MICHIGAN
STATE HIGHWAY DEPARTMENT
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CONCRETE DURABILITY STUDIES

By

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DURABILITY STUDY

A survey of concrete pavements in Michigan shows that approximately ten percent of the surface is scaled in varying degrees.

Consequently, in 1939, a study of scaling, its causes and methods for prevention has been incorporated into the plans of the Research Division of the Michigan State Highway Department as a definite project under the title "Durability Study of Concrete".

The investigation has been divided into two separate studies. First, a field study including a survey of existent concrete pavements and the construction of a special pavement for field observations, and second, a laboratory study on concrete durability. The investigation will attempt to establish certain fundamental principles in concrete construction and to correlate certain laboratory studies with construction methods in order to develop more durable concrete pavements.

Embodied in these considerations are the newer concepts of concrete mix design as regards proportioning and grading of aggregates with definite recognition of the materials passing 200 mesh; the comparative effect of various types of additives, cement blends and cements produced with grinding aids. Also, the evaluation of the effect of variations in construction factors. Consideration has been given to crushed limestone aggregates with especial attention to the finer fractions. The effect of various curing methods and the membrane curing agents are included.

Field Study: The field survey consisted of a visual examination of all concrete pavements constructed on the Michigan State trunkline system.

Numerous factors incidental to pavement construction which may effect surface conditions and their relationship to scaling will be studies. To supplement the field study, cores will be taken from selected projects for further laboratory analysis.

Michigan Test Road - Durability Section

The performance of concrete under severity of service cannot be predicated upon laboratory studies. In order to make observations under service conditions on controlled factors, a concrete pavement has been built. The purpose of this pavement was not only to make observations under service conditions but to afford a field laboratory to obtain accelerated action of chloride salts or ice on concrete pavements and to study the resultant action. This pavement was constructed in conjunction with a complimentary pavement project for the study of pavement design. Both roads are constructed on M-115 in the north central part of Michigan's lower peninsula. The durability study project is 7.7 miles in length with a 22 foot concrete surface.

Complete observations were made during the construction of the pavement on all factors incidental to construction practice. Subsequent observations will be made periodically on the finished pavement.

The cements used included two brands of regular Portland cement as normally used in the construction of concrete pavements in Michigan. Admixtures included the use of certain proprietary materials known as Plastiment, Pozzolith, Orvus and Vinsol Resin. Natural cement was also included which was ground with and without the use of calcium stearate. Mix designs include regular proportioning by the mortar void design method as well as the addition of fines supplementing the fine aggregates. Short test

sections were included to determine the relation of scaling to methods of curing.

A comparative study of brooming versus burlap drag as a final finishing operation has been considered.

Subsequent studies to be conducted on the durability section will pertain to scaling as affected by construction methods, curing methods and the application of controlled calcium chloride treatments. The latter study will continue over a period of 3 to 5 years starting this winter.

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

The laboratory program is divided into three main divisions, namely -

1. Preliminary work incidental to construction of durability section of test road.
2. The causes of scaling.
3. Methods of preventing scale.

Incidental to the construction of the durability section of the test road a preliminary laboratory investigation was necessary in order to evaluate the various materials involved, and to determine what effect these materials would have upon the design and physical characteristics of their respective concrete mixtures.

The study of causes of scale divides itself naturally into three phases, chemical and physical and mechanical causes. Under chemical causes

are included such subjects as -

1. Compilation of data pertinent to salt solutions. Involving a bibliological study and a field study to determine the probable concentration of salt solutions.
2. Scale formation on concrete as effected by chloride salts. Involving such studies as the chemical reaction of chloride salts on constituents of concrete and the formation and distribution of chemical end products conducive to scaling.
3. The chemical action of chloride salts on set neat cements. Mortars and concrete under different test conditions.

The physical phase involves two main subjects -

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

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

Scale prevention studies will include -

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

Conclusions

To date, the investigation has concerned itself with studies incidental to the construction of the test road and certain experimental laboratory researches. Consequently, nothing conclusive can be presented, however, a few significant observations will be mentioned.

1. Microscopic analyses of scale and parent concrete show an abundance of calcium hydroxide crystals deposited throughout the scale and on the surface of the parent concrete. In the case of unscaled pavements, the deposit of calcium hydroxide was confined entirely to the surface.
2. Microscopic analyses of neat cement specimens show that when they are subjected to calcium chloride treatments there is a deposit of large calcium hydroxide crystals on the surface of the specimens. Also crystals of calcium oxychloride are present.
3. Construction observations reveal that the concrete is overworked and that there is a definite lack of equipment coordination from mixer to curing operations.
4. The addition of special fines to fill the grading gap between 50 and 200 mesh with a definite percentage passing the 200 sieve materially improves the workability of the concrete with consequent water reduction.
5. Controlled calcium chloride treatments to remove ice from panels on test road have produced scale, after 9 cycles, on all different types of concrete mixtures with the exception of those containing Orvus or Vinsol Resin.