LOW - ACTIVATION CONCRETE

Daria Jóźwiak-Niedźwiedzka

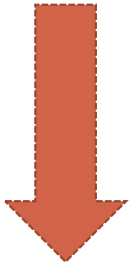
RADCON meeting, 11-14 March, 2019, Smolenice – Slovak Academy of Sciences

Outline

- **Goal of the research**
- **Research plan**
- **Expected results**

Motivation

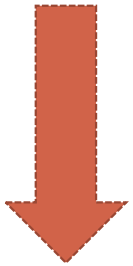
- **Collaboration within RADCON Project**



multi-author articles, papers, …

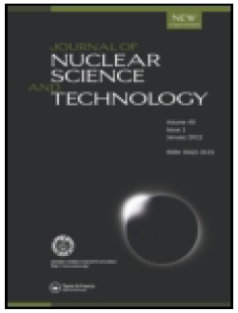
Goal of the research

The lowest possible activated cement based material



Low-activation concrete

What is already known



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Raw Materials for Low-Activation Concrete Neutron Shields

Masaharu KINNO , Ken-ichi KIMURA & Takashi NAKAMURA

To cite this article: Masaharu KINNO , Ken-ichi KIMURA & Takashi NAKAMURA (2002)

- **the raw materials for low-activation concrete were: low-activation limestone, quartzite, colemanite, alumina-ceramics, white Portland cement and high-alumina cement**
- **concrete surrounding a nuclear reactor**

What is already known

Fujita Technical Research
Report No.43 2007

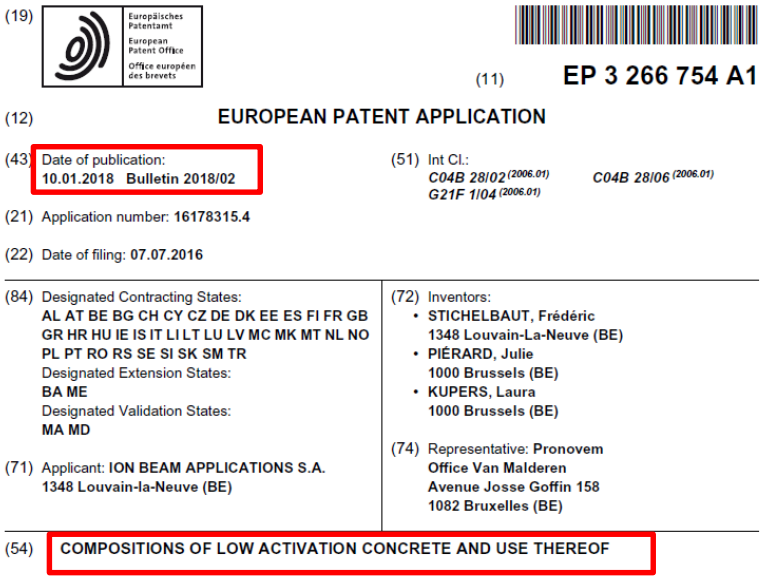
Low-Activation Reinforced Concrete Design Methodology

-Fundamental Investigation for various Types of Low-Activation Concrete-

Ken-ichi Kimura, Masaharu Kinno, Hirokazu Nishida, Noritcika Katayose,
Mikihiro Nakata[2], Katsumi Hayashi[3], Mikio Uematsu[4] and Akira Hasegawa[1]

- **3 kinds of aggregates (fused alumina ceramics, silica sand and limestone) and 2 kinds of cements (high alumina cement and white cement) were selected as raw materials for the low–activation concrete**
- **long-term use in a nuclear power plant**

What is already known



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(54) COMPOSITIONS OF LOW ACTIVATION CONCRETE AND USE THEREOF

- **high-purity limestone aggregate and white cement**
- **high-purity limestone aggregate and aluminous cement**
- **the present invention relates to the use of low-activation concrete in radiation protection structures, preferably for particle accelerators**

What is already known

Application of low-activation concrete

Neutron-shielding (biological shielding)

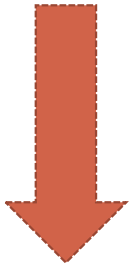
What about concrete properties?

The concrete with high alumina cement:

- **high drying shrinkage**
- **long term durability (low w/c ratio)**
- **heat generation**

Goal of the research

The lowest possible activated cement based material



Low-activation concrete

- **Cask storing spent fuel (low-activation concrete)**
- **Long term durability of concrete (liquid and gaseous media)**

Cask storing spent fuel

the Yankee NPP, Connecticut

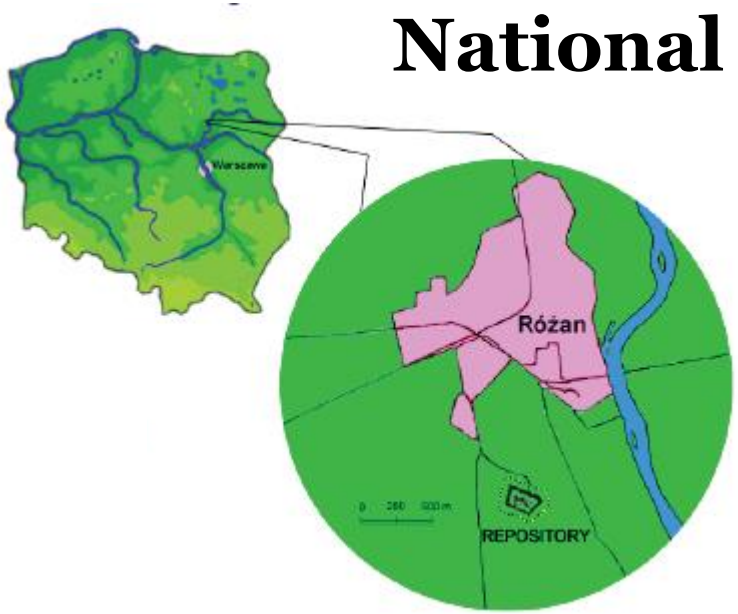
HI-STORM is engineered for maximum shielding, … twenty-six inches of concrete (0.66 m)

https://holtecinternational.com

the Zion NPP, Illinois

http://www.zionsolutionscompany.com

National Radioactive Waste Deposit Poland



bitumen

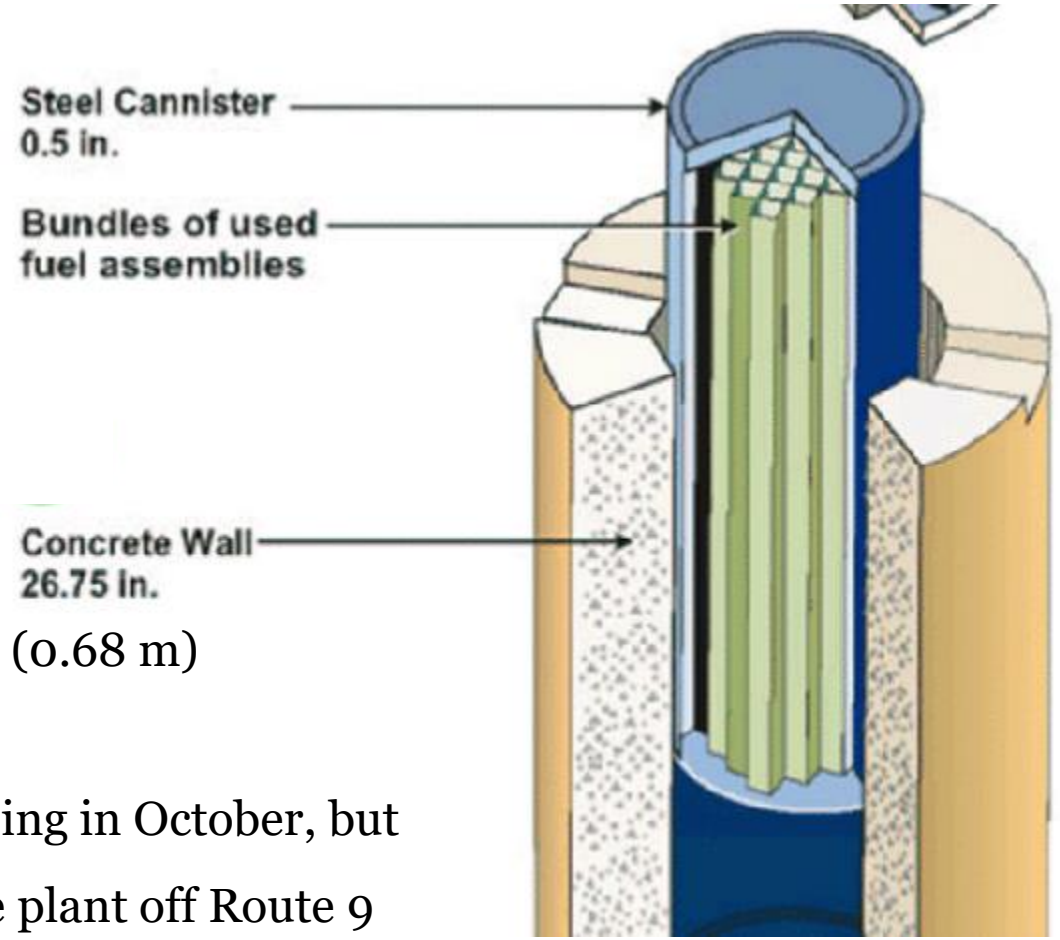
concrete - insulation

cask storing spent fuel

soil

concrete - construction

the Oyster Creek NPP, New Jersey



(0.68 m)

The Oyster Creek NPP may be closing in October, but the spent nuclear fuel stored at the plant off Route 9 here for nearly 50 years isn't going anywhere.

Feb 6, 2018

https://patch.com/new-jersey/lacey/oyster-creeks-spent-nuclear-fuel-casks-arent-going-anywere

Goal of the research

The lowest possible activated and durable cement based material for cask storing spent fuel

The design of the low-activation or even non-activation concrete

What we are looking for?

- **The trace elements predominantly responsible for the activation of concrete materials**
- **Eu and Co are dominant materials for activation in the cement and concrete**

The three radioisotopes 60Co, 152Eu and 154Eu alone occupy 99–100% of the total residual radioactivity in ordinary concrete at the time of decommissioning

Radiochemical analyses: Co, Eu, Cs, Fe and Sc

Research plan

- **Selection of aggregates, cements and additives (fly ash, slag, …) as raw materials to design and perform the low–activation concrete**
- **Evaluation of materials by radiochemical analyses (NAA, PGAA ???) which assessed the quantities of dominant trace elements for the activation under specific conditions**
- **Design and perform of special concrete for cask storing spent fuel**
- **Properties of fresh mix (workability, heat generation, …)**
- **Fundamental mechanical properties**
- **Durability test (gas and water permeability, …)**

Expected results

1. **Activation analysis of cements, aggregates and additives (fly ash, slag, …)**
2. **The design of 4 or 6 of concretes (mortars)**
   - **Low-activation concrete**
   - **Durable concrete (liquid and gaseous media)**
3. **Activation analysis of performed concretes**
4. **Results of the long term durability of concretes**
5. **Database for Monte Carlo simulations ?**

Any other ideas?

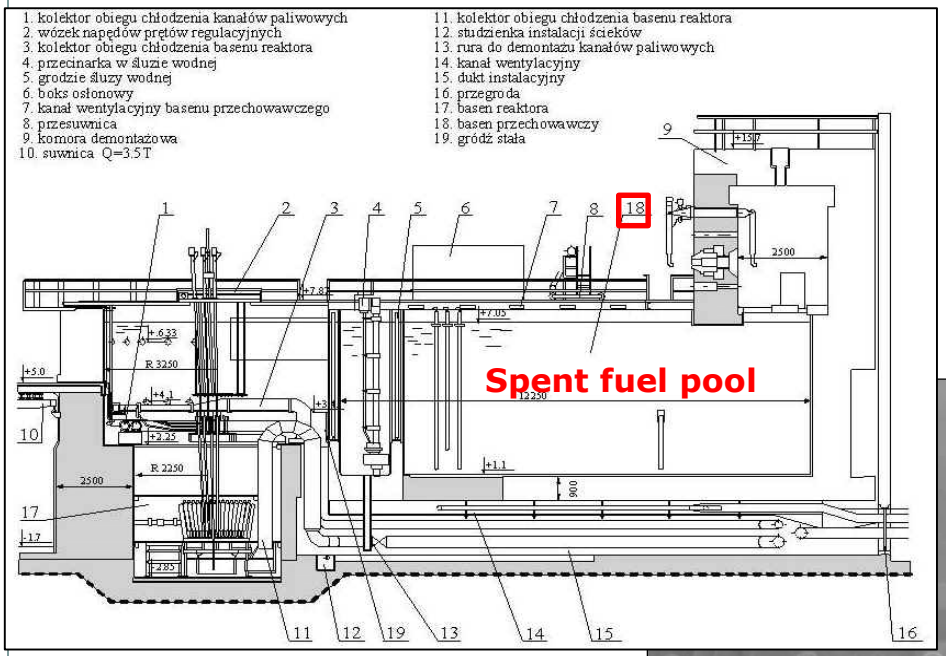
...

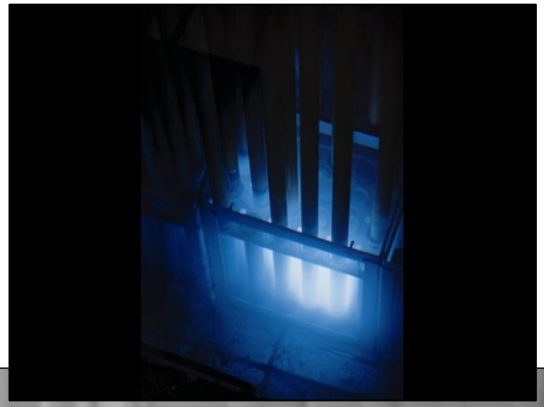
Activation analysis of cement and supplementary cementitious materials

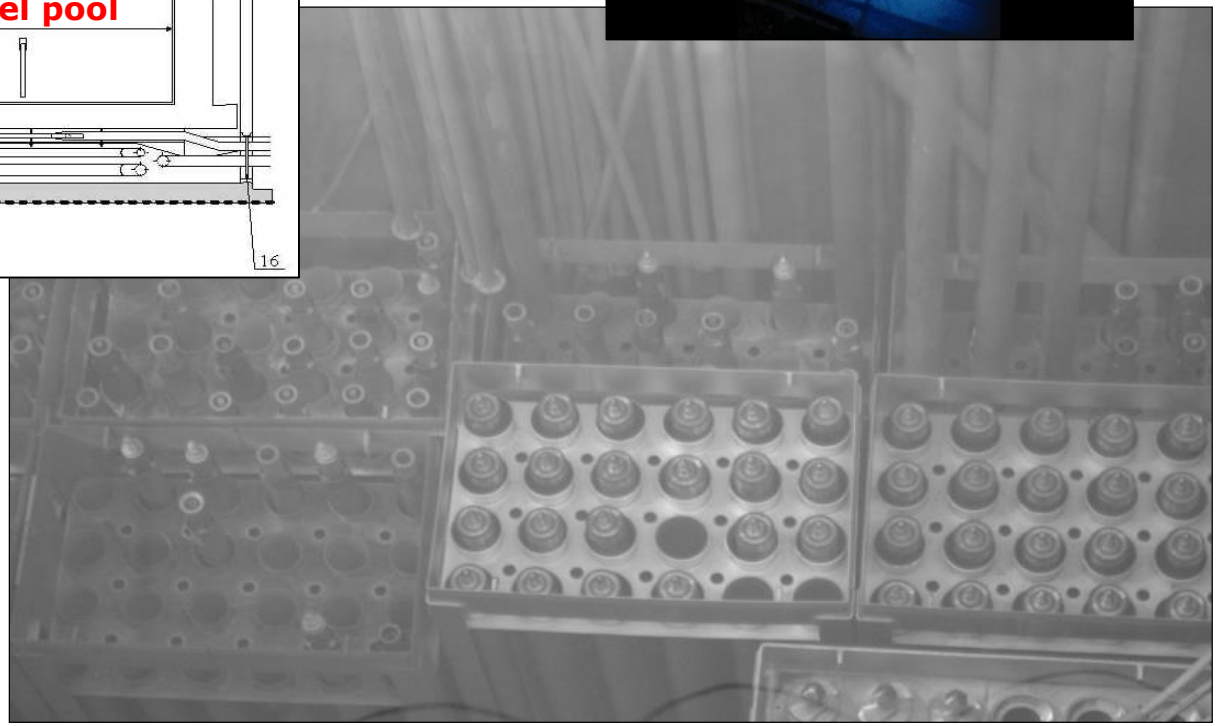
Material	Isotope	$T_{1/2}$	mass [mg]	kBq/g	10 x $T_{1/2}$ [kBq/kg]
Cem I 42.5R	Sc-46	83.785 d	246	4.9	4.8
	Sc-47	3.349 d		39.2	38.2
	Fe-59	44.495 d		3.9	3.8
	In-114m	1.198 m		0.8	0.8
Ground granulated blast furnace slag	Sc-46	83.785 d	241	15.2	14.89546
	Sc-47	3.349 d		30.3	29.64591
Fly ash	Sc-46	83.785 d	178	27.0	26.41156
	Fe-59	44.495 d		11.7	11.4513
	Co-60	5.274 y		1.8	1.827315

5 min in reactor MARIA, neutron flux $2x10^{14}$ $cm^{-2}s^{-1}$

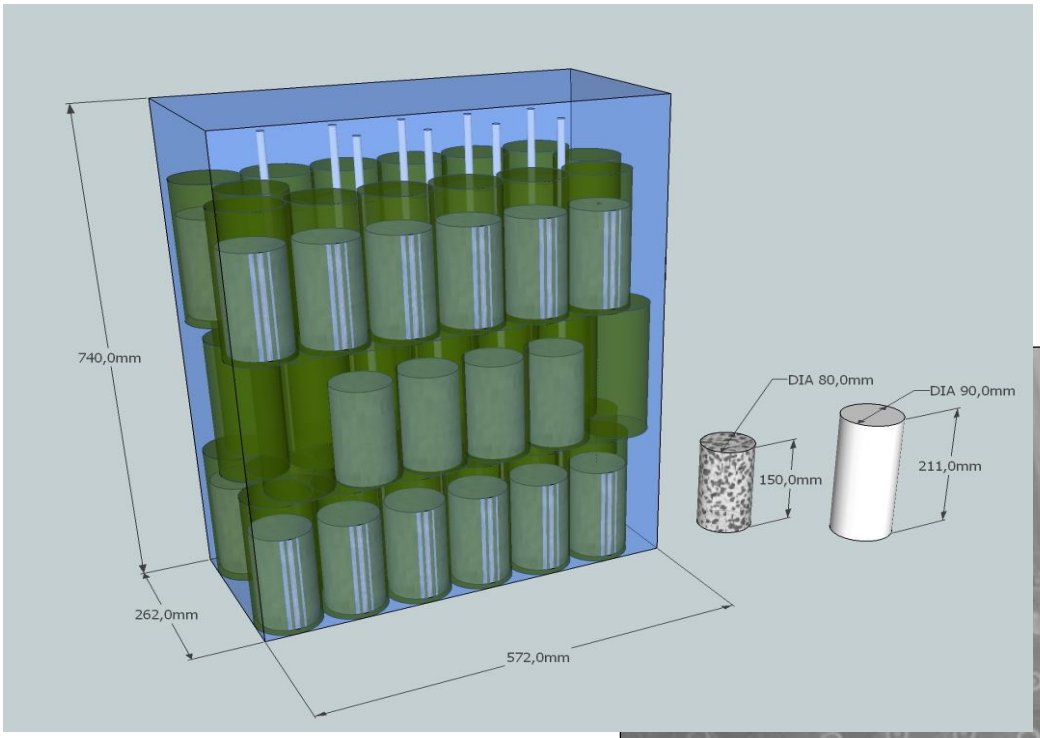
Irradiation of concrete specimens – separator with spent fuel

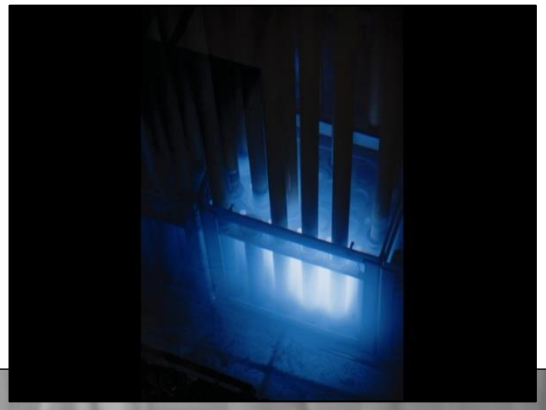


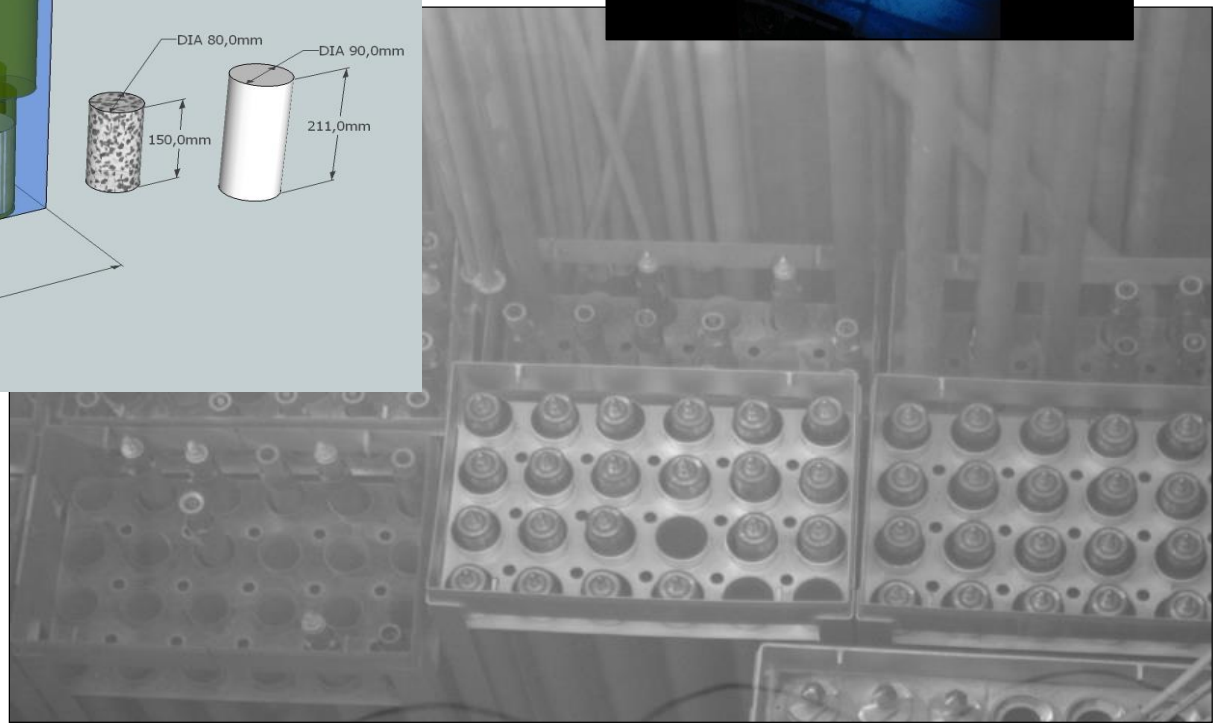




Irradiation of concrete specimens – separator with spent fuel







a central sealed container placed in a separator surrounded by 16 fuel elements

10 months >10^7 Gy

Thank you for your attention

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