# Simulating mixing processes with water addition using DEM – From bulk material to suspension

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## ABSTRACT

Simulation is a tool that can be successfully applied to optimise mixing processes. Both fluids and bulk materials can be modelled using Computational Fluid Dynamics (CFD) or the Discrete Element Method (DEM). Currently, however, dry and fluid phases combined in a mixing process can be replicated only to a limited extent, particularly if both phases represent a high volume fraction. The approach outlined in this paper aims to simulate exactly this type of mixing process, reflecting the entire transfer from dry to moist bulk material and eventually to a suspension whilst considering changes in material behaviour at each of the intermediate stages. A parameterisable simulation model is necessary for each of the material states and the related transfers to represent the specific states in a process-oriented manner. Such a model was developed with a focus on fresh concrete using the DEM approach. One of the key steps of this model is to replicate how moisture is transferred to, and absorbed by, the individual particles. For this purpose, an additional moisture variable is allocated to each particle to simulate the moisture content and type of liquid, such as water, cement paste or mortar. The transfer speed is based on the models by Darcy and Washburn. Initially, water is added in particulate form. A time- and state-dependent transfer of moisture occurs upon contact between water and dry particles. The volume and moisture content of the initially dry particles increase over time, whereas the volume of the water particles is reduced. In the first step, the dry particles become wet. When a sufficient amount of liquid has been transferred, these particles can also be represented as a liquid (suspension particles that simulate mortar or cement paste), or a two-layer particle with a solid core and outer liquid film is formed. At the time of inter-particle contact, the contact model is selected depending on the moisture variables of the particles and the overlap. A friction model is used for dry particles, whereas additional liquid bridging forces based on [1] are considered for moist particles. These cohesive forces are calculated depending on the particle size, liquid volume, surface tension of the liquid and inter-particle distance. In the case of a high liquid volume, a specific model is needed to adequately simulate the suspension behaviour. For this purpose, particles are represented by the two-layer model referred to above, and interact according to a Bingham model described in [2]. Moisture distribution can be directly monitored by including the moisture variables at various stages and implementing the associated contact characteristics. Thus, this simulation model is a powerful tool to analyse the mixing state and quality for complex wet-mixing processes and a wide range of consistencies.

## REFERENCES

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