



AGGREGATE DURABILITY AND THE PERFORMANCE OF PCC PAVEMENTS

MDOT materials engineers and technicians working in Michigan's "wet-freeze" environment, must take into consideration the effects numerous freeze-thaw cycles have on pavement performance. The freeze-thaw effect on aggregate durability is especially a concern with pavements constructed of portland cement concrete that are susceptible to D-cracking (see MATES Issue Nos. 7 and 24).

The August 1992 issue of MATES (Issue No. 66) described MDOT's development of freeze-thaw testing and its contribution toward predicting the durability of aggregates in service as part of a concrete pavement. The predictive capability of freeze-thaw testing has always been questioned for many reasons by Michigan's aggregate industry, which is very competitive in trying to sell us all types of aggregates for our pavements and bridges. Considerable debate takes place regarding the contribution made by aggregates with "poor" or "excellent" durability characteristics when compared to other factors that affect the performance of concrete pavements.

To help provide more definitive information about aggregate contribution to performance, it was decided to construct a concrete pavement using different types of coarse aggregates with varying freeze-thaw properties, but keeping all other factors of the mix design constant. This past summer, six miles of southbound US 23 in Monroe County were constructed in this manner to evaluate what long-term effects aggregate durability has on the performance of concrete pavement.

Project Construction

Figure 1 shows the location of the project and its layout. The pavement is 10-1/2-in. jointed reinforced concrete with tied reinforced concrete shoulders. The contraction joints were spaced at 27 ft. The mainline pavement and shoulders were divided into five groups (A through E), each using a different type of coarse aggregate. Pavement groups A and D used crushed limestone, group B used a blast-furnace slag, and groups C and E used natural gravel aggregates. Project specifications required that the aggregate for each group meet specific requirements for gradation, deleterious content, bulk specific gravity, 24-hour absorption, and unit weight based on previous freeze-thaw testing, so that a supplier would not furnish a premium quality aggregate where a poorer quality is intended for evaluation purposes.

Between each group, a paving transition zone of 500 ft was designated where the contractor could change from one aggregate type to another. This was accomplished by batching and mixing the concrete until the feed bin containing the aggregate in use was depleted. Once the feed bin was empty, the next aggregate group would be loaded into the feed bin so the concrete mixing, batching and the paving operation could continue with little or no interruption. It was particularly impressive to find that the contractor was able to complete the transition from one group to another within each of the proposed transition areas. Project specifications required that the concrete mixture for all groups be the same except for the coarse aggregate. That is, if flyash, water-reducing agents, etc., were to be added in one group it should be used throughout the paving operation for all groups with the same mixture proportioning.

The special provision written for the sampling and acceptance procedures used for the aggregate played a key role in the project. The provision required that each group be placed in stockpiles clearly labeled "MDOT Group ____" and kept separate from other stockpiles, both at the aggregate source and at the batch plant. Samples for project acceptance were taken from each stockpile as the aggregate was being produced for delivery to the batch plant. Personnel from the Pavement Technology Unit were present on a daily basis to document the construction of each pavement group and collect aggregate samples for eventual testing at the department's laboratory.

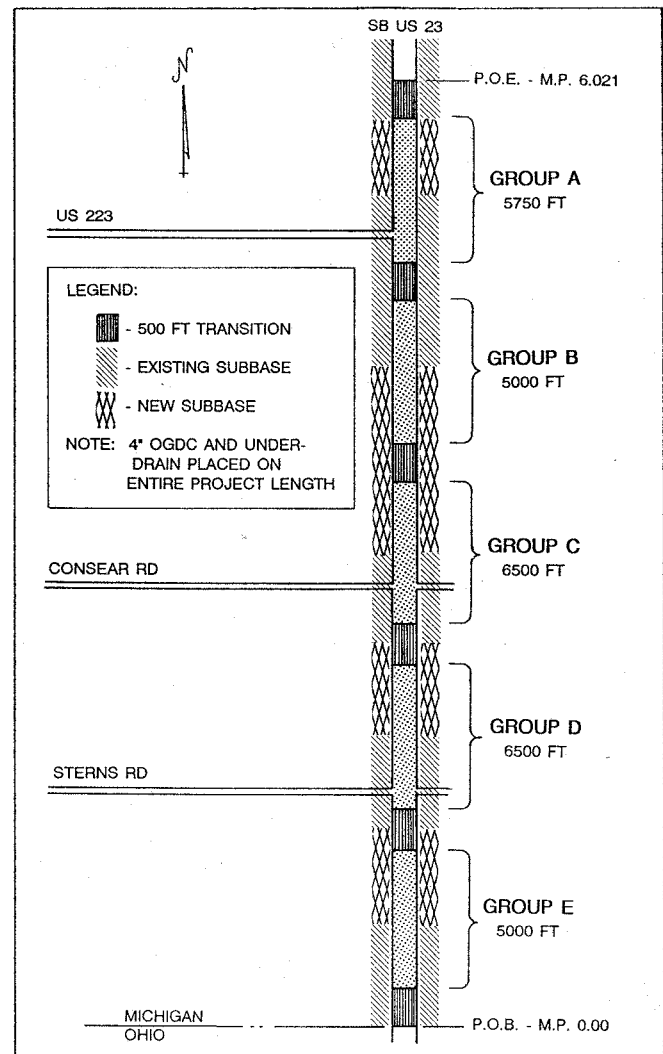


Figure 1.

Complete reconstruction was called for on this project so the old pavement was removed down to the existing sand subbase. The subbase was known to be impermeable based on laboratory permeability tests and soil borings. In an effort to study the effects of a poorly draining subbase on concrete durability, the project was constructed using two

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different materials for the subbase along with other features that aid in removing water from under the pavement. Each of the five pavement groups was constructed with half of its length on the existing subbase and the other half on a permeable subbase that met special drainability requirements after compaction. Each pavement group was constructed with a 4-in. asphalt-stabilized opengraded drainage course (OGDC) over a 3-in. gravel separator base course. Four-inch open-graded underdrains were installed along each pavement edge on the entire length of the project.

Long Term Evaluation

It's expected that the Pavement Technology Unit will be conducting evaluations of each pavement group during the next 20 years recording physical evidence of aggregate related performance. Freeze-thaw damage manifests itself visibly in the form of popouts causing surface disfigurements, or D-cracking deterioration along joints and cracks. The performance of each pavement group will be compared to the laboratory freeze-thaw results of the different aggregates used. Samples for freeze-thaw testing were collected as the aggregate was used in batching concrete for each pavement group. The freeze-thaw testing done in the lab will help to predict the relative performance of each aggregate type. Hopefully, a better correlation with field performance can be established with aggregate durability testing.

The following tabulation contains the cost of each pavement group along with the other features which were part of the project.

ITEM DESCRIPTION	COST
Group A Pavement	\$13.00/SYD
Group B Pavement	\$13.65/SYD
Group C Pavement	\$14.00/SYD
Group D Pavement	\$13.35/SYD
Group E Pavement	\$14.85/SYD
Permeable Subbase	\$ 9.00/SYD
Stabilized 4" OGDC	\$ 2.30/SYD
4" Underdrain	\$ 2.25/LFT

This project will provide a major part in the understanding of how varying aggregate durability affects the performance of concrete pavements. It will then be possible to predict what increase in pavement lives can be obtained for the higher costs of using premium materials.

-Henry Quiroga

OUR MISSION TO IMPROVE QUALITY AND PROVIDE LONGER LASTING PAVEMENTS

For many years, the MDOT research has indicated that there is a detrimental effect on pavement performance caused by the use of low durability aggregates. This has been a point of contention with the aggregate producing industry, they have demanded more proof.

It is true that various factors play a role in the ultimate performance of a concrete pavement. The Department has undertaken several courses of action to eliminate and resolve some of these deleterious parameters. These efforts are paying off.

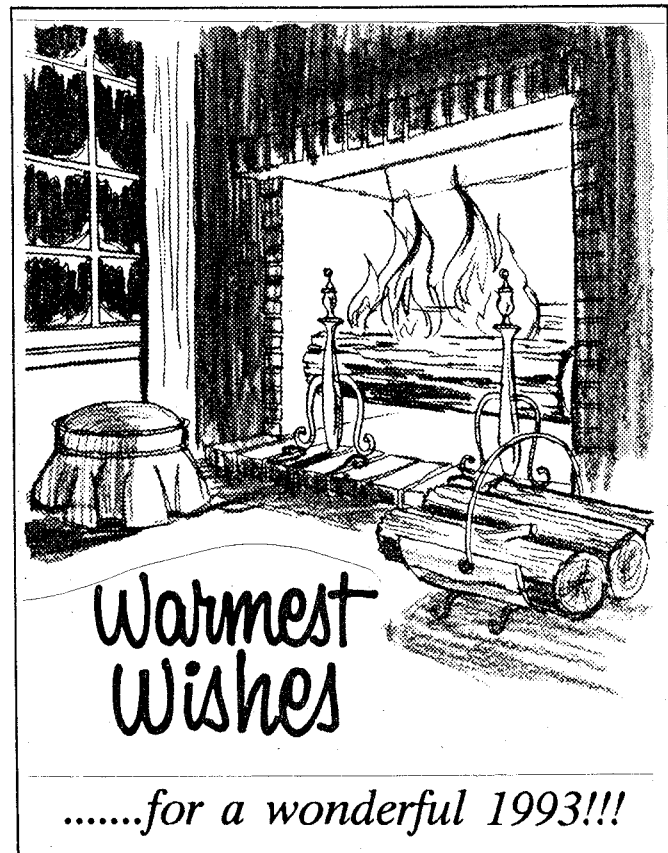
One of the major stumbling blocks to greater success has been the resistance to our efforts to increase aggregate durability and improve long-term pavement performance through the use of premium materials. This giant step in the right direction has been resisted and slow to gain acceptance.

Use of premium designs and materials has met with great success in the European Community. Their highly successful experience with premium aggregates is well documented. In October 1992, two MDOT engineers participated in a 12-day tour of European roadways sponsored by the FHWA. The trip was intended to give us more insight into their design and construction practices. Based on the observations made and the information gathered, we judged the concepts to have merit and determined that their potential application in Michigan should be investigated. The Engineering Operations Committee has approved a trial project to be under construction in 1993. It will coincide with the annual AASHTO meeting to be held in Detroit in October, 1993. Michigan's aggregate durability test road will increase our understanding of how varying aggregate durability affects concrete pavement performance. It will draw together the pieces of the puzzle that are currently scattered around the state and place them side by side under the same physical and environmental conditions.

Understanding the relationship between aggregate durability and pavement performance will make it easier to predict pavement life for given materials. Increased pavement performance, through extended life and reduced maintenance, may make it more cost effective to absorb a little higher initial cost when using premium materials. Indications are that the cost of premium materials will be more than offset by the substantial savings produced over the extended life of the pavement.

This is a significant factor in our mission to provide total quality products to better serve the coming generation.

-Jon Reincke



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