Contribution ID: **131** Type: **Oral**

Non-destructive testing of concrete using fast neutron transmission spectroscopy

Monday, 15 April 2024 14:55 (15 minutes)

The non-destructive testing of concrete used in nuclear facilities is critical as the concrete is exposed to various unfavourable conditions such as corrosion, radiation, extremely varying temperatures, and cyclic loadings over its lifetime. Such exposure can lead to concrete deterioration and moisture loss, thus compromising the shielding and structural integrity of the concrete [1, 2]. This concern is particularly relevant as the Koeberg nuclear power plant approaches the end of its planned operational lifespan, with Eskom seeking a 20-year extension overseen by the National Nuclear Regulator (NNR) [3].

Fast neutron transmission spectroscopy involves irradiating a sample with a well-characterized beam of neutrons and analysing the transmitted neutron spectrum to infer the elemental composition using a deconvolution technique [5]. In this study, we present an experimental and simulated validation of this technique using HDPE and graphite (C) to derive energy dependent removal cross sections for hydrogen. In parallel, Si, SiO2, and H2O were used to derive energy dependent removal cross sections for oxygen. Measurements were taken at the n-lab at UCT [6], using a collimated beam of neutrons produced by an americium-beryllium (AmBe) neutron source incident on samples of HDPE, C, Si, SiO2 and H2O. Neutron energy spectra transmitted through the samples were measured using an EJ-301 organic liquid scintillator coupled with spectrum unfolding methods, enabling determination of the energy-dependent effective removal cross section for each sample. To validate the use of simulated data where physical measurements may not be possible, these results were compared with removal cross sections obtained from simulations using FLUKA.

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Primary author: SEGALE, Nalesi (University of Cape Town)

Co-authors: HUTTON, Tanya (University of Cape Town); Mr MHLONGO, Sizwe (University of Cape Town); BUFFLER, Andy (UCT)

Presenter: SEGALE, Nalesi (University of Cape Town)

Session Classification: The MeASURe Experience - Part 1