Predictive Model Of Landfill Settlement With COMSOL Multiphysics® Employing (THMB) Coupled Processes

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Abstract

Municipal Solid Waste (MSW) landfills typically experience significant settlement associated with various multi-physical factors such as waste property, placement timing, total height, and environmental conditions such as temperature and saturation throughout the lifetime of the facility. Therefore, to accurately estimate the settlement of an MSW landfill, a multi-physical modeling framework employing Thermo-Hydraulic-Mechanical-Biochemical (THMC/B) processes in the landfill is needed. In this study, a predictive modeling framework employing THMC/B processes for MSW settlement is proposed and implemented in COMSOL Multiphysics® Geomechanics Module. Modified Cam-Clay (MCC) model within Elastoplastic soil material domain was chosen as the main physics module to estimate the short-term (time independent) stationary settlement of the landfill. Long-term settlement for considering mechanical and biodegradation creep settlement as a function of temperature and saturation were manually implemented into COMSOL Multiphysics®. Each long-term settlement expression reflecting mechanical and biodegradation creep was added to the total displacement equation in MCC's equation view section. Moreover, considering the evolving nature of MSW with time, a placement strategy plan for settlement prediction is required. Therefore, a placement strategy was defined to consider the change of input parameters such as total biodegradation strain, decay rate, creep and biodegradation coefficients with time. To validate the proposed modeling framework, actual settlement data of different layers measured at St. Sophie landfill in Quebec, Canada were compared with the simulation results. The initial waste properties were determined from field database at the landfill and in-house MSW laboratory measurements. The comparison results showed consistency of settlement prediction with measured landfill settlements both in short-term and long-term. The results show that the modification and custom options in COMSOL Multiphysics® allow a convenient implementation of coupled models into the program with reliable outcomes.