CORRELATION OF DYNAMIC AND STATIC MODULUS OF ELASTICITY OF UHPC

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Abstract

Modulus of Elasticity of concrete is an important parameter which shows the ability of concrete to deform elastically. Ultra-High Performance Concrete (UHPC), also being of ultra-high strength, requires higher Modulus of Elasticity to maintain its stiffness, to prevent excessive deformation, leading to cost effective design and longer durability. The present experimental study correlates the Static and Dynamic Modulus of Elasticity of UHPC with and without coarse aggregates. The mix design of UHPC is validated and modified, optimising the density using Particle Packing approach for arriving at design mix proportions. Binders and fillers are replaced with 5% metakaolin, 10% micro silica and 20% quartz powder along with well graded aggregates (up to Nano level). The 28day compressive strength was assessed as per IS 516-1959 procedures and an average strength of 75 to 80MPa could be achieved for the mixes at W/B ratio of 0.3 and 90-100MPa at a W/B ratio of 0.22. Dynamic Modulus of Elasticity (E_d) computed using UPV test (E_d=53.2GPa to 60.1GPa) and Static Modulus Elasticity (E_s) of cylindrical specimens determined experimentally as per the standard procedure mentioned in IS 516:1959 (range of E_s=59 to 62.2GPa) are correlated graphically. The correlation between (E_d) and (E_s) obtained for the mix with coarse aggregates and without coarse aggregates is negligible.

Keywords: Packing Density, Elasticity, Static, Dynamic, Modulus, Elasticity, Alternative Materials, UHPC.

1. INTRODUCTION

The vast demand of infrastructural requirement of urban cities due to fast growing economy has led to the scarcity of urban land, necessitating vertical growth. During the past three decades, concrete technology is evolving at a greater pace than ever before with drastic improvement in its strength, durability and other structural properties, resulting in the development of materials like Ultra High Performance Concrete (UHPC), to cater to the constructional need of slender members of Tall Structures and long span bridges. With the use of most appropriate combinations of industrial by-products namely Silica Fumes, GGBS and Metakaolin and use of Quartz as a portion of Fine Aggregates (FA), a sustainable UHPC with improved mechanical properties can be produced with varied dosage of super/hyper plasticizer as concrete admixture to reduce the water binder (W/B) ratio and improved rheology. The increased flexural resistance, shear strength and durability of concrete structures is attributed to enhanced mechanical properties of UHPC. The current applications of UHPC is extended to the construction of precast waffle panels for bridge decks, precast/pre-stressed bridge girders and as a jointing material between pre- cast concrete deck panels and girders. Ductal UHPC is one such product, a premix of UHPC available in the United States. The mix of Ductal consists of Quartz powder of size 10μm dia., steel fibers with 2600MPa as tensile strength and Fine aggregates of 150-600μm dia., as a macro-filler component.

Around the world research is carried out to define suitable materials for UHPC, to establish a standard mix design procedure to correlate different properties of hardened UHPC. Knowledge of the Modulus of Elasticity is an essential property for the designer to estimate the deformation of structural elements under service conditions of reinforced and prestressed concrete.

Modulus of Elasticity is one of the important properties affected when the fine sand is replaced with the natural gradation sand or fly ash which can reduce the cost of production of UHPC and widen its applications to buildings and underground or mass concrete structures. The microstructure of concrete is improved with the use of natural-gradation sand or fly ash which possibly affects the concrete stiffness, particularly Modulus of Elasticity (MOE). An addition of 2.0% of steel fibers by fraction volume increased the MOE by 6%. The MOE is anticipated to decrease when the fine sand is replaced by natural-gradation sand or fly ash in UHPC. Therefore, the existing equations or reported MOE values may not accurately represent UHPC mixtures containing natural sand or fly ash as fine materials. The equation proposed by ACI Committee 318-14 is widely used to estimate the MOE of concrete. However, test data indicates that the equation

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proposed overestimates the MOE of high-strength concrete. When the compressive strength increases, the MOE also increases, but not at the same rate as normal-strength concrete. Therefore, the ACI Committee 363 proposed a new equation to predict the MOE of high-strength concrete. It is anticipated that an appropriate equation taking into consideration of important variables of concrete is necessary for UHPC since the compressive strength of UHPC is higher and the concrete

2. LITERATURE REVIEW

2.1 Summary of Past Work

After studying the published literatures on UHPC, it is clear that the mineral admixtures namely GGBS, Micro Silica, Metakaolin, Fly Ash etc. being extensively used as Supplementary Cementitious Materials (SCM). The mineral admixtures used are finer than the Cement, expected to fill the voids between

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