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Sponsor

Michigan Department of
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Project Number

RC-1459

Project Title

Mineral Characterization
and Cataloging of Quarried
Aggregate Sources Used in
Michigan Highway
Construction

Co-Investigators

University of Michigan
Dr. Will Hansen

Project Summary

Technology Transfer Outreach Publication

Chemical and Physical Properties of Michigan Quarried Aggregate Source: Development of an On-line Database

The physical and chemical properties of quarried aggregates play an important role in determining their suitability for use in portland cement concrete (PCC). Mechanical strength, coefficient of thermal expansion, chemical reactivity, and soundness are a few of the hardened PCC properties significantly affected by the aggregate's attributes. The effect of aggregate properties on concrete durability has been, and continues to be, the topic of much research. Ultimately, to integrate knowledge about aggregate properties into modern construction practices, it is necessary for Michigan quarried aggregate sources to be characterized and cataloged in a user accessible database for easy reference by engineers or technicians.

Research Objectives

The objective of this project was to develop an easy-to-access, graphically-based, database of aggregate properties for the most common aggregate sources used in PCC. This database is of tremendous benefit to anybody involved in pavement planning, maintenance or durability research. The database includes information about aggregate mineralogy, grain size, porosity, pore geometry, and thermal-mechanical characteristics.

Methodology

- **Literature Review** - A literature review was performed to establish what is known about aggregate reactivity and soundness in wet-freeze environments with common deicers. A synthesis of this literature was performed and included as part of the project final report.
- **Sampling** - In cooperation with MDOT, the 13 most common quarried aggregate sources used in Michigan were identified. Within each source, different aggregate types were identified by visual characteristics and samples were obtained by hand sampling production material. Over 60 different rock types were identified for analysis from all 13 quarries.
- **Laboratory Analysis** - The specimens obtained were analyzed in Michigan Tech Transportation Institute laboratories and at the University of Michigan. The analyses were performed on polished slabs and thin sections produced from larger pieces of aggregate sampled from each source. Mineralogy, grain size, porosity, pore geometry, and chemical composition were determined using, as appropriate, optical petrography, scanning electron microscopy, x-ray microanalysis, x-ray microscopy, and x-ray diffraction. Specimens were sent to the University of Michigan for coefficient of thermal expansion (CTE) determination.
- **Creation of Database** - An accessible database was established using ArcView, a GIS application that is widely used by state agencies (<http://www.esri.com/software/arcview/>). ArcView allows the user to view data in geographical setting. For example, the Minnesota Department of Transportation (MnDOT) uses ArcView to display gravel pit locations electronically stored in their Aggregate Source Information System (ASIS). Although the proposed aggregate characterization study was focused only on the chemical and physical properties of the aggregates, the information obtained can be combined with other databases. For example, maps can be created with combined information from an aggregate properties database, a pavement construction database, and a pavement management database to look for trends between materials used and pavement performance.

Project Summary

Technology Transfer Outreach Publication



University Facts

Total Enrollment	6,550
Graduate Enrollment	916
Number of Faculty	417
Placement Rate	95%

Michigan Tech is located in Houghton, MI on the south shore of Lake Superior. This rural area is known for natural beauty, pleasant summers, abundant snowfall, and numerous all-season outdoor activities. In addition, the University maintains its own downhill and cross-country ski facilities and golf course. There are numerous cultural activities and opportunities on campus and in the community. Michigan Tech has also been rated as one of the safest college campuses in the United States, and the local community provides excellent resources conducive to an outstanding quality of life.

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Research Findings

Distress in PCC can be put into the general categories of design/construction-related and materials-related distress. For design/construction-related distress, one critical characteristic is the CTE value of the aggregate. In this study, CTE values for the sources examined were found to be in excellent agreement with values reported in the literature for each of the dominant rock types and were considered not likely to contribute to design/construction-related distress under normal circumstances.

With regards to materials-related distress, there are four characteristics that can be related to the durability of an aggregate used in the production of PCC. These include chemical composition, grain size, mineralogy, mineralogical texture, and porosity.

- **Chemical Composition** - None of the aggregate sources analyzed had chemical compositions that by themselves indicate potential durability problems.
- **Grain Size** - The estimate of grain size for each rock type was determined by petrographic microscopy and image analysis, with these values ranging between approximately 17 and 149 microns. From the literature, fine-grained rocks tend to be more alkali-carbonate reactive (ACR) as compared to coarse-grained rocks.
- **Mineralogy** - None of the aggregates studied exhibited the classic ACR texture where dolomite rhombs are dispersed in a fine-grained calcite matrix with clay.
- **Mineralogical Texture** - Rating the degree of interlocking and grain formation is best done by examining the environmental scanning electron microscope (ESEM) images from the fracture surfaces of each rock type. For this study a general classification of texture was made.
- **Porosity** - Quantitative determination of porosity requires careful analysis of polished specimens under conditions where topography is not a factor in detecting or measuring the pore sizes. Most of the aggregate sources analyzed have the over 40% of their pores occurring in 1 to 5 micron class. Water absorption values for each aggregate source correlated well with the measured volume fraction of pores in each rock type.

A relative rating of each different characteristic determined for each source is provided where "1" indicates that the characteristic has negligible significance and little to no influence on durability. A value of "5" indicates the characteristic is highly significant and almost certainly indicates potential durability issues. A median value of "3" indicates that in combination with other characteristics, the measured value may be significant. The average of these values was used as a relative means of ranking the various sources with regards to their performance in PCC pavements, with respect to durability.

Implementation

The final database was placed on-line and is accessible at the following URL:

http://www.michigan.gov/mdot/0,1607,7-151-9622_11045_24249-115398--,00.html

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