Analysis and design of a liquefied natural gas storage tank under spill and fire load conditions

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ABSTRACT

A study of the concrete outer structure of a full-containment liquefied natural gas (LNG) storage tank under spill and fire load conditions respectively is performed using a nonlinear finite element analysis technique. The study concentrates on the thermal aspects associated with the transient effects of the temperature changes and the coupling of thermal effects with the structural problem. The thermal stress is combined with the structural stress response given by the structural loads such as horizontal pre-stress and dead load to provide the final stress maps. The modeling of the different construction phases as well as the different loads valid in each phase is taken into consideration by implementing a complete phased analysis. The transient nature of the thermal analysis required that thermal conductivity, specific heat and density characteristics of the materials used were taken as temperature dependent in the range of -200^{o}C to 850^{o}C.
The design criteria include both serviceability limit state (SLS) and ultimate limit state (ULS) conditions: reinforcement stresses, crack width control, compression zone thickness and compression zone average stresses are analyzed thoroughly. The SLS analysis involves different liquid spill cases, the ULS analysis comprises fire load conditions; the results were checked for SLS and ULS requirements respectively. A parametric study was performed to highlight the influence on the nonlinear transient and steady-state temperature profiles using a phased staggered flow structural analysis. The study was carried out using realistic modeling of the various material properties in the wide range of temperatures considered above. Finally, the analysis results of a specific spill case and a fire load case are discussed.