Michigan State Highway Department. These related activities are in keeping with the objectives and functions of the organization and include cooperation in educational programs, public relations, cooperative research, graduate study, membership in technical societies, and research testing.

### Educational

Schools and conferences are desirable from time to time in order to acquaint members of the Department and other interested persons with the new developments in highway technology. In these schools and conferences the Research Laboratory has taken an active part since its inception.

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 by the College.

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 purpose of the design and durability projects of the Michigan Test Road, as well as to point out and discuss the work of the Highway Department in their attempt to solve 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. The meeting was held in July, 1941.

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 State College in December, 1941, the Research Laboratory was invited to cooperate in preparing a program for the conference concerning standards, techniques, and methods of application of knowledge of the character of snow to the problem of snow control in highway transportation.

The proceedings of this conference were published in 1942 by the College.

Michigan Concrete Conference: The Michigan Concrete Conference, the first of its kind in Michigan, was sponsored by the School of Engineering of Michigan State College in cooperation with the Michigan State Highway Department and the Portland Cement Association. The conference program was designed to give practicing engineers, municipal and county engineers, highway engineers, contractors and other persons interested in concrete as a material an opportunity to become better acquainted with the subject of air entrainment in modern concrete practice. The conference was held on the Michigan State College Campus, December 1 and 2, 1948.

#### Public Relations

The Research Laboratory is open at all times to visitors on Campus, as well as faculty members and students, and many have taken this opportunity to obtain a firsthand perspective of what the Department is doing to provide the public with better highways.

Before the war the Research Laboratory participated with the Engineering School in the Annual Farmer's Week Program by preparing exhibits and acquainting laboratory visitors with the work of the organization and the benefits derived therefrom.

### Cooperate Research Work

College personnel in the Engineering School, as well as in other departments on the Campus, including in particular Chemistry, Bacteriology, Physics, Soils, Geology and Forestry are familiar with the work of the Laboratory, and in some instances have cooperated in problems of mutual interest. A cooperative research project on turf growth is in active progress with the Soils Science Department of the College.

The Research Laboratory also maintains close relationship with the Engineering Experiment Station at the College by participating jointly in research projects. This affords the Laboratory an opportunity to work with the Engineering staff members on mutual problems, and it also provides an outlet for publishing research information. The Research Laboratory is represented on the Advisory Committee to the Director of the Engineering Experiment Station.

The facilities of the Research Laboratory have always been available to students interested in highway research problems. Many students in the Engineering School have taken advantage of this opportunity to work on problems of mutual interest as a partial fulfillment of the requirements for a degree.

In the pursuance of the research program the laboratory engages the service of several students on a part-time basis to assist with the work. Such a policy has many good features in that it not only helps the student financially and scholastically, but it serves as a training school from which the Department may later select personnel for permanent positions.

### Graduate Study

Through a working arrangement with the College authorities, it is possible for students working toward advanced degrees to do research work for thesis credit in the Research Laboratory under joint supervision of his major professor and an

experienced staff member of the Research Laboratory. In this manner it is possible for the laboratory to enjoy to a greater extent the academic facilities of the College in connection with the pursuance of its research activities.

#### Technical Societies

To keep abreast of the constantly expanding field of research and its relationship to highway problems, it is imperative that an association be maintained with technical societies to obtain authoritative information on properties and tests of materials, and to have available the latest data on researches which involve the efforts of hundreds of engineers and the expenditures of large sums yearly. In return the Research Laboratory can be of service by sharing experience and knowledge on similar problems by participating in programs of research, by constructive criticism of standards and by helping promote the use of quality specifications and standard tests. As part of its research activities, the Laboratory engages in committee work with national organizations. Members of the research organization are represented on technical committees of the Highway Research Board and the American Road Builders Association. Staff personnel hold memberships in the Highway Research Board, American Society of Civil Engineers, American Concrete Institute and American Chemical Society.

Contact is maintained with the Public Roads Administration, the Portland Cement Association, Calcium Chloride Association, Natural Sand and Gravel Association, National Slag Association, National Crushed Stone Association, Wire Reinforcing Institute, Rail Steel Bar Association, Asphalt Institute, American Society for Testing Materials and American Association of State Highway Officials. Contact has also been maintained with various engineering conferences, such as the Michigan Highway Conference, and Purdue Highway Conference.

## Research Testing

In addition to its research activities, the Research Laboratory performs special research tests on new materials submitted by various manufacturers. It also cooperates with the Testing Laboratory in Ann Arbor in the matter of routine testing of materials requiring special consideration. The Testing Laboratory reciprocates by performing routine testing on materials associated with certain research investigations.

## GENERAL ACCOMPLISHMENTS

Since the establishment of a research organization in 1939, many important contributions have been made to promote better highway construction. These contributions appear as bulletins, magazine articles, technical papers and unpublished Departmental reports. Altogether since 1939, the total reports comprise six bulletins, seven journal contributions, twenty-six technical papers and ninety-three Departmental reports.

Among the outstanding accomplishments of the Research Laboratory is its investigational work associated with the Michigan Test Road. This experimental concrete pavement project, which was constructed in 1940 in cooperation with the Public Roads Administration, is one of the most comprehensive projects of its kind in the country at the present time. Several current features in concrete pavement construction practice, such as scale resistant concrete, long reinforced slabs, less use of expansion joints, mechanical form tampers, and bituminous-rubber joint seals, are closely associated with this work. These features should increase the economic life of pavements, provide better riding qualities and at the same time effect a considerable reduction in maintenance costs.



BIBLIOGRAPHICAL INFORMATION

<u>Report No.</u>	<u>Title</u>	<u>Date</u>	<u>Purpose</u>
1	Research Activities of Mich. State Highway Department	7-1-40	Article in Michigan Engineer
2	Field Study of Joint Sealers	10-10-40	Report to A.S.T.M. Comm. on Joints
3	Michigan Test Road	11-1-40	Editorial for Roads & Streets, Nov. 1940
4	Investigational Concrete Pavement in Michigan	11-22-40	Paper, Highway Research Board, Nov. 1940
5	Design of Load Transfer Joints in Concrete Pavements	11-22-40	Paper, Highway Research Board, Nov. 1940
6	Changes in Characteristics of Slow Curing Asphaltic Oils	12-2-40	Paper, A.A.P.T. Dallas, Texas, Dec. 1940
7	Activities of Research Division	1-22-41	News Release, Michigan State News, 1-22-41
8	Summary, Michigan Test Road	1-28-41	Report to Highway Advisory Board, Jan. 1941
9	Value of Concrete Spreader in Concrete Pavement Construction	1-29-41	Paper, A.R.B.A. Jan. 1941
10	Pavement Joints and Their Functions	1-29-41	Paper, A.R.B.A. Jan. 1941
11	Concrete Durability Studies	2-18-41	Report to A.C.I. Meeting, Washington, Feb. 1941
12	Construction of Michigan Test Road	2-14-41	Paper at Houghton Conference, Feb. 1941
13	Natural Conditions Affecting Performance of Soils	3-4-41	Paper at Soils Conference M.S.C, March 1941
14	Fundamental Principles and Factors Embodied in Michigan Test Road	5-1-41	Article in Roads & Streets, May, 1941
15	Report on Manufactured Stone Sand and Its Uses in Concrete Mixtures	5-15-41	Departmental Report

<u>Report No.</u>	<u>Title</u>	<u>Date</u>	<u>Purpose</u>
16	Report on Claims Presented By W. L. Thon Co., Projects F 16-20, C4 and F 67-37, C6	5-16-41	Departmental Report
17	Proposed Specifications for Slow Curing Liquid Asphalt	6-15-41	Departmental Report
18	Construction and Subsequent Studies of Concrete Durability Project, Michigan Test Road	7-28-41	Meeting of Cement Manufacturers at M.S.C. July 1941
19	The Library-Laboratory Research	8-16-41	Editorial Roads & Streets December, 1941
20	Movie Script of Michigan Test Road	8-26-41	Michigan Test Road Movie
21	Pamphlet on Michigan Test Road	9-30-41	For A.A.S.H.O. Convention, Detroit, Oct. 1941
22	Research Activities of Mich. State Highway Department	11-14-41	Michigan Section, ASCE Detroit, Nov. 1941
23	General Observations on Concrete Scaling	12-5-41	Article for Roads & Streets, Dec. 1941
24	Comments on Concrete Scaling Studies	12-10-41	News Release to Associated Press, Dec. 1941
25	Effect of Various Axle Loadings on Highway Pavements	2-1-42	Departmental Report
26	Selected Bibliography on Airport Construction for National Defense	2-1-42	For Highway Dept. Committee on Flight Strip Construction in Michigan
27	Design and Construction of Flight Strips	3-10-42	Departmental Report
28	Summary of Research Projects	4-1-42	Departmental Report
29	Agrifil as a Mineral Filler for Bituminous Mixtures	4-1-42	Departmental Report
30	Construction of Experimental Soil-Cement Stabilization Road Surface, Stockbridge	4-1-42	Departmental Progress Report
31	Curing of Concrete by Calcium Chloride Integral Mixed	4-1-42	Departmental Report

<u>Report No.</u>	<u>Title</u>	<u>Date</u>	<u>Purpose</u>
32	Grayling Cement and Bituminous Soil Stabilization Projects	5-1-42	Departmental Report
33	Membrane Curing Compounds	5-15-42	Specifications
34	Limestone Dust in Mortar	6-1-42	Departmental Report
35	Research Laboratory Report for Biennium 1940-1942	7-1-42	Department Biennial Report
36	Progress Report on Houghton Project, December, 1941 to July 1942	7-19-42	Departmental Report
37	Research Laboratory Activities	8-1-42	Annual Report to Dean of Engineering, M.S.C.
38	Color Treatment of Concrete Pavements for Camouflage Purposes	7-7-42	Departmental Report
39	Accelerated Scaling Studies on Concrete Pavement Surfaces	8-1-42	Departmental Report
40	Reflectorized Sign Material Study	11-10-42	Departmental Report
41	Digest of the Michigan Test Road	12-21-42	American Concrete Institute
42	Discoloration Phenomenon in Reflectorized Highway Sign Materials	1-10-43	Departmental Report
43	Research Activities 1939-1943	5-1-43	Laboratory Report
44	Color in Concrete Pavement	5-18-43	Departmental Report
45	Design of Concrete Resurfacing	5-21-43	Departmental Report
46	Design Recommendations for Industrial Express Highway No. 3	6-28-43	Departmental Report
47	Determination Of Young's Modulus of Frozen and Thawed Concrete Specimen by Sonic Method	8-3-43	Departmental Report

<u>Report No.</u>	<u>Title</u>	<u>Date</u>	<u>Purposes</u>
48	Michigan's Experiences in the Use of Air Entraining Materials for Concrete Pavement Construction	10-21-43	Paper at 35th Annual Meetings of Engineering Society of Wisconsin
49	"Sealz" Joint Seal Study	1-12-44	Departmental Report
50	Condition Survey of Concrete Recapped Projects	3-10-44	Departmental Report
51	The Research Laboratory	3-15-44	Departmental Report
52	Compilation of Design and Construction Data for Concrete Pavements	6-1-44	Departmental Report
53	Para-Plastic Joint Sealing Material	6-2-44	Departmental Report
54	Air-Entraining Concrete	6-8-44	Paper, Houghton Conference, June 1944
55	Report on Research Laboratory July 1943 - July 1944	6-15-44	Annual Report to Dean of Engineering, M.S.C.
56	Study of Blowups on Bituminous Capped Pavements	7-28-44	Departmental Report
57	Study of Transit Mixed Concrete in Relation to a Proposed Change in Batch Quantities on Project 9-8, C3	8-3-44	Departmental Report
58	A Study of Concrete Pavement Cracking on Project 49-7, C1	9-8-44	Departmental Report
59	A Preliminary Progress Report on Design Project, M.T.R.	10-2-44	Paper Presented by H. C. Coons at Highway Research Board Meeting, 1944
60	Research Laboratory Report for Biennium 1942-1944	10-7-44	Department Biennium Report
61	Microscopic Study of Scaled and Unscaled Concrete	11-1-44	Eng. Experimental Station, Bulletin M.S.C., No. 101
62	Recommendations for the Design of Concrete Pavements	11-20-44	For H.C. Coons at A.A. S.H.O. Meeting, Cincinnati, 1944

<u>Report No.</u>	<u>Title</u>	<u>Date</u>	<u>Purpose</u>
63	Use of Vinsol Resin Cement in Concrete Bridge Structures	11-24-44	Departmental Report
64	Pavement and Subgrade Moisture, Michigan Test Road	12-5-44	Highway Research Board
65	Hardening of Wood by Chemical Processes	12-9-44	Departmental Report
66	Concerning Changes in Senate Bill 102 Relative to Motor-buses	2-21-45	Departmental Report
67	Soil Action Under Bridge Piers, D.I.E.	5-14-45	Departmental Report
68-R	Design of Concrete Pavements for Postwar Construction	3-15-45	Departmental Report
69	Determination of Benzene in Asphaltic Road Oils	4-1-45	Departmental Report
70-R	Asphaltic Oil-Latex Joint-Sealing Compound	4-2-45	Publication in ACI Journal, June 1946
71	Report on Research Laboratory 1944-1945	7-10-45	Annual Report to Dean of Engineering, M.S.C.
72	A Model Study of Slab Action in Concrete Pavement	7-16-45	Departmental Report
73	Inspection of Concrete Pavement in the Province of Ontario, Canada	6-13-45	Departmental Report
74-R	The Application of Chloride Salts to Concrete Pavements for Ice Control	8-17-45	Departmental Report
75	Factors to be Considered in the Use of Air-Entraining Concrete for Highway Construction	9-14-45	Departmental Report
76	Investigation of Anti-Freeze Preparations, Ethylene Glycol Type	11-10-45	Departmental Report
77	Investigation of Kapco Membrane Curing	12-1-45	Departmental Report

<u>Report No.</u>	<u>Title</u>	<u>Date</u>	<u>Purpose</u>
78	The Muskegon Experimental Project After Seven Years in Service	12-10-45	Departmental Report
79	Prevention of Scale on Concrete Pavement Surfaces by Air Entrainment	1-1-46	Paper Presented by Comm. Ziegler at 32nd Annual Road School, Purdue Univ. 1-22-46
80	A Model Study of Slab Action in Concrete Pavements	1-8-46	Paper for Highway Research Board, Okalahoma City, 1946
81	Comments on Bituminous-Rubber Joint Sealing Compounds	1-21-46	Departmental Report
82	Condition Survey, Grayling Project - 1946	4-15-46	Departmental Report
83	First Condition Survey of Hot Poured Bituminous-Rubber Joint Seal Installation on US-16, West of Lansing	5-1-46	Departmental Report
84	Investigation of Hinged Bar Mat	6-3-46	Departmental Report
85	Report on Research Laboratory for 1945-1946	7-9-46	Annual Report to Dean of Engineering at M.S.C.
86	Investigation of Pen Kote "500" Maintenance Paint	7-25-46	Departmental Report
87	Preserving and Reconditioning of Concrete Bridges	9-30-46	Departmental Report
88	Non-skid Bituminous Surface Treatments, Projects M 5-17, C2 and M 69-5, C3	10-7-46	Departmental Report
89-R	Cracked versus Uncracked Asphaltic Materials	10-16-46	Departmental Report
90	Study of Slab Action in Concrete Pavements	10-31-46	Departmental Report
91-R	Investigation of Concrete Paving Forms.	4-4-47	Departmental Report
92	Modern Highway Loadings in Relation to Design Requirements and Methods of Control	1-2-47	Departmental Report

<u>Report No.</u>	<u>Title</u>	<u>Date</u>	<u>Purpose</u>
93	Gradation and Consolidation of Porous Backfill	2-14-47	A.R.B.A. Committee on Compaction of Soil, Chicago, Feb. 18, 1947
94	Resealing of Old Expansion Joints with Bituminous-Rubber Compound in Relation to Highway Maintenance	3-14-47	Departmental Report
95	Experience in the Use of Carbon Black as a Color Pigment in Concrete Pavement	3-19-47	Departmental Report
96	Bituminous Fiber Board for Joints	5-2-47	Departmental Report
97	Abnormal Cracking and Settlement of Pavement Slabs in the Willow Run and Detroit Industrial Expressway System	4-1-47	Departmental Report
98	Wood Joint Filler Investigation	5-28-47	Departmental Report
99	The Research Laboratory	7-15-47	Departmental Report
100	Research Activities	7-1-47	Annual Report to Dean of Engineering
101	"Sealz Melter" Heating Kettle for Rubber Joint Sealing Compound	9-3-47	Departmental Use
102	Liquid Chloride Application	9-17-47	Departmental Report
103	Rubber Compound Heating Kettle Chaussee Model R-115	9-18-47	Departmental Report
104	Progress Report on Load Deflection Tests Dealing with Length and Size of Dowels	11-30-47	Highway Research Board December, 1947
105	Cracking of Concrete Patches Project 49-7, C1	12-15-47	Departmental Report
106	Progress Report on Study of Turf Growth on Soil Mixtures	12-24-47	Highway Research Board December, 1947
107	Consolidation of Porous Backfill	1-23-48	Comm. Report ARBA

<u>Report No.</u>	<u>Title</u>	<u>Date</u>	<u>Purpose</u>
108	Detroit Manufactured Brick for Catch Basins and Manholes	3-1-48	Departmental Report
109	The Use and Treatment of Granular Backfill	3-3-48	Exp. Station Bul. #107 Michigan State College
110	Deterioration and Restoration of Concrete Bridges of State Trunk-line System	3-15-48	Departmental Report
111	Study of New American Decalcomania Reflective Material	3-26-48	Departmental Report
112	More Durable Concrete by Air Entrainment	4-30-48	Annual Meeting of M.F.S. April, 1948
113	A Study of Fiberglass Fabrics for Membrane and Joint Waterproofing	6-1-48	Departmental Report
114	Effect of Foreign Material on Quality of Concrete on Pavement F 43-16, C2	3-1-48	Departmental Report
115	Operational Comparison of Premixed and MSHD Specification Materials for Reflectorized Centerlines	8-25-48	Departmental Report
116	Shoulder Construction Practices in Michigan	11-20-48	Committee Report HRB Roadside Development of Shoulders
117	Investigation of Slippery Condition of Stone Sand Concrete Pavement	12-1-48	Departmental Use
118	An Appraisal of the Membrane Method of Curing Concrete Pavements	12-15-48	Bulletin #108, Eng. Exp. Sta., M.S.C.
119	An Improved Sonic Apparatus for Determining the Dynamic Modulus of Concrete Specimens	1-15-49	Departmental Distribution
120	Michigan's Experiment in Snow and Ice Removal on Highways by Radiant Heat	1-15-49	Departmental Distribution
121	Field Tests of Reflectorized Stripes	1-26-49	Departmental



<u>Report No.</u>	<u>Title</u>	<u>Date</u>	<u>Purpose</u>
122	Concrete Curb Design	2-15-49	Departmental
123	Application of White Membrane on Project F 74-41, C1, US-25, North of Port Sanilac	3-1-49	Departmental Specifications
124	Relative Resistance to Thermal and Mechanical Shock of Various 26-A Modified Aggregates Used in Bituminous Concrete Resurfacing	3-7-49	Departmental
125	Field Check of Design of Positive Type Shear Developers	3-7-49	Departmental
126	Spalling of Joints on Project 14-33, C1	3-4-49	Departmental
127	Investigation of Hydron Form Lining	4-1-49	Departmental
128	The Use of Non-Shrinking Mortar for Anchoring Bolts in Concrete Members	5-1-49	Departmental
129	Longitudinal Cracking on Project F 17-42, C4	5-6-49	Departmental
130	Performance and Cost Information Relative to Michigan's Experiment in Snow and Ice Removal by Radiant Heat	5-10-49	Departmental
131	Air Entraining Concrete on Bridge Project FB2 of 3-8-1, C1, Plainwell	5-13-49	Departmental

## APPENDIX A

SUMMARY OF COMPLETED PROJECTS

<u>Item</u>	<u>Project No.</u>	<u>Title</u>	<u>Date</u>	<u>Report Number</u>
1	36 G-3 (1)	Snow Drift Control by Highway Design	9-1-39	M.S.C. Exp. Sta.Bul #86
2	36 G-4 (2)	Ford Road Joint Seal Study	10-10-40	2
3	39 B-11 (6)	Durability of Concrete Containing Stone Sand	5-15-41	15
4	36 E-5 (3)	Calcium Chloride Stabilized Road Mixtures	12-15-41	M.S.C. Exp. Sta.Bul. #97
5	42 G-21 (1)	Selected Bibliography on Airport Construction for National Defense	2-1-42	26
6	39 F-7 (7)	Theoretical Considerations of Multiple Axle Loadings	2-1-42	25
7	42 G-21 (2)	Design Recommendations for Flight Strips	3-10-42	27
8	42 G-20 (2)	Agriofil as a Mineral Filler for Bituminous Mixtures	4-1-42	29
9	42 B-14 (1)	Membrane Curing Compounds	5-15-42	33
10	39 B-11 (1)E	Admixtures and Grinding Aids in Mortars and Concrete	6-1-42	34
11	42 B-10	Color Treatment of Concrete Pavement for Camouflage Purposes on D.I.E.	7-15-42	38
12	39 B-11(4)	Houghton Research Project	7-19-42	36
13	42 G-19 (1)	Comparative Study of Reflectorized Sign Types	11-1-42	40
14	42 G-19 (2)	Discoloration Phenomenon in Beaded Reflectorized Highway Sign Materials	1-10-43	42
15	43 B-10	Colored Concrete for Ramps on D.I.E.	5-18-43	44,95

<u>Item</u>	<u>Project No.</u>	<u>Title</u>	<u>Date</u>	<u>Report Number</u>
16	43 F-8	Design of Concrete Resurfacing	5-21-43	45
17	43 F-9	Design Recommendations for Detroit Industrial Expressway No. 3.	6-25-43	46
18	39 B-11 (1)G	Freeze-Thaw Durability Test	8-3-43	47
19	44 F-10	Survey of Concrete Recapped Projects	3-10-44	50
20	43 G-23	Compilation of Design and Con- struction Data for Concrete Pavements	6-1-44	52
21	44 G-25	Study of Blowups on Bituminous Capped Pavements	7-28-44	56
22	44 G-26	Study of Transit-Mixed Concrete	8-3-44	57
23	44 G-27	Concrete Pavement Cracking Project 49-7, C1	8-8-44	58
24	39 B-11(1)B	Microscopic & Chemical Study of Scaled and Unscaled Concrete	11-1-44	61
25	42 B-17	Use of Vinsol Resin Cement in Bridge Structures	11-24-44	63
26	44 G-24	Hardening of Wood by Chemical Process	12-9-44	65
27	39 F-7 (4)	Subgrade Friction Studies	3-15-45	68-R
28	36 G-4 (1)	Development of Asphalt-Latex Joint Seal Compound	4-1-45	70,78
29	45 G-29	Investigation of Anti-Freeze Preparations (Ethylene Type)	11-16-45	76
30	45 G-28	Investigation of Membrane Curing Compound	12-1-45	77
31	39 B-11 (5)	Sodium Chloride Scaling Studies	12-10-45	74-R
32	43 G-22	Maintenance of Highway Signs	4-1-46	No Report
33	46 G-32	Hinged Joint Bar Mat	6-3-46	84

<u>Item</u>	<u>Project No.</u>	<u>Title</u>	<u>Date</u>	<u>Report Number</u>
34	48 G-31	Investigation of Pen-Kote "500" Maintenance Paint	7-23-46	86
35	46 F-12	Load Limitations on Highway Pavements and Bridges	1-2-47	92
36	46 B-20	Abnormal Cracking and Settlement of Pavement Slabs in the Willow Run and Detroit Industrial Expressway Systems	4-1-47	97
37	46 G-30	Concrete Paving Form Investigation	4-4-47	91-R
38	47 G-34	Bituminous Fiber Board Investigation	5-2-47	96
39	36 G-4 (7)B	Wood Material Joint Fillers	5-28-47	98
40	44 F-11	Model Study of Slab Action	11-1-47	72,90
41	47 G-27	Cracking of Patches on F 49-7, C1	12-15-47	105
42	47 G-39	Manhole Brick Investigation	3-1-48	108
43	42 G-19(4)	Study of New Decalcomania Reflective Material	3-26-48	111
44	47 G-35	Fiberglass for Membrane Waterproofing	6-10-48	113
45	47 A-9	Durability Studies on Dolese & Shepard Limestone Aggregate 26A	3-7-49	124
46	48 B-22	Effect of Foreign Material on Quality of Concrete, Project F 43-16, C2	6-10-48	114
47	45 B-18	Preserving and Reconditioning of Concrete Bridges	3-15-48	87,110
48	42 B-14 (2)	An Appraisal of the Membrane Method of Curing Concrete Pavements	12-15-48	118,123

<u>Item</u>	<u>Project No.</u>	<u>Title</u>	<u>Date</u>	<u>Report Number</u>
49	39 F-7(10)	Concrete Curb Design	2-15-49	122
50	48 F-18	Joint Failures on Project F14-33, CI	12- 1-48	126
51	48 G-41	Investigation of Slippery Condition of Stone Sand Concrete Pavements	12- 1-48	117
52	49 G-44	Use of Non-Shrinking Mortar for Anchoring Bolts in Concrete	5- 1-49	128

APPENDIX B

SUMMARY OF RESEARCH PROJECTS BY SUBJECT MATTER

Status: (1) Completed; (2) Completed, report in progress; (3) Active; (4) Inactive;  
 (5) Planned.

<u>Subject</u>	<u>Project Number</u>	<u>Status</u>	<u>Report Number</u>
<u>Admixtures</u>			
Limestone Dust	39 B-11 (1) E	1	34
Agrifil	42 G-20	1	29
H. P. 7	39 B-11 (10)	3	
Silica Dust	39 B-11 (2)	3	39
Pozzoloth	39 B-11 (2)	3	39
Plastiment	39 B-11 (2)	3	39
<u>Aggregates</u>			
Evaluation of Sources	47 A-7	3	
Material Surveys	47 A-8	3	
Heating of Aggregates	47 A-9	1	124
<u>Anti-Freeze</u>			
	45 G-29	1	76
<u>Bituminous Material</u>			
Slow Curing Asphaltic Oils	36 C-1	3	6
Specification Changes	36 C-1	3	17
Benzene Determination	36 C-1	1	69
Cracked versus Uncracked Oils	36 C-1	1	89-R
Weathering Inhibitors	47 C-5	3	
<u>Bituminous Mixtures</u>			
Surface Treatments	46 D-13	3	88
Rubber Admixtures	46 B-14	3	
Bituminous Capping Blowups	44 G-25	1	56
<u>Bituminous Pavement Design</u>			
Concrete Base Course	39 F-7 (9)	4	
<u>Bridges</u>			
Consolidation of Backfill	45 E-11	1	93,107,109,M.S.C. Bull.
Stress Distribution	47 F-14	3	#107
Vinsol Resin Cement Concrete	42 B-17	1	63
Orvus in Sidewalk	42 B-13	1	
Spiral Shear Developers	48 F-17	3	125
Preserving and Reconditioning	45 B-18	1	87,110
Form Lining (Hydron)	48 G-42	1	127
<u>Brick</u>			
Manhole Brick Detroit Area	47 G-39	1	108
<u>Chloride Salts</u>			
Rust Inhibition on Auto Vehicles	48 G-43	3	

<u>Subject</u>	<u>Project Number</u>	<u>Status</u>	<u>Report Number</u>
<u>Concrete, Colored</u>			
Camouflage Highways	42 B-10	1	38
For Ramps on D.I.E.	43 B-10	1	44, 95
<u>Concrete Curb Design</u>	39 F-7 (10)	1	122
<u>Concrete Curing</u>			
Membrane Curing Specifications	42 B-14 (1)	1	33
Membrane Curing Compounds	45 G-28	1	77
Appraisal of Membrane Curing	42 B-14 (2)	1	118, M.S.C. Bull.
Calcium Chloride	39 B-11 (2)	1	31 #108
<u>Concrete Durability</u>			
Stone Sand	39 B-11 (6)	1	15
Freeze--Thaw Test	39 B-11 (1) E.	1	47
Air-Entraining Concrete	39 B-11 (7)	3	48, 54, 63, 75, 79, 112
Durability Project M.T.R.	39 B-11 (2)	3	See Exp. Projects
Influence of Soda Ash in Mix	48 B-22	1	114
<u>Concrete Pavement Construction</u>			
Concrete Paving Forms	46 G-30	1	91-B
Foundations	45 E-11	3	
Construction Costs	41 G-18	4	
Guard Rail Expansion Take-up	46 G-33	3	
Guard Rail Anchors	46 G-33	3	
Guard Rail Post Preservation	39 G-15	3	
Hinged Bar Mat	46 G-32	1	84
Mechanical Concrete Spreader	39 F-7 (2)	1	9
<u>Concrete Pavement Design</u>			
Load Transfer Devices	39 F-1	3	5, 10, 68-R
Design Recommendations	39 F-7 (1)	3	62
Subgrade Friction	39 F-7 (4)	1	68-B
Concrete Resurfacing	43 F-8	1	45
Detroit Industrial Expressway # 3	43 F-9	1	46
Concrete Recapping	44 F-10	1	50
Design and Construction Data	43 G-23	1	52
Joint Fillers	36 G-4 (7)	1	98
Bituminous Fiber Board	47 G-34	1	96
Slab Action-Static Loads	44 F-11	3	72, 80, 90
Slab Action-Dynamic Loads	47 F-13	5	
Design Project, M.T.R.	39 F-7	3	See Exp. Projects
Subgrade Modulus	39 F-7 (3)	4	68-R
Subgrade Moisture	39 F-7 (2)	3	64
<u>Concrete Pavement Cracking</u>			
Willow Run and D.I.E. Expressway	46 B-20	1	97
Project F 49-7, C1	44 G-27	1	58
Projects F 40-11, C2; 5-15, C2	43 F-6	3	
Longitudinal Cracking, F 17-42, C2	47 F-16	1	129

<u>Subject</u>	<u>Project Number</u>	<u>Status</u>	<u>Report Number</u>
<u>Concrete Pavement Joints</u>			
Spalling on F 14-33, C1	48 F-18	1	126
<u>Concrete, Physical Properties</u>			
Autogenous Volume Changes	47 B-21	5	
Physical Properties at Early Age	39 F-7 (8)	3	
Effect of Low Temperatures	42 B-16	4	
<u>Concrete Scaling</u>			
Microscopic and Chemical Study	39 B-11 (1) B	1	61, M.S.C. Bull.
Sodium Chloride Studies	39 B-11 (5)	1	74 #101
Scaling Studies M.T.R.	39 B-11 (2)	1	25, 39
Project F 15-11, C2, US-131	45 B-19	3	
Houghton Project	39 B-11 (4)	1	36
<u>Concrete, Transit Mix</u>			
	44 G-26	1	57
<u>Experimental Concrete Pavement Projects</u>			
Michigan Test Road, Design Project	39 F-7 (2)	3	3,4,8,9,12,14,16,20, 21,41,59,64
Michigan Test Road, Durability Project	39 B-11 (2)	3	3,8,12,14,18,20,21, 25,31,39,41,48,64,79
Manistique, M 75-28, C2	39 B-11 (4)	3	36
Muskegon, M 61-27, C5	39 B-11 (8)	3	78
Rogers City, M-71-24, C1	39 B-11 (10)	3	
Grand Rapids, F 41-34, C6	39 F-7 (5)	3	
Grand Ledge, F 23-6, C4	39 F-7 (12)	3	
Houghton Project	39 B-11 (4)	1	36
<u>Flight Strips</u>			
Bibliography on Airport Construction	42 G-21 (1)	1	26
Design Recommendations	42 G-21 (2)	1	27
<u>Hardening of Wood</u>			
	44 G-24	1	65
<u>Highway Signs</u>			
Reflectorized Sign Types	42 G-19 (1)	1	40
Discoloration Phenomenon	42 G-19 (2)	1	42
Maintenance	43 G-22	1	No Report
Reflector Buttons, Specifications	39 G-14 (2)	3	
Decalcomania Reflective Material	42 G-19 (4)	1	111
Relative Cost	48 G-40	3	
Spec. Bead-Reflectorized Material	42 G-19 (5)	1	
Spec. Prefabricated Signs	42 G-19 (6)	1	
Spec. Beads on Paint Signs	42 G-19 (7)	1	



<u>Subject</u>	<u>Project Number</u>	<u>Status</u>	<u>Report Number</u>
<u>Joint Sealing</u>			
Asphalt-Latex	36 G-4 (1)	1	70-R, 78
Ford Road Project	36 G-4 (2)	1	2
Experimental Field Studies	36 G-4 (3)	3	49, 53, 81, 83, 94
Bond Studies	36 G-4 (4)	4	
Asphalt-Synthetic Latex	36 G-4 (5)	4	
Bituminous-Rubber, Hot-Pour Type	36 G-4 (6)	3	103
<u>Liquid Chloride</u>			
Dust Palliative and Rust Inhibitors	47 G-37	3	
<u>Maintenance Paint</u>			
	46 G-31	1	86
<u>Membrane Waterproofing</u>			
Use of Fiber Glass	47 G-35	1	113
<u>Mortars</u>			
Non-Shrinking for Anchor Bolts	49 G-44	1	128
<u>Pavement Marking</u>			
Glass Beads	47 G-36	3	115
Paints	47 G-36	3	
<u>Pavement Surface Condition</u>			
Pavement Roughness	47 F-15	3	
Skidding Properties	47 G-38	3	
Slippery Condition on US-2	48 G-41	1	117
<u>Performance Surveys</u>			
Projects of Post War Design	39 F-7 (14)	3	
Prewar Pavements	39 F-7 (6)	3	73
Projects using State Cement	39 F-7 (13)	3	
<u>Research Activities</u>			
Publication	Research	1	1, 7, 9, 22
Biennial Report	Research	1	35, 60
Dean of Engineering, M.S.C.	Research	1	37, 55, 71, 85
Departmental	Research	1	28, 43, 51, 99
<u>Snow Removal and Ice Control</u>			
	36 G-3 (1)	4	M.S.C. Bull. #86
Radiant Heating	36 G-3 (7)	3	120
<u>Soil Action Under Bridge Piers</u>			
	44 E-10	4	67
<u>Soil Stabilization</u>			
Bituminous, Grayling	36 E-5 (1)	1	32, 82
Cement, Grayling	36 E-5 (1)	1	32, 82
Cement, Stockbridge	36 E-5 (2)	1	30
Calcium Chloride	36 E-5 (3)	1	M.S.C. Bull. #97
Chemical	47 E-12	4	

<u>Subject</u>	<u>Project Number</u>	<u>Status</u>	<u>Report Number</u>
<u>Traffic</u>			
Changes in Motor Bus Loading	39 F-7 (1)	1	66
Multiple Axle Loadings	39 F-7 (7)	1	25
Load Limitations	46 F-12	1	92
Wheel Load Frequencies	39 F-7 (11)	3	
<u>Turf Growth on Shoulders</u>	42 E-9	3	* 106