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SUM NOTES

Preparation of Concrete

Introduction

Concrete, which has been used as a construction material for more than a century, is still a popular building material. The low cost, great compressive strength and durability make concrete an ideal construction material for highways, bridges, sidewalks, buildings and countless other structures.

Concrete is basically a mixture of two components: aggregates and paste. The paste is primarily comprised of cement and water. Cement binds the aggregates (sand and gravel or crushed stone) into a rocklike mass.

In order for concrete to withstand freezing and thawing cycles, it is important to maintain control of the air voids distribution. The microscopic voids provide free space within the paste to relieve hydraulic pressure when concrete freezes. Without voids, the paste may crack as it freezes because water expands 9% in volume when it turns to ice. These cracks may lead to the disintegration and eventual failure of the structure.

Air voids are often referred to as either entrained or entrapped. Entrained voids are intentionally created in concrete by using an air-entraining admixture. There is also some air, entrapped air, which gets trapped in the concrete during mixing. Concrete with a large number of entrapped air voids generally has lower strength and durability.

To analyze the air voids in the concrete, the surface should be ground and polished. It is important to maintain the true void structure throughout the preparation process. If the periphery of an air void is crumbled or rounded, the operator will need to estimate the edge position. This can result in a skewed estimation of the air void content. For this reason impregnation of the surface is recommended. In addition, if automated image analysis techniques are being used, the contrast of the voids and paste can be further enhanced using the method outlined here.

Preparation Procedure

1. Obtain initial samples of concrete from the field or laboratory environment by coring, sawing, or otherwise removing concrete from the original structure or product.

2. Section the specimen to a suitable working size. Unless otherwise specified, the section for observation should be approximately perpendicular to the layers in which the concrete was placed or perpendicular to the finished surface.

   For larger samples, the Lapro® Slab Saw is recommended. The Lapro Saw is a high quality, durable machine designed specifically for cutting rocks, minerals, concrete, glass, ceramics, tile and other hard brittle materials. It features a unique hydraulic and dead weight controlled feed system that ensures proper feed rate and maximum blade life. Smaller sections, less than 3.75in. (95mm), can be handled with the Delta® PetroCut™ Geological Cutter.

Concrete specimen prepared for void analysis. The voids have been filled with oxide (white) and the matrix has been inked (black).

3. Clean the specimen and dry thoroughly. Note: the use of ultrasonic cleaners may be harmful to the surface by artificially increasing the appearance of the void size.

4. Impregnate the cross section with a low viscosity epoxy, such as EpoHeat™ Epoxy System. The low viscosity epoxy readily penetrates the voids and cracks. When the voids are filled with epoxy, the void walls will not collapse during preparation.

   In order to enhance the optical contrast between the voids and the matrix a white pigment is added to the epoxy. To facilitate complete mixing of the pigment into the epoxy, follow these steps:
   - Measure the proper amount of resin and then add the titanium dioxide powder
   - Mix it thoroughly to break up any clumps
   - Add the appropriate amount of hardener
   - Pour enough epoxy over the specimen to fill any voids. It may be helpful to use a flat stick to spread the mixture across the specimen.
   - Cure at 150 °F (65 °C) until the epoxy cannot be dented with your fingernail

5. There are two routes to choose from for the next preparation step.

   If you are using a standard metallographic grinder-polisher, grind the impregnated surface with a 600 (P1200) grit SiC CarbiMet® Abrasive Disc using oil based lubricant.

   If you are using a traditional lapping machine, lap the impregnated surface using SiC abrasive in sizes ranging from 240 (P2800) to 1000 (P2000) grit.

6. Polish the specimen using the following steps on a standard platen. Select a speed that allows you to securely hold the concrete flat against the platen with even pressure.
   - TexMet® 2500 with 6µm MetaDi® Diamond Paste and an oil based lubricant, AutoMet® Lapping Oil
   - TexMet® 1500 with 1µm MetaDi® Diamond Paste and AutoMet® Lapping Oil

   To determine if the time is sufficient, observe the specimen surface under a stereoscope at the end of each step. Pits and scratches proportional to the current abrasive size will be present. A uniform scratch pattern that doesn't improve regardless of the time spent indicates that the current step is complete.

7. Wash the sample thoroughly and dry it in an oven at 100-200 °F (38-93 °C) for several hours.

8. Wet a stamp pad with black India ink (do not over saturate) and press against the polished surface several times to blacken the surface.

9. Dry the specimen in an oven for several hours until the ink is completely dry.

10. Regrind the surface for as short a time as possible with a fine abrasive paper or 1000 (P2000) grit SiC (used previously) to remove ink stains from the white pigmented epoxy. Voids should appear white against the dark background creating a specimen ideal for manual or automated microscopic observations.

Air Void Content Analysis

Observation of the air void content can be used to develop data which estimates the likelihood of frost damage to concrete or to explain why it has occurred. Analysis of the air void content is often accomplished based on the ASTM standard C 457, Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete. This test method describes procedures for microscopic determinations of the air content of hardened concrete and of the specific surface, void frequency, spacing factor, and paste-air ratio of the air-void system in hardened concrete (1).

Two procedures are included in the test method; Procedure A, the linear-traverse method and Procedure B, the modified point-count method. In both cases, the prepared sample will be analyzed using a microscope with an overall magnification in the range of 50X to about 125X. Select the magnification based on the void sizes of interest and maintain that same magnification throughout the analysis.

Automation is possible for either of these procedures and is desirable from a timesavings and repeatability point of view. The procedure can be slightly modified to accommodate the equipment employed as long as the fundamental principles are applied.

References

1. Powers, T.C. "The Air Requirement of Frost-Resistant Concrete," Proceedings, Highway Research Board, Vol 29, 1949, pp.184-211.

Equipment*
Lapro® Slab Saw
Delta® PetroCut® Geological Cutter
Alpha or Beta Grinder/Polisher
Vector® Power Head

Consumables*
Notched Rim Diamond Blade
EpoHeat® Low Viscosity Epoxy
Titanium Dioxide Discs
CarbiMet® Abrasive Discs
TexMet® 2500 or 1500
MetaDi® Diamond Paste
AutoMet® Lapping Oil
India Ink/ Stamp Pad
For a complete listing of Buehler Equipment and Consumables, please refer to Buehler's Equipment Buyer's Guide and Buehler's Consumables Buyer's Guide

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