

MICHIGAN  
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A DIGEST  
OF  
THE MICHIGAN TEST ROAD  
FOR  
AMERICAN CONCRETE INSTITUTE

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Research Laboratory  
Testing and Research Division  
Report No. 41  
December 21, 1942

## THE MICHIGAN TEST ROAD

An experimental concrete pavement project designated "The Michigan Test Road" was built by the Michigan State Highway Department in 1940 in cooperation with the Public Roads Administration for the purpose of obtaining, under actual service conditions, an evaluation of modern theories of design and construction of concrete pavement.

The project was constructed under regular contract and construction procedure using the Michigan State Highway Department 1940 plans and specifications with necessary supplementals. The Test Road is located on M-115 between US-10 and M-66 in Clare and Osceola counties and consists of 17.6 miles of 22 foot width concrete pavement. The experimental road is divided into two test projects: one project 10.1 miles in length is devoted to a study of principles and factors incidental to design and construction, the remaining 7.7 mile project provides the means for a study of factors involved in the durability of concrete, more particularly in regard to scaling.

### DESIGN PROJECT

The design project of the Michigan Test Road coincides in a general way with the Public Roads Administration's plans and procedure for construction of experimental roads which were submitted to various state highway organizations in 1940. Among the special features under study are those pertaining to joint spacing and design, cross-section dimensions and reinforcing.

Joints have been one of the most controversial subjects in the design of concrete pavements. Therefore, they were given considerable attention in the Michigan Test Road.

Emphasis is placed upon joint spacing expansion space and joint construction. Several different spacings of expansion joints from 120 feet to 2700 feet were used for various cross-sections and various amounts of reinforcing steel. Correspondingly various spacings of contraction joints from 10 to 60 foot intervals were used.

The proper spacing of joints will be determined by permissible maximum stress intensities induced by linear frictional restraint and flexural weight restraint.

Various types of expansion and contraction joints were installed to evaluate load transfer and the preservation of mutual elevation of slab ends. In this connection, a study of thickened slab ends at expansion joints, as well as the effectiveness of aggregate interlock at contraction joints will be studied. In this project a study of required expansion space for different spacings will also be made.

In regard to the design of the pavement slab itself, thought has been given to the study of reduced thickness on prepared subgrades, and equivalent uniform thickness versus the balanced cross-section. In this respect, four different types of cross-sections were set up for study on this project; namely, 9-7-9 Michigan State Highway Department standard cross-section; 8" uniform, the approximate equivalent of 9-7-9, 8-6-8 and its approximate equivalent 7" uniform.

In planning the Michigan Test Road, it was felt that a study of

reinforcing steel should be included because of the many unanswered questions concerning its use among which are: (1) the amount of reinforcing steel required, (2) economics of reinforced pavement versus unreinforced pavement with adequate jointing and (3) the relation of plain uniform cross-section to reinforced "balanced" cross-section. To this end, sections were constructed using 9-7-9, 8 and 7 uniform cross-section using plain concrete, and reinforced concrete with 60 pounds per hundred square feet and 37 pounds per hundred square feet.

For proper appraisal of the structural efficiency of the elements of design considered in this project, periodic visual examinations together with measurement of displacements and physical conditions must be made.

Throughout the entire project, special measuring devices and reference points have been installed including: (1) electrical strain gauges for measuring stress, (2) thermocouples for temperature studies, (3) moisture cells for determining moisture content of concrete and subgrade soil, (4) reference monuments for detecting slab movement, (5) reference points for measuring changes in joint width, (6) elevation points for measuring vertical displacement at the joint, (7) meteorological station for obtaining complete record of weather conditions and (8) a traffic counter for recording vehicle movement over the test road.

Incidental with the construction of the Test Road, additional studies have been made which are of particular interest to the Michigan State Highway Department and pertinent to the improvement of concrete pavement construction. They are: stress curing of concrete, mechanical spreading of concrete and the use of various types of joint sealing materials.

Eighteen hundred feet of concrete pavement was placed by the stress curing method of construction which eliminates steel reinforcement and transverse joints other than expansion. The purpose of the experiment was to determine the economic and physical value of stress curing.

With the exception of 600 lineal feet, the concrete on the design project was placed and consolidated by means of a mechanical concrete spreader. The purpose of this study was to compare the relative merits of mechanical spreading versus hand spreading of concrete.

Several types of joint sealers having desirable characteristics were included in the design project for comparative study.

A mechanical form tamper was specified for use on the design project for comparative study of mechanical versus hand methods of tamping forms on sandy subgrades.

#### DURABILITY PROJECT

The performance of concrete under the severity of service cannot be predicated upon laboratory studies alone. Although laboratory studies will aid in the discovery of factors affecting the deteriorating and scaling of concrete pavements, the combined physical, chemical and mechanical action as experienced in actual use cannot be predicted. Consequently, the durability project was established to make observations under service conditions on controlled factors which have been determined to be of importance in the durability of concrete. Also the durability project would afford a field laboratory to obtain accelerated action of chloride salts or ice on concrete pavement and the study of resultant action.

The durability project includes an evaluation of the effect of various factors relative to the construction and materials used in concrete pavements. Embodied in these considerations are: the proportioning and grading of aggregates with definite recognition of the material passing the 200 mesh, the comparative effect of various types of additives including physical and chemical varieties as well as cement blends and cements produced with grinding aids. Consideration has been given to crushed limestone aggregates with special attention to the finer fractions. The effect of various curing methods on scaling is being studied as well as methods of finishing.

Poorly graded aggregates are inducive to poor workability, segregation, difficult finishing, bleeding and laitance. These properties are contributory in a certain degree to inferior concrete with subsequent scaling and disintegration of the surface of pavements.

On the durability project the standard concrete design method was supplemented by incorporating fines with the fine aggregates. These fines were added to increase density and workability of the mix and a possible resultant reduction of scaling. The fines included natural sand and mineral fillers.

The natural sand and mineral filler admixtures are inert and act wholly as a physical addition to produce a workable and anticipated durable concrete. To obtain the same end, concrete mixes were designed incorporating chemical additives.

The proprietary additives selected for use on the durability project were of the liquid and powder types which included, Orvus, Vinsol Resin,

Calcium Chloride, Pozzolite and Plastiment. A blend of natural cement was also included which was ground with and without the use of Calcium Stearate.

A portion of the durability project was set aside for the study of limestone aggregates with and without added fines. The main objections to its use in concrete is reduced workability, excessive bleeding, difficult finishing and its tendency to excessive scaling of pavement surfaces in which it is used.

The relative merits of the various curing methods have been based, in general, on laboratory strength tests. Very little information is available on the subject of curing methods in relation to durability of concrete pavements. Therefore, a study of curing methods under actual field conditions was included in the durability project. Embodied in the curing study are such factors as moisture movement in the slab, relative thermo insulation value of various curing methods, membrane curing versus wetted coverings and relative durability of the slab surface.

The various curing methods studied are asphalt emulsion, cut-back asphalt, wetted straw, paper curing with and without initial curing, wetted earth, ponding, double burlap, Calcium Chloride integral mixed and a transparent membrane.

The brooming of concrete surfaces with stiff brooms as a final finishing operation has been used to reduce the amount of fine superficial material. It is believed by some engineers that this method provided grooves for concentration of salt solutions and a resultant unsatisfactory condition of

aggravated scaling. Therefore, a comparative study has been made between burlap finish and brooming to obtain comparative data relative to the two methods of finishing concrete pavement surfaces.

In conjunction with the five major durability studies discussed above special observations were conducted on the different concretes during the process of mixing and placing. These observations termed "incidental studies" were essentially a visual and physical evaluation of the physical characteristics of the various concrete mixtures. They consisted of determining certain physical characteristics of the concrete during placing, mechanical analysis of the fresh concrete, setting time and concrete test specimens.

#### SUBSEQUENT STUDIES

It is planned to make periodic visual examinations together with measurements of physical conditions over an indefinite period of years. These observations and measurements throughout both projects of the Michigan Test Road will include continuation of measurements of moisture content, slab temperature, slab movement, joint width, joint elevation, concrete stresses and surface condition surveys. Special consideration has been given to a study of surface scaling due to accelerated weathering tests with calcium chloride and ice.

#### SUMMARY

At this writing the Michigan Test Road is two years old. It will require a considerable period of time before sufficient data will have been



accumulated from the design project to make final conclusions relevant to the several factors being studied on that project. The data accumulated thus far, especially in regard to joint spacing and slab movement, is beginning to show promising results.

On the durability project two winter scaling studies have been completed. It is believed that sufficient data on scaling has been obtained to warrant cessation of the accelerated scaling studies. In conjunction with the accelerated scaling studies, field test specimens consisting of beams and cores are being subjected to freezing and thawing tests in the laboratory. The resultant data from these studies will be correlated with those of the accelerated scaling studies before final conclusions are presented.

Since the prime objective of the durability project was to develop a concrete pavement surface totally resistant to scaling, it may be stated at this time that this objective has been realized as judged by the qualifications of the accelerated scaling tests. It appears possible to obtain a scale resistant concrete pavement surface by incorporating into concrete mixtures certain additives without those additives producing any apparent harmful affect on the structural characteristics of the concrete.

Plans are now under way to publish within the next few months, the first progress report pertaining to the facts and findings of the Michigan Test Road. This progress report will contain the results from the concrete durability studies pertinent to the durability project of the Michigan Test Road.