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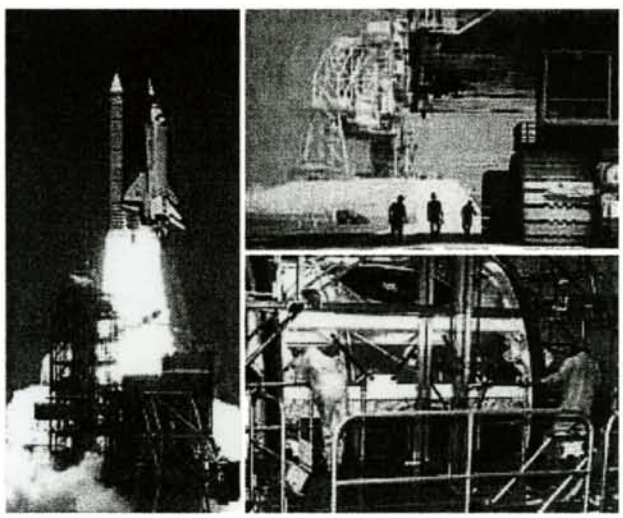

A Vision of Yesterday, Today, and Tomorrow

OHIO SPACE GRANT CONSORTIUM

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Freeze-Thaw Durability and Nondestructive Testing (NDT) of Pervious Concrete (PC)

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Abstract
One of the main benefits of pervious concrete is the reduction in storm water runoff produced in comparison to other non pervious pavements. The recently passed Federal Clean Water Act has placed restrictions on the amount of storm water volumes and the water pollution associated with storm water runoff. Pervious Concrete greatly reduces runoff by allowing water to infiltrate through it. There have been many installations of pervious concrete in areas where freeze-thaw cycles are minimal or nonexistent. In order to broaden the use of pervious concrete in areas where freeze-thaw cycles are an issue, satisfactory freeze-thaw strength must be documented. Also, ways to evaluate the performance of pervious concrete must be developed.

Project Objectives
The two objectives of this research project are to investigate the freeze-thaw durability of pervious concrete and also the use of nondestructive evaluation methods for the investigation of pervious concrete. The freeze-thaw durability of a particular mixture of pervious concrete will be determined in terms of how many freeze-thaw cycles a sample made of the mixture can undergo without losing a significant amount of mass or strength. The strength of the samples will be measured using nondestructive testing so that further freeze-thaw cycles can be achieved.

Methodology Used
Three different mixtures were used to prepare the samples. Mixture one contained no fine aggregate, mixture two contained 13.2% fine aggregate, and mixture three contained 2% lightweight fine aggregate replacement. Three different types of compaction were used, one for each mixture. Two levels of compaction were implemented for each type of compaction. A Marshall hammer was used at five locations on center for mixture one, two hits per location for batch one and six hits per location for batch two. A vibratory table was used for mixture two, five seconds for batch one and ten seconds for batch two. A Hilti hammer with a square head was used for mixture three, one second for batch one and four seconds for batch two.

The freeze-thaw durability was evaluated using an automated machine that rapidly froze and thawed the samples. The testing was done in accordance with ASTM standard C 666 – 97, procedure A. The procedure called for the samples to be fully saturated while frozen and thawing.

The strength of the samples was found in terms of the dynamic Young's modulus of elasticity. The dynamic Young's modulus was calculated using the longitudinal resonant frequency, which was found in accordance with ASTM standard C 215 – 02. The equation given for the dynamic Young's modulus, in Pascals, is (ASTM, 2003):

$$\text{Dynamic } E = DM(n')^2$$

Where:

$D = 4\,(L/bt)$

L = length of specimen in meters

t, b = prism cross section dimensions, in meters with t being in direction of driver

M = mass of specimen in kilograms

n' = fundamental longitudinal frequency in Hertz

The void ratio of each sample was also found. It has been found that as the void ratio of a pervious concrete specimen increases, the permeability increases and the strength decreases (Schaefer et al, 2006). The equation used to determine the void ratio as a percentage is (Park and Tia, 2004):

$$\text{Void Ratio} = [1 - (W_2 - W_1) / (\rho_w * \text{Vol})] * 100$$

Where:

W_1 = weight under water force
W_2 = dry weight
ρ_w = density of water
Vol = volume of sample

The nondestructive testing methods used to determine the resonant frequency were ultrasonic-pulse velocity (UPV), impact echo (IE), and sonometer. The UPV and IE equipment used were an Acoustic Concrete Tester and a Pile Integrity Tester, respectively. Both pieces of equipment were products of Pile Dynamics, Incorporated. The sonometer used was a Geotest sonometer.

Results Found

At the time of reporting the samples had undergone thirty-one freeze-thaw cycles. The samples had sustained some minimal visual damage and loss of mass, but were still intact. As the number of cycles increased, the dynamic Young's modulus was found to decrease, and the void ratio was found to increase. The three nondestructive testing methods used yielded approximately the same resonant frequency at zero cycles, but began to vary as the cycles increased.

Significance and Interpretation of Results

The three nondestructive testing techniques yielded different resonant frequencies at the time of reporting, which was translated into the dynamic Young's modulus of each sample. Further testing such as cylinder compression testing is required to determine which method yielded the most accurate dynamic Young's modulus. More freeze-thaw cycles will also be performed in the future to determine the maximum number of cycles each sample can undergo while remaining intact.

Figures

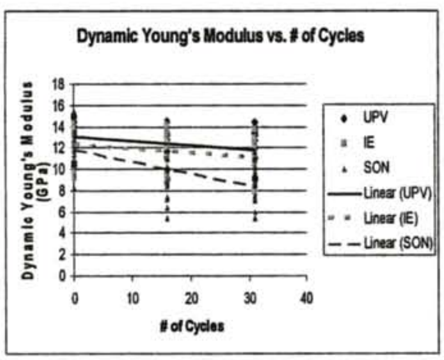

Figure 1

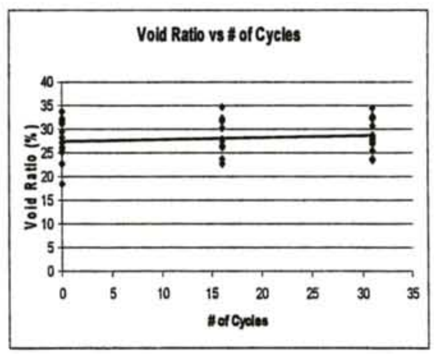

Figure 2

References

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