Project Research — **Establishment of Optimal Risk Management**

Rational Radiation Safety Technology

Background and Objective

Methodology on how to ensure radiation safety (i.e., no health effects due to radiation) for the public has been pointed out as a significant issue of interest since the Fukushima Daiichi nuclear accident occurred. It is required now more than ever before to explain the validity of criterion regarding radiation safety, maintaining transparency for society.

In this project, a rational concept and assessment method for ensuring radiation safety are proposed to the relevant experts including newly developed criteria after the Fukushima Daiichi nuclear accident for the purpose of the improvement of accountability to society regarding radiation safety.

Main results

1 Verification of the Screening Level for the Decontamination Implemented after the Fukushima Daiichi Nuclear Accident

The Fukushima Daiichi nuclear accident caused the release into the environment of a substantial amount of radioactive materials, and a screening level for decontamination was implemented for the surface of the human body and for handling contaminated objects. In order to verify the screening levels for decontamination, the doses that arise from external irradiation, ingestion, inhalation, and skin contamination were assessed (Table 1).

The results show that the annual effective doses that arise from handling objects contaminated with the screening level for decontamination (i.e., 100,000 counts per minute) are lower than 1 mSv y^{-1}, which can be considered as the intervention exemption level in accordance with the International Commission on Radiological Protection (ICRP) recommendations. Furthermore, the screening level for decontamination is also found to protect the skin from the incidence of a deterministic effect because the absorbed dose of the skin that arises from direct deposition on the surface of the human body is calculated to be lower than the threshold of the deterministic effect assuming practical exposure duration. Therefore, it can be considered that the emergency response regarding the screening level for decontamination implemented after the Fukushima Daiichi nuclear accident was the appropriate countermeasure from the viewpoint of risk management under such emergency conditions.

2 Clarification of the Low Diffusivity in the Radioactive Waste Disposal System

As for the radiation safety of a radioactive waste disposal system, it is necessary to clarify the accuracy of parameters for the performance assessment of the repository in the new guidelines of the licensing safety review. In a sub-surface disposal system, the closely packed concrete layer is expected to retard the migration of radionuclides from the repository to the biosphere. Therefore, the diffusion of radionuclides in FAC*1, which is a candidate material for the construction of a sub-surface repository, is a very important parameter. In this study, focusing on the pore structure of FAC, the diffusion of trace ions (which are hardly sorbed on cementitious materials) in hardened cement pastes was examined through diffusion experiments. As a result, the effective diffusion coefficients, D_e, of the trace ions for FAC were 1–3 orders of magnitude smaller than those for OPC*2 (Fig. 1) because of the continuous change in the pore structure (Fig. 2) (L11008).

*1 Low-heat Portland cement containing fly ash
*2 Ordinary Portland cement

Other reports: H. Ogino et al., Radiat. Prot. Dosim., Vol. 151, No. 1, pp. 36-42, 2012

Ratio of radioisotopes (I-131 : Cs-134 : Cs-137)			Case 1	Case 2	Case 3	Case 4	Case 5
			<- I-131 rich ratio			I-131 poor ratio ->	
			100:1:1	10:1:1	1:1:1	0.1:1:1	0.01:1:1
Surface contamination density [Bq cm^{-2}]		I-131	410	360	150	23	2.4
		Cs-134	4.1	36	150	230	240
		Cs-137	4.1	36	150	230	240
Contaminated objects	Manually handling objects [0.1 m^2]	Ingestion [mSv y^{-1}]	0.50	0.44	0.24	0.11	0.085
		Skin [mSv y^{-1}]	1.7	13	56	83	87
	Closely handling objects [1 m^2]	External [mSv y^{-1}]	0.041	0.11	0.35	0.51	0.53
		Inhalation [mSv y^{-1}]	0.00076	0.00099	0.0019	0.0024	0.0025
	Remotely handling objects [10 m^2]	External [mSv y^{-1}]	0.028	0.058	0.17	0.24	0.25
		Inhalation [mSv y^{-1}]	0.00011	0.00015	0.00028	0.00036	0.00038
Direct deposition to skin		Skin [mSv h^{-1}]	1.0	1.0	1.1	1.1	1.1

Table 1: Calculation of doses that arise from contaminated objects and direct deposition to skin regarding the screening level for decontamination (i.e., 100,000 counts per minute)

On 19th March 2011, the Nuclear Safety Commission of Japan technically suggested the screening level for decontamination to be 100,000 cpm by assuming the use of a typical GM survey meter with a 5-cm bore. In this study, the surface contamination densities that correspond to the screening level for decontamination were calculated by assuming five cases for the ratio of radioisotopes, and the doses that arise from external exposure, internal exposure (inhalation and ingestion), and skin contamination were calculated. Even assuming that a similar deterministic effect can be observed in the case where the time integration of the absorbed dose rate of the skin from chronic irradiation (e.g., 1.0 mSv h^{-1}) reaches the lowest threshold of acute irradiation (>3 Sv), the implemented screening level for decontamination can be considered to prevent the skin from the incidence of a deterministic effect such as temporal epilation (3 Sv), erythema (5 Sv), and permanent epilation (7 Sv).

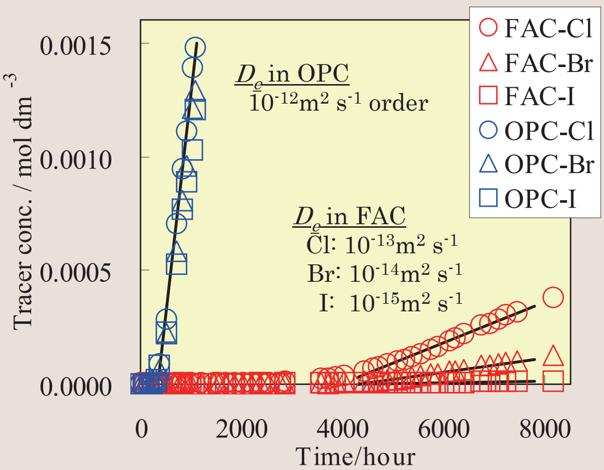

Fig. 1: Diffusion of Cl, Br, and I through the hardened cement pastes

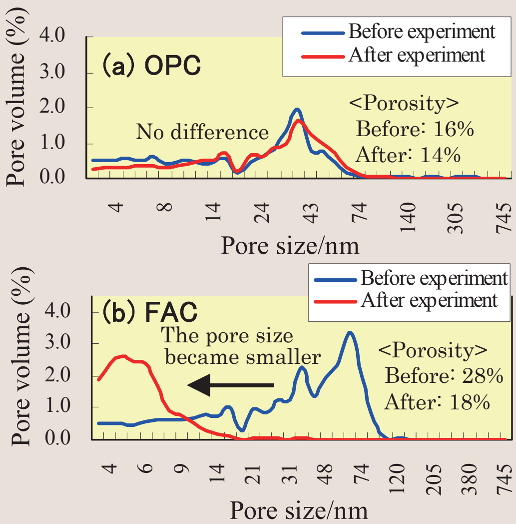

Fig. 2: Pore size distribution

The effective diffusion coefficient (D_e) of anion (chloride, bromide, and iodide) depends on the pore structure of the hardened cement pastes. D_e in FAC is much smaller than that in OPC (Fig. 1). As shown in Fig. 2, the pore size distribution and porosity of FAC changes to become a more closely packed structure because of the pozzolanic reaction in which pozzolanic materials react with portlandite to form insoluble silicate compounds. Such changes of the micro structure of FAC lead to the low diffusivity of FAC.