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H. Kallel, H. Carré, C. La Borderie, B. Masson, N.C. Tran

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Effect of temperature and moisture on the instantaneous behavior of concrete

H. Kallel[a,b,*], H. Carré[a], C. La Borderie[a], B. Masson[b], N.C Tran[c]

[a] *SIAME EA-4581 University of Pau, France*
[b] *Electricité de France (EDF), SEPTEN, F-69628 Villeurbanne, France*
[c] *Electricité de France (EDF), R&D, F-77181 Moret sur Loing, France*

Abstract

In nuclear power plants, a severe accident in the containment building results in an increase in pressure, temperature and relative humidity that can reach respectively 5 bars, 140 °C and the saturation of water vapour. As well as the regulatory calculations, accurate knowledge of the thermal and mechanical behaviour of materials and more specifically of concrete is required to carry out more precise numerical simulations.

Our study aims to investigate the mechanical behaviour of concrete under homogeneous conditions of moisture and temperature. An experimental apparatus was designed in order to assess the evolutions of the fracture energy, modulus of elasticity and tensile strength of concrete. Different temperature levels up to a maximum of 90 °C and at different values of the controlled moisture content were investigated. The equipment was used to perform DCT (Disk-shape Compact Tension) tests at 30 °C and 90 °C. Five levels of degree of liquid water saturation (S_w) were investigated for each temperature level. Finite-element computations with the code Cast3m were carried out to determine the modulus of elasticity and the tensile strength from the results of DCT tests.

The fracture energy is the same at 30 and 90 °C and decreases with S_w between 36 and 100 %. The modulus of elasticity decreases with temperature between 30 and 90 °C, decreases with S_w between 36 and 55 % and increases between 72 and 100 %. The tensile strength decreases with temperature between 30 and 90 °C and increases with S_w between 36 and 100 %

Keywords: concrete, temperature, water content, fracture energy, tension strength, modulus of elasticity

1. Introduction

The confinement building of nuclear reactors must ensure the safety of the population and workers by their tightness in the event of a severe accident. When such accidents occur, temperature, pressure and relative humidity in the confinement building increase respectively up to extreme conditions: 140 °C, 5 bars and water vapour saturation [1]. In order to predict as precisely as possible the behaviour of concrete under these particular conditions, in-depth knowledge of the mechanical characteristics of concrete is required: modulus of elasticity (E), tensile strength (f_t) and fracture energy (G_f).

The influence of temperature on the elasticity and compression strength of concrete has been widely studied [2, 3, 4, 5, 6, 7, 8]. Some investigations have focused on the role of drying on

*Corresponding author