Materials Structure Changes Due to Irradiation: Comparison of Impact on Radionuclide Transport Performance of Selected Porous Materials

Václav Kočí[1, S, C], Jiří Maděra[1] and Igor Medveď[1]

[1]*Faculty of Civil Engineering, The Czech Technical University in Prague, Praha, Czechia*
vaclav.koci@fsv.cvut.cz

Representing one the clearest sources, nuclear energy deals with a radioactive waste treatment and storage which represent the weakest point of this reliable, sustainable and eco-friendly solution that is supposed to be the most promising candidate to replace fossil fuels in the nearest future. Its key parameters such as stable and sufficient power supplies cannot be offered by any of the know alternatives, solar or wind energy in particular. The solution seems to be represented by underground waste repositories designed in such a way to restrict or slow down radionuclides transport that represents nowadays the most topical solution proposed. The material selection process of suitable materials for particular barriers of the repository is the key factor deciding about the proper facility function. Among others, it must therefore involve changes in the materials structure that might be induced due to a long-term exposure to various kinds of radiations. This paper compares a long-term performance of cement- (UHPC) and non-cement (geopolymers) solutions while the time-irradiation-dependent structure changes are assumed. A hypothetical leakage scenario is then simulated using computational modelling to identify/predict radionuclide concentration fields in a long-term period and evaluate the materials solution appropriateness and efficiency. The preliminary results indicated, cement-based solution provides a better performance (hypothetical maximal concentration of the ^{90}Sr radionuclide was found to reach 1.02×10^{13} $Bq \cdot m^{-3}$ after 103 y, while 4.45×10^{13} $Bq \cdot m^{-3}$ after 274 y was identified in the case of geopolymer) but both proposals might be promising as the radionuclide concentration in the surrounding environment was found to be negligible, while the concentration values in the single barriers get back to normal after less than 2000 years. Aiming at the structure changes, the theoretical aspects of the material design and proposal are further discussed.