University of Southern Queensland

AN INVESTIGATION INTO THE EFFECT OF MATERIAL COMPOSITION ON THE FUNDAMENTAL PROPERTIES OF PERMEABLE CONCRETE

A Dissertation submitted by

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CERTIFICATION OF DISSERTATION

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

I also certify that I have written this thesis and that any help that I have received in my research work and in the preparation of this thesis has been acknowledged. I also certify that I have fully referenced all sources of information and literature that I have used in this thesis.

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ABSTRACT

The use of permeable concrete in the construction industry has been increasing around the world during the last few years. The fundamental properties of permeable concrete must thus be comprehensively evaluated and elucidated in order to obtain the full benefits of this material. This research investigated the effects of material composition on the mechanical properties (compressive strength, stress-strain behaviour and the modulus of elasticity) and on the hydraulic properties (porosity ratio and permeability) of the permeable concrete.

Eight different permeable concrete mix designs were prepared with two aggregate sizes in two different proportions, different sand ratios, two aggregate to cement ratios and a constant water to cement ratio. The target 28-day compressive strength was designed to be between 15MPa and 35MPa. The porosity ratio was designed to be between 25% and 15%, whilst the permeability was designed to be between 12mm/sec to 2mm/sec.

A review of the published literature revealed no standard experimental procedure for determining the stress-strain behaviour and the modulus of elasticity of permeable concrete using the strain gauge method. The only method in use was the platen-to-platen method. This research involved the development of a testing method for determining these properties using the strain gauge method. The results are compared with those that were obtained using the platen-to-platen method. A significant difference was found between the properties that were measured by these two methods.

A semi-empirical equation to represent the complete stress-strain behaviour for unconfined permeable concrete is proposed as part of this research. Various existing models for low-strength concrete and normal-strength concrete were used and

compared with the experimental data. Various parameters were studied and their relationships were experimentally determined. The only parameters needed to run the new model is the ultimate compressive strength and the density. The proposed semi-empirical stress-strain equations were compared with actual cylinder tests results under axial compression; the new model gives a good representation of the mean behaviour of the actual stress-strain response of the permeable concrete.

LIST OF PUBLISHED PAPERS

Hussin, M, Zhuge,Y, Bullen ,F & lokuge, W 2011, 'Laboratory Evaluation of the Stress-Strain relationship of Permeable Concrete', *Advanced Materials Research*, vols. 243-249, pp. 3259-3262, viewed item: DOI: 10.4028/www.scientific.net/AMR.243-249.3259.

Hussin, M, Zhuge,Y, Bullen ,F & lokuge, W 2012, 'Investigation of Some Fundamental Properties of Permeable Concrete', *Advanced Materials Research*, vol. 487, pp. 869-73, viewed item: DOI: 10.4028/www.scientific.net/AMR.487.869.

Hussin, M, Zhuge,Y, Bullen ,F & lokuge, W 2012, 'A mathematical model for complete stress-strain curve prediction of permeable concrete'. Submitted to 22nd AUSTRALASIAN CONFERENCE ON THE MECHANICS OF STRUCTURES AND MATERIALS (ACMSM). ACMSM will be held at the University of Technology Sydney, Australia on 11-14 December, 2012.

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LIST OF SYMBOLS

P	*Porosity ratio*
M_{dry}	*Oven dry weigh*
M_{sub}	*Submerged weigh*
V_T	*Total volume*
ρ_w	*Density of water*
P_c	*Correct porosity in the site*
P_i	*Porosity in the site*
D_a	*Maximum aggregate size*
D_c	*Core diameter*
P_{min}	*Minimum porosity*
P_{max}	*Maximum porosity*
K	*Permeability coefficient*
a	*Cross-section area of the cylinder pipe*
A	*Cross-section area of the specimen*
L	*Length of the specimens*
t	*Time for water to pass from level* h_1 *to* h_2
h_1	*Initial water level (290mm)*
h_2	*Final water level (70mm)*
E_{itsg}	*MOE for the strain gauge*
E_{itp}	*MOE for the platen-to-platen*
E_{it}	*Initial tangent modulus of elasticity*
E_o	*Secant modulus of elasticity at peak stress*
β	*Material parameter*
f_c	*Concrete stress*
f'_c	*Maximum stress*
ε_{max}	*Concrete strain when concrete stress is equal to 0.5* f'_c *on the descending part of the stress-strain curve*
ε	*Concrete strain*
ε_d	*Strain corresponds to a stress value of 0.3* f'_c *in the descending part of the stress-strain curve*
ε_o	*Corresponding strain at maximum stress*
λ	*Power transformation*
d_n	*Number averaged pore size*
$\emptyset_A$	*Area fraction of pores*
d_{MFS}	*Mean free spacing of pores*
S_p	*Specific surface area of pores*

Γ_{3D}	*Three-dimensional of pore distribution density*
$\alpha_0, \alpha_1, \alpha_2$	*Parameters*
ρ	*Dry unit weight*
n	*Parameters*
$P_{area}\%$	*Percentage of the pore area*
A_p	*Total cross-section pores in the specific part of the specimen*
A_t	*Total cross-sectional area of the specific part of the specimen*