

Prestressed concrete containment building: Creep, ageing and leakage. Application to VERCORS mockup

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Abstract:

The containment building (CB) is known as the third and last of the safety barriers. Its main function is to protect the environment from diffusion of radioactive products either in case of normal operating situation or in case of severe accident circumstance. Therefore, leak-tightness is an important factor to assess the serviceability life of the CB. In this context, Électricité de France (EDF) launched VERCORS project in 2014 [1] to improve the knowledge of leak-tightness in the CB under air pressure loading and ageing effects. It consists in a 1/3 scaled containment mock-up representing a 1300 MWe CB of a typical French PWR, and is designed in prestressed concrete. It is composed of a double wall structure with an active depressurization system in the inner wall space. Along with this project, international benchmarks have been proposed in order to compare different numerical simulations techniques, eventually to identify the best modeling practices related to the mechanical behavior of the containment. For the double wall system, the leak-tightness of the internal wall is directly related to cracks length and cracks opening, while the cracks are especially controlled by the prestress of the tendons. Thus, the estimation of prestress loss is a key step in the simulation. To this end, the computation of the delayed strains in concrete and the relaxation of tendons are necessary.

This paper presents the results of the simulation on VERCORS mockup in the prestress phases and pressurization phases, which is performed on a finite element code Cast3m [2]. Concrete is modeled through 3D elements while rebar and tendons are modeled by 1D elements. The delayed strains including creep and shrinkage are calculated through BPEL99 model [3]. The loss of prestress caused by friction and relaxation are taken into account. Besides that, pressure load and ageing scenario are included. To describe cracks in concrete, an elastic damage model [4] is used for the concrete elements, and the post processing of leak-tightness is based on the internal variable of the damage model and hydraulic analysis. The mechanical results give different damage zones on the CB, which are distributed at gusset, hatch and dome. During the high-pressure load (over the dimensioning pressure), the damage at the dome dominates. The issues of the impact of potential simplification in the mockup description and/or of modeling choices are finally discussed.

Reference:

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