STRUCTURAL CHARACTERISATION AND QUALITY ASSESSMENT OF PRIMARY REINFORCED CONCRETE BUILDING MATERIALS

By

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CERTIFICATION

This is to certify that this thesis was undertaken by OPEYEMI JOSHUA, it has not been published anywhere else and should not be replicated or produced in any form but could be used for literary purpose only. It meets the requirement for the award of Doctor of Philosophy (Ph.D) in Building Structures in the Department of Building Technology, Covenant University, Ota. Nigeria.

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DEDICATION

This work is dedicated to the almighty God to whom all the glory associated to this study belongs, the gift of life and all the directions necessary for the completion of this study and to my parents, Late Mr. T. E. Joshua, and mummy, Mrs. E. O. Joshua, whom God have used tremendously to impact discipline and build the fear of God in me.

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Abstract

This research assessed the structural characteristics and quality of reinforced concrete primary materials which are cements, aggregates (fine and coarse) and reinforcing steel used in concrete works in Lagos State with a view to determining the extent to which they conform with the requirements of relevant standards. This is achieved by using relevant laboratory procedures to determine their physical, mechanical, chemical and microstructural properties and compare them with the relevant standards. Concrete cube crushing and pullout bond strength tests were performed in standard manner to measure the performance of the studied materials in reinforced concrete. The results of the various tests were analysed using relevant statistical tools such as Analysis of variance, mean standard deviation and relevant characteristic formulae as recommended in the appropriate standards. The highest 28-day cement mortar strength developed by the tested cement brands was 45.06 MPa (Brand C3). Two of the tested cement brands had 28-day compressive strengths below 28 MPa and hence did not meet the strength requirements, 32.5 MPa or 42.5 MPa, as specified in standards and they were the brands whose strength details (strength class and type) were not displayed on the bags unlike the other brands that complied. The cement microstructures complements the findings in the chemical and mechanical analyses. The fine aggregates met most of the standard requirements but the river-dredged fine aggregates performed better than its burrow-pit counterparts with both containing higher chloride content of about 0.3% as against the specified maximum of 0.2% with the river-dredged sand recording higher values (0.304% average) than the burrow-pit sand (0.152% average). All the coarse aggregates possesses satisfactory mechanical properties with samples G3 and G4 slightly more satisfactory. The physical and chemical properties of the steel brands were marginally satisfactory though None of the tested steel samples measured up to the actual diameter. The reduced bar diameter reduced the strength further by as high as 23%. The performance of these primary materials in normal strength concrete was marginally satisfactory as they produced concrete of around 20 MPa but concretes made with cements brands with unbranded strength properties performed a little below standard (0.205 MPa mean deviation lower from the standard value) and others produced 2.893 MPa, mean deviation higher from the standard value; higher 28-day concrete compressive strengths were obtained with the river-dredged fine aggregate when compared with values recorded using the burrow-pit sand as fine aggregates in the tested concrete samples. The difference in the coarse aggregate performance was also marginal with the coarsest performing least in normal concrete. It was observed that interaction of fine aggregates and coarse aggregates had significant effects ($\alpha < 0.05$) on the compressive strengths of the resulting concrete. The 12mm diameter steel rebars possess better bonding properties than its 16mm counterpart and steels with higher relative rib area possess better bond strength with concrete. The best concrete performance was obtained with a combination of tested cement brand C3, fine aggregate sample S3 and coarse aggregate sample G3, with the recorded mean strength of 26.51 MPa, 32.5% above targeted mean value of 20 MPa. The study further revealed that the concrete's primary materials available in Lagos State are adequate to produce a good normal concrete but the steel reinforcements possess deficient mechanical properties that could compromise its role in reinforced concrete structures. It is recommended that only branded cements with defined type and strength label be utilized in concrete production, fine aggregates be sieved and washed before application in concrete for optimum performance and Nigerian Standard Organizations should further monitor the steel industry for greater compliance with standards.