An efficient computational procedure for modelling the flow of fibre suspended self-compacting concrete

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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 and fibres in the matrix).

From a computational point of view, being a mesh-free particle method, the Smooth Particle Hydrodynamics (SPH) offer 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 an 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 and L-box tests [1– 2]. 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 a novel computational method to assess the orientation and distribution of short steel fibres in self-compacting concrete mixes during flow. The flow of self-compacting fibre reinforced concrete (SCFRC) is simulated using three-dimensional Lagrangian SPH, which is simpler and more efficient to simulate the flow and to monitor the distribution of fibres and their orientation during the flow. Further, mix proportions of SCFRC will be investigated to predict effective compressive strength and yielding parameters will be computationally verified. The numerical simulations will be conducted to recreate laboratory flow tests to confirm the consistency of the produced SCFRC mixes. The effectiveness and accuracy of the proposed computational technique will be demonstrated via a number of numerical simulations.

REFERENCES

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