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Early Age Behavior of Wind Turbine Gravity Foundations

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Abstract : The current practice during the repowering phase of wind turbines is deconstruction of existing foundations and construction of new foundations to accept larger wind loads or once the foundations have reached the end of their service lives. The ongoing research project FUI25 FEDRE (Fondations d'Eoliennes Durables et REpowering) therefore serves to propose scalable wind turbine foundation designs to allow reuse of the existing foundations. To undertake this research, numerical models and laboratory-scale models are currently being utilized and implemented in the GEOMAS laboratory at INSA Lyon following instrumentation of a reference wind turbine situated in the Northern part of France. Sensors placed within both the foundation and the underlying soil monitor the evolution of stresses from the foundation's early age to stresses during service. The results from the instrumentation form the basis of validation for both the laboratory and numerical works conducted throughout the project duration. The study currently focuses on the effect of coupled mechanisms (Thermal-Hydro-Mechanical-Chemical) that induce stress during the early age of the reinforced concrete foundation, and scale factor considerations in the replication of the reference wind turbine foundation at laboratory-scale. Using THMC 3D models on COMSOL Multi-physics software, the numerical analysis performed on both the laboratory-scale and the full-scale foundations simulate the thermal deformation, hydration, shrinkage (desiccation and autogenous) and creep so as to predict the initial damage caused by internal processes during concrete setting and hardening. Results show a prominent effect of early age properties on the damage potential in full-scale wind turbine foundations. However, a prediction of the damage potential at laboratory scale shows significant differences in early age stresses in comparison to the full-scale model depending on the spatial position in the foundation. In addition to the well-known size effect phenomenon, these differences may contribute to inaccuracies encountered when predicting ultimate deformations of the on-site foundation using laboratory scale models.

Keywords : cement hydration, early age behavior, reinforced concrete, shrinkage, THMC 3D models, wind turbines
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