THE EFFECT OF FIRING TEMPERATURE ON MICRO-STRUCTURAL PROPERTIES OF NON-EXPANSIVE CLAYS IN DEVELOPMENT OF EFFECTIVE INTERNAL CURING CONCRETE AGGREGATE

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ABSTRACT

Internal curing concrete provides number of advantages in the concrete construction industry. It provides adequate water to hydrate all the cement. Moreover, internal curing increases the durability, compressive strength and eliminates the formation of shrinkage cracks. The most popular internal curing materials are the manufactured and natural lightweight aggregates. Those aggregates generally produce using expansive clays. Natural lightweight aggregates and expansive clay mines are not available in most countries limiting the production of internal curing concrete to a few countries. Moreover, those aggregates have various disadvantages in use of internal curing concrete production. Mainly, it reduces the compressive strength of concrete. Furthermore, some aggregates have lower water absorption capacity, and some have lower water desorption capacity. Thus, the main focus of this research is to develop an effective pore structure for internal curing aggregate using non-expansive clays.

Different clay samples were obtained from local mine in Nachchaduwa, Dankotuwa, Metiagoda, and another clay sample was imported from China. Subsequently, those were chemically analyzed, and the percentage of each chemical composition was obtained. Afterwards, selected clay types were identified as bloating and unbolting clays according to the method that was suggested by Charles M. Riley. Nachchaduwa and dankotuwa; Metiagoda and China clay samples were identified as bloating and unbolting clays respectively. After that, the level of expansion was identified based on the bloating coefficient. All the clay samples showed lower bloating coefficient than 2.5. Thus, they were categorized as non expansive clays.

The requirements for effective internal curing aggregates were identified through an extensive literature review and limits of those parameters were defined based on the literature review. Moreover, a aggregate production process was established by considering various effect of clay heating on development of pore structure. The effective range of heating temperature of each clay type was identified according to a simultaneous thermal analysis. Subsequently, clay specimens of equal sizes were prepared using each clay samples and heated at selected range of temperature to produce various pore structures within the clay specimens. Afterwards, heated samples were cooled, crushed, and fine aggregates were produced. Pore size, pore connectivity, pore strength and the pore expansion of each aggregate were identified through an extensive analysis of the pore structure. Afterwards, the aggregates were categorized based on the properties of the pore structure of each aggregate.

The internal curing properties of those pore structures were measured based on water absorption, water desorption and density of the aggregates. Afterwards, performance of those pore structures was identified, and limits of the effective pore structures were defined. Bloted non-expansive clay materials were identified as the most suitable materials to produce effective pore structure within heated clay mass. Conversely, unbloted non-expansive materials were not suitable to produce internal curing aggregate. According to the research findings, the effective pore structure should contain at least 27% of open porosity. The mean pore radius and the pore expansion should range from 0.3 to 0.5μm and from 1.1 to 1.5 mean bloating coefficient respectively. Furthermore, the compressive strength of pore structure should be greater than 10N/mm^2.

Finally, two different aggregates which have the effective pore structure and less effective pore structure were selected for verification process. The selected aggregates were produced in larger scale using industrial facilities of Rajarata and Midaya factories. Subsequently, three different types of grade 30 concrete were prepared from each aggregate type to validate the effectiveness of pore structure. Those concrete types were external curing concrete (ECC), non-curing concrete (NCC) and internal curing concrete (ICC). Moreover, internal curing concrete with 3 days external curing (ICC/3EC) was prepared to study the combined effect of external and internal curing. ECC specimens were kept under submerged for curing, ECC/3EC samples were kept in submerged only for 3 days. NCC and ICC specimens were kept in open space. During the preparation of concrete specimens, workability of the samples was measured. Afterwards, concrete specimens were tested to obtain the compressive strength values at 7, 14 and 28 days. Subsequently, the drying shrinkage of the internal curing concretes which contain the selected aggregates was measured. According to those results, the aggregates which contain the effective pore structure exhibit effective internal curing properties while other aggregate failed to act as an effective internal curing aggregate.

Keywords: Self-expansion; Poorly expansive clay; Black coring; Porous structure; Water absorption; Sand replacement; Strength

DEDICATION

- To my mother who could not get a better sleep for the last 28 years.
- To my father who went through all the troubles to make me who I am today.
- To my supervisor who believed in me and empowered me to achieve this dream.
- To the people of Sri Lanka whom I owe a debt of gratitude for paying for my education

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LIST OF ABBREVIATIONS

Abbreviation	Description
ICC	Internal Curing Concrete
LWA	Lightweight Aggregate
ICA	Internal Curing Aggregate
K_P	Bloating coefficient
W/C	Water to cement ratio
FM	Fineness Modulus
EICA	Effective Internal Curing Aggregate
SAP	Superabsorbent Polymers
EPS	Effective Pore Structure
BNEC	Bloated-non Expansive Clays
UNEC	Unbloated-non Expansive Clays
SSD	Surface Saturated Dry
STA	Simultaneous Thermal Analysis
DSC	Differential Scanning Calorimetry
TGA	Thermogravimetry Analysis