ENGINEERING PROPERTIES OF POLYSTYRENE AGGREGATE CONCRETE

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CERTIFICATE

I certify that this thesis has not already been submitted for any degree and is not being submitted as part of candidature for any other degree.

I also certify that the thesis has been written by me and that any help that I have received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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ABSTRACT

The project reported in this thesis was concerned with the ultilization of re-cycled polystyrene granulates as lightweight aggregate for use in concrete. A manufacturing process for the conversion of polystyrene waste from the packaging industry into chemically coated expanded polystyrene aggregate was developed by Building Systems Technology (BST) Pty. Ltd. When the treated polystyrene aggregates are incorporated into fresh mortar or concrete they are uniformly and evenly distributed in the cement paste or the mortar matrix.

The polystyrene aggregate produced by BST was used to establish the workability, strength, deformation, bond strength, and the functional properties of the concrete. The properties of the concretes made with the polystyrene aggregate were compared with concretes made with normal weight aggregates of equivalent mix proportions using General Purpose Portland (Type GP) cement.

It was found that it is generally feasible to manufacture structural grade lightweight concrete from treated re-cycled polystyrene aggregate. No reduction was observed in the compressive and tensile strengths, and the modulus of elasticity of concretes made with the polystyrene aggregate, and cured in water over a period of about one year. The maximum cylinder compressive strength of concrete made with the treated polystyrene aggregate satisfied the strength requirement of medium strength structural reinforced concrete.

This investigation has shown that structural grade polystyrene aggregate concrete having saturated surface-dry density of 1800 kg/m^3 to 2400 kg/m^3 can be produced with cylinder compressive strength up to 32 MPa. The test results have shown that, for a stress/strength ratio of 30% of the 28-day cylinder compressive strength, the creep strain of polystyrene aggregate concrete compares well with concrete made with normal weight aggregates. The functional properties such as impact resistance and freezing and thawing durability of concrete is improved when polystyrene aggregate is incorporated.

From the conclusions derived, design recommendations are suggested. Limitations of the investigation and suggestions for future work are presented.

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DEDICATION

This work is dedicated to the memory of my father SAMUEL DOKU SABAA.

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9.1 Properties of materials 430

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NOTATION

c = Creep of concrete
c_p = Creep of paste
E_a = Modulus of elasticity of aggregate
E_c = Static modulus of elasticity
E_d= = Dynamic modulus of elasticity
E_m = Modulus of elasticity of matrix (or mortar)
$f_{c.28}$ = Compressive strength of concrete at 28 days
f_{cyl} = Cylinder compressive strength
f_{cf} = Flexural tensile strength of concrete
f_{ct} = Indirect tensile strength
f_{cu} = Cube compressive strength
f_o = Compressive strength of reference concrete
G_d = Dynamic modulus of rigidity
g = Volumetric content of aggregate
K = Bulk modulus of elasticity
k = A coefficient, ratio or factor used with and without numerical subscripts
p = Porosity
t = Time
α = A coefficient
β = A coefficient with or without numerical subscripts
Δ = Positive or negative increment
ε = Strain
ε_i = Instantaneous strain
ε_c = Strain due to concrete creep
ε_{sh} = Strain due to shrinkage
$\varepsilon_{sh.o}$ = Shrinkage strain of reference concrete
ε_{sp} = Total load induced strain per MPa
$\phi(t)$ = Creep coefficient
μ = Poisson's ratio
λ = Wavelength of vibration
ρ = Density of concrete
ρ_o = Density of reference concrete

ABBREVIATIONS

ACI = American Concrete Institute
ASTM = American Society for Testing and Materials
CEB = Euro-International Committee for Concrete
CUR = Commissie voor Uitvoering van Research
CUW = Calculated unit weight
DOE = Department of the Environment (Building Research Establishment, Watford, UK)
FIP = International Federation for Prestressing
LWC = Lightweight concrete
LWAC = Lightweight aggregate concrete
MUW = Measured unit weight
NWC = Normal weight concrete
PA = Polystyrene aggregate
PAC = Polystyrene aggregate concrete
RILEM = International Union of Testing and research laboratories for Materials and Construction