DEVELOPMENT OF PERVIOUS CONCRETE

by

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CERTIFICATE OF AUTHORSHIP

I certify that the work in this thesis has not previously been submitted for any degree nor has it been submitted as part of requirements for a degree except as fully acknowledge within the text.

I also certify that the thesis has been written by me. And help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Candidature

(Yukari Aoki)

June 2009

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ABSTRACT

In many developed countries, the use of pervious concrete for the construction of pavements, car parks and driveways is becoming popular. In order to develop material specification for pervious concrete, it is necessary to conduct testing to evaluate the performance of this new type of high-performance concrete. In addition, carbon dioxide emission from Portland cement production is significant and contributes to global warming which leads to undesirable climate change. Therefore, it is necessary minimise the use of Portland cement in pervious concrete mixes by partially replacing the cement with industrial by-product, such as fly ash and slag which have been used successfully as supplementary cementitious materials in structural concrete mixes.

The pervious concrete is produced by using conventional cementitious materials, aggregates, and water. This concrete is tested for its properties, such as density, porosity, compressive strength, water permeability and drying shrinkage. The most important property of pervious concrete is its water permeability. Currently, there is no standard experimental procedure to determine to this property. A method was therefore developed to determine the water permeability. Fly ash is used as a supplementary cementitious material to partially replace Portland cement in pervious concrete mixes up to 50% by weight.

To improve the acceptance of pervious concrete, it is necessary to improve the surface texture. Due to the rough surface texture and bigger void content, it may be difficult for pervious concrete for wide acceptance by the construction industry. Therefore, fine textured pervious mortar is produced using cementitious materials, aggregate and water, and its properties are investigated. New type of pervious pavement, a combination of pervious concrete and pervious mortar, is developed and its properties are studied.

Pervious concrete having density around 1800 kg/m^3 shows the following properties, porosity 0.32 to 0.36, 28-day compressive strength between 5.7 MPa and 10.1 MPa, water permeability between 9.2 mm/s and 17.3 mm/s, and 56-day drying shrinkage between 470 and 600 microstrain.

The properties of pervious mortar having 0.35 water/cement ratio with hand compaction are as follows; density of 1690 kg/m^3, porosity of 0.34, 28-day compressive strength of 5.8 MPa, water permeability 2.6 mm/s, and 56-day drying shrinkage of 490 microstrain.

Combination of pervious concrete and pervious mortar is tested in density and water permeability. The density is around 1750 kg/m^3, while the water permeability between 2.3 mm/s and 3.0 mm/s. Further investigation on the development of this system to have adequate water permeability, strength and durability is recommended.

LIST OF PUBLISHED PAPERS

Y. Aoki and R. Sri Ravindrarajah (2008) *Shrinkage of Environmentally friendly sustainable pervious concr*ete, Proceeding of International Conference on Sustainable Concrete Construction, February, 2008, Ratnagiri, India

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Y. Aoki, R. Sri Ravindrarajah and H. Khabbaz (2009) *Effect of fly ash performance of pervious concrete,* Proceeding of Tenth CANMET/ACI International Conference on Recent Advances in Concrete Technology and Sustainability Issue, 15-17 October, 2009, Seville, Spain.

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A	cross-sectional area of cylinder
A_1	cross-sectional area of the specimen
A_2	cross-sectional areas of the tube
A_B	total surface area of the pervious concrete block
A_c	continuous air void content
A_P	surface area of the pervious concrete block occupied by pores
A_s	specific surface area of materials
A_t	total air void content of porous concrete
C_0	empirical constant
C_c	percent volumetric compaction of the column
F_s	generalized factor to account for different pore shapes
G	gravimetric air void ratio
g	gravitational acceleration
h	total height
h	water head (head difference)
h_1	initial water head
h_2	final water head
k	water permeability (water permeability coefficient)
k_{eff}	theoretical effective permeability of sand-clogged or covered pervious concrete block system
k_s	hydraulic conductivity
k_{sand}	permeability of sand (cm/s)
$\mathrm{k_T}$	water permeability at Tc$^\circ$
l	length of the specimen
M_1	buoyant mass of the saturated specimens in water
M_2	dry mass in the air for 24 hours
M_3	buoyant mass of the saturated specimens in water after 24 hours drying in the air
M_b	buoyant mass of the saturated specimens in water
M_d	oven-dry mass of the specimens

M_s mass of saturated surface-dry specimens

P, p average porosity

P_y theoretical porosity at the hight ‘y’

Q quantity of water

ρ_w density of water

S_0 specific surface area of pores

T mass of unit volume in the assumption of no air

t time

v kinematic viscosity of water

V_1 total volume of specimens

V_2 sum of absolute volume of all materials on the concrete of $1m^3$

Vol volume

V_r porosity (void ratio)

W mass of unit volume in the container

W_1 weight under water

W_2 oven dry weight

W_3 mass in the air after 24 hours

W_4 total mass of all materials on the concrete of $1m^3$

y height

β_H hydraulic connectivity factor

τ tortuosity

φ_P porosity