Synthesis of RADCON Project results obtained at IPPT PAN

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Topics of investigation at IPPT PAN

1. Selection of concrete constituents for shielding and containment structures

- The relationship between the composition of mix constituents and the performance indicators for concrete in nuclear environment was studied.

2. Influence of short gamma irradiation on the setting and early hardening of cement and concrete

- Effects of composition of mix constituents (cement composition, mineral admixtures) on the gamma irradiation sensitivity of the material properties at setting and early hardening was studied.

Topics of investigation at IPPT PAN

3. Influence of prolonged gamma irradiation on the volume stability, porosity and initiation of steel corrosion in concrete

- Effects of composition of mix constituents (mineral composition of aggregates, chemical composition of blended cement) on the gamma irradiation sensitivity of the selected hardened material properties/steel protection indicators was studied.

4. Enhanced concrete microstructure evaluation by combined use of X-ray/neutron tomographic imaging and optical reflection imaging

- Studies of possible complementary use of three imaging techniques.

1. Selection of concrete constituents for shielding and containment structures

- This investigation included effects of both chemical, mineral and phase composition of constituents, like coarse mineral aggregates (normalweight, heavyweight, hydrogen-bearing), fine aggregates (mineral sands), mineral admixtures (boron bearing, rare earth), supplementary cementitious materials (blastfurnace slag, fly ash).
- The target concrete properties were: early age thermophysical properties, the strength and permeability of hardened concrete, the stability of microstructure, the susceptibility to harmful alkali-silica reactions, the content of long-lived radioisotopes (susceptibility to activation by neutron beam).

List of journal publications

Topic 1. Selection of concrete constituents

Cement hydration, early strength, neutron shielding:

- T.Piotrowski, J.Glinicka, M.A.Glinicki, P.Prochoń, The influence of gadolinium oxide and ulexite on cement hydration and technical properties of mortars for neutron radiation shielding purposes, **Construction and Building Materials**, 195, 2019, 583-589; https://doi.org/10.1016/j.conbuildmat.2018.11.076

Temperature control of massive concrete at early age:

- A.Długosz, I.Pokorska, R.Jaskulski, M.A. Glinicki, Evolutionary identification method for determining thermophysical parameters of hardening concrete, **Archives of Civil and Mechanical Engineering**, 21, 2021, 35-1-14; https://doi.org/10.1007/s43452-020-00154-7

Chloride ion permeability, carbonation and porosity:

- D. Jóźwiak-Niedźwiedzka, M. Dąbrowski, K. Bogusz, M.A. Glinicki, Influence of slag cement on the permeability of concrete for biological shielding structures, **Energies**, 2020, 13(17), 4582; doi:10.3390/en13174582

Phase composition and microstructure:

- M.A. Glinicki, D.Jóźwiak-Niedźwiedzka, M.Dąbrowski, The influence of fluidized bed combustion fly ash on the phase composition and microstructure of cement paste, **Materials**, 12, 2019, 2838; doi:10.3390/ma12172838

List of journal publications

Topic 1. Selection of concrete constituents - continued

Alkali-silica reaction:

- D.Jóźwiak-Niedźwiedzka, M.A.Glinicki, K.Gibas, T.Baran, Alkali-silica reactivity of high density aggregates for radiation shielding concrete, **Materials**, 11, 2018, 2284; doi:10.3390/ma11112284
- D. Jóźwiak-Niedźwiedzka, A. Antolik, K. Dziedzic, K. Gméling, K. Bogusz, Laboratory investigations on fine aggregates used for concrete pavements due to the risk of ASR, **Road Materials and Pavement Design**, 2020, doi:10.1080/14680629.2020.1796767

Content of long-lived radioisotopes:

- D.Jóźwiak-Niedźwiedzka, K.Gméling, A.Antolik, K.Dziedzic, M.A. Glinicki, Assessment of long-lived isotopes in alkali-silica resistant concrete designed for nuclear installations, **Materials**, 14, 2021, 4595; https://doi.org/10.3390/ma14164595
- D. Jóźwiak-Niedźwiedzka, K. Gméling, I. Harsányi, K. Dziedzic, M.A. Glinicki, Assessment of long-lived residual radioisotopes in cement induced by neutron radiation, MATBUD'2020 Scientific-Technical Conference: E-mobility, Sustainable Materials and Technologies, MATEC Web of Conferences 322, 01019 (2020); https://doi.org/10.1051/matecconf/202032201019

List of journal publications

Topic 2. Gamma irradiation on cement setting and early hardening

- M. Dąbrowski, M.A. Glinicki, K. Dziedzic, D. Jóźwiak- Niedźwiedzka, S.Sikorin, V.S. Fateev, E.I. Povalansky, Early age hardening of concrete with heavy aggregate in gamma radiation source – impact on the modulus of elasticity and microstructural features, **Jour. Advanced Concrete Technology**, 19, 2021, 555-570; https://doi.org/10.3151/jact.19.555
- M.A. Glinicki, M. Dąbrowski, A. Antolik, K. Dziedzic, S. Sikorin, V. Fateev, E. Povolansky, Gamma irradiation sensitivity of early hardening cement mortar, **Cement and Concrete Composites**, submitted in 2020 (under review)
- Y. Khmurovska, et al. Effects of gamma-ray irradiation on hardened cement mortar, **International Journal of Concrete Structures and Materials**, 15:17, 2021; doi: 10.1186/s40069-020-00452-7

List of journal publications

Topic 3. Prolonged gamma irradiation effects

Two papers in preparation to be submitted in 2021:

a) on the passivation of steel in cement mortars

b) on the volume stability and porosity of concrete with mineral aggregates

Findings:

a) Electrochemical measurement revealed a significant impact of gamma irradiation with dose up to 1 MGy on the passivation of steel in cement mortars:

- a decrease of corrosive potential and passivation potential of steel in mortars
- an increase of corrosive current density (higher for reduced portlandite content)
- γ irradiation promoted decrease of impedance and phase shift to smaller values for low frequency of current (→increased corrosion risk)

b) Significant linear expansion of mortar bars due to gamma irradiation at 10.6 MGy for flint aggregates. The shape of expansion - time curve under irradiation similar to these obtained at elevated temperature of 38°C. Effects of elevated temperature on the linear expansion of mortar specimens were dependent on the mineral composition of reactive rock aggregate.

List of journal publications

Topic 4. Combined use of X-ray/neutron tomographic imaging and optical reflection imaging

- Paper on air void distribution in concrete to be prepared in 2021
  if supplementary calculations are performed on X-ray microtomograms (Yonsei Univ.)

- H.-T.Kim, et al., Reconstruction of concrete microstructure using complementarity of X-ray and neutron tomography, **Cement and Concrete Research**, 148, 2021, 106540

Publications in total:

- Numer of journal publications: 10 (+1 under review)
- Journal papers in preparation in 2021: 3
- Published conference papers: 1
- Conference posters: 2 scheduled in October 2021

The formal finish of RADCON Project in Poland is Dec.31, 2021

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Thank you for your attention!