Recent developments in Modelling Self-Compacting Concrete Flow using Smooth Particle Hydrodynamics Method

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ABSTRACT

Due to the demand for highly durable concrete structures, self-compacting concrete (SCC) with its unique characteristics (flow-ability, passing ability and stability) has been developed, and is increasingly replacing vibrated concrete (VC) in various structural applications. SCC, which is characterised in its fresh state by high flow-ability and rheological stability, has excellent applicability for structural elements with complicated shapes and congested reinforcement. It has rationalised the construction process by offering several economic and technical advantages over VC.

Since the main characteristic of SCC is its flow-ability, its fresh property cannot be thoroughly comprehended without understanding its rheology. The quality control and accurate prediction of the SCC rheology are crucial for the success of its production. The accurate prediction of the SCC flowing behaviour is not a simple task, particularly in the presence of heavy reinforcement, complex formwork shapes and large size of aggregate. In this regard, the indispensable and inexpensive approach offering considerable potential is the numerical simulation of SCC flow. This approach will deepen the understanding of the SCC mix flow behaviour and evaluate its ability to meet the necessary self-compacting criteria of passing ability and segregation resistance (i.e. homogeneous distribution of coarse particles in the matrix).

From a computational point of view, the Smooth Particle Hydrodynamics (SPH), being a mesh-free particle method, offers considerable potential in modelling SCC flow. Identifying SCC as a homogeneous fluid that consists of particles of different sizes and shapes, SPH is an ideal computational method to represent its rheological behaviour with an acceptable level of accuracy. This methodology has been used and proved to be efficient and accurate in modelling the flow and monitoring the movement of large aggregates and/or short steel fibres of SCC in the cone slump flow, L-box and J-ring tests [1– 3]. The SPH simulation methodology also provides a useful tool for predicting the yield stress (τ_y) of SCC mixes accurately in an inverse manner from the flow spread [4]. This is particularly relevant to the characterisation of an SCC mix because the measurement of τ_y by rheometers is inconsistent and fraught with inaccuracies. In addition, computational simulations can also assist in proportioning SCC mixes, thus improving on the traditional trial and error SCC mix design.

This paper will present the state of the art modelling of SCC mix flow using SPH approach. This methodology will provide a thorough understanding of whether or not an SCC mix can satisfy self-compatibility criteria during slump flow, L-box, J-ring and V-funnel tests. The accuracy of the SPH predictions will be benchmarked against the observations made in the laboratory tests.

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