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A Parametric Study of the Building Wake Effect in the Atmospheric Dispersion Model of MACCS2 on the Off-Site Consequence

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1. Introduction

A research project has been conducted to verify that the operating facilities handling radioactive materials on the Korea Atomic Energy Research Institute (KAERI) site are satisfied with the domestic nuclear safety goals through the research site risk profile assessment. A risk profile can be obtained from the full scope of level 1/2/3 Probabilistic Safety Assessment (PSA) [1]. Level 1/2/3 PSA has been performed on HANARO and Post Irradiation Examination Facility (PIEF) in research site.

We are focusing on the off-site consequence analysis of severe accidents, which is technically level 3 PSA area. MACCS2 (MELCOR Accident Consequence Code System 2) input model has been developed for the level 3 PSA on the KAERI site [2] and a parametric study has been performed to identify the relative importance of the values of MACCS2 input model [3-5].

We conducted a limited parametric study of the building wake effect on plume dispersion in MACCS2 code.

2. A Parametric Study of Building Wake Effect for Off-Site Consequence Analysis

2.1 Building wake effect in MACCS2 code

The initial size of plume is calculated in MACCS2 code based on the assumption that the building wake effect determined the initial plume dimensions. In MACCS2, the initial dimensions of plume (σ_y, σ_z) are determined based on the user-specified building height and width. σ_y and σ_z are initialized to the building width divided by 4.3 and the building height divided by 2.15, respectively [6].

2.2 Input parameters

The building structure of PIEF is in the shape of an "L". There are studies showing that the building shape affects the building wake effect [7, 8]. However, in MACCS2 code, the only variable input options that can consider the building wake effect are the building width and height, and the building shape cannot be considered. Therefore, this study was conducted in a limited scope, considering only variables that users can handle.

The building width of PIEF varies depending on the direction. To consider building wake effect, the building width perpendicular to the wind direction is applied as the input value. Since only a single input value can be applied to the calculation, it is not possible to consider the width of the building according to the wind direction.

Since PIEF has a building width of 29.7, 59.4 and 91.8 m depending on the direction, calculations were performed for the four cases presented below, including the case where there is no building wake effect.

① No building wake (point source)
② Building height=14.2 m, building width=29.7 m
③ Building height=14.2 m, building width=59.4 m
④ Building height=14.2 m, building width=91.8 m

MACCS2 input parameters for the KAERI site were obtained from the previous study [2]. Source term data for a hypothetical accident scenario (Configuration 2, lowgap) at PIEF was obtained from the calculation result of MELCOR performed in the research project [9]. MACCS/WinMACCS version 4.0.0 and MELMACCS version 2.0.1 were used in this study.

3. Results and Discussions

To analyze the building wake effect in the atmospheric dispersion model of MACCS2 on the off-site consequence, the calculations were performed on ground-level air concentrations and centerline ground concentrations of radionuclides for a hypothetical accident scenario at PIEF. Radionuclide ground-level air concentration (Bq·s/m^3) represents the centerline ground-level integrated air concentration from the plume segment averaged over the spatial interval's length. And, radionuclide centerline ground concentration (Bq/m^2) means the centerline ground concentration after passage of the plume averaged over the spatial interval's length.

Figure 1 shows ground-level air concentrations of Cs-137, Te-127m and Kr-85 for the four building dimensions in PIEF accident case. Among the radionuclides in the source term, only the calculation results for the representative radionuclides of each chemical element group are presented.

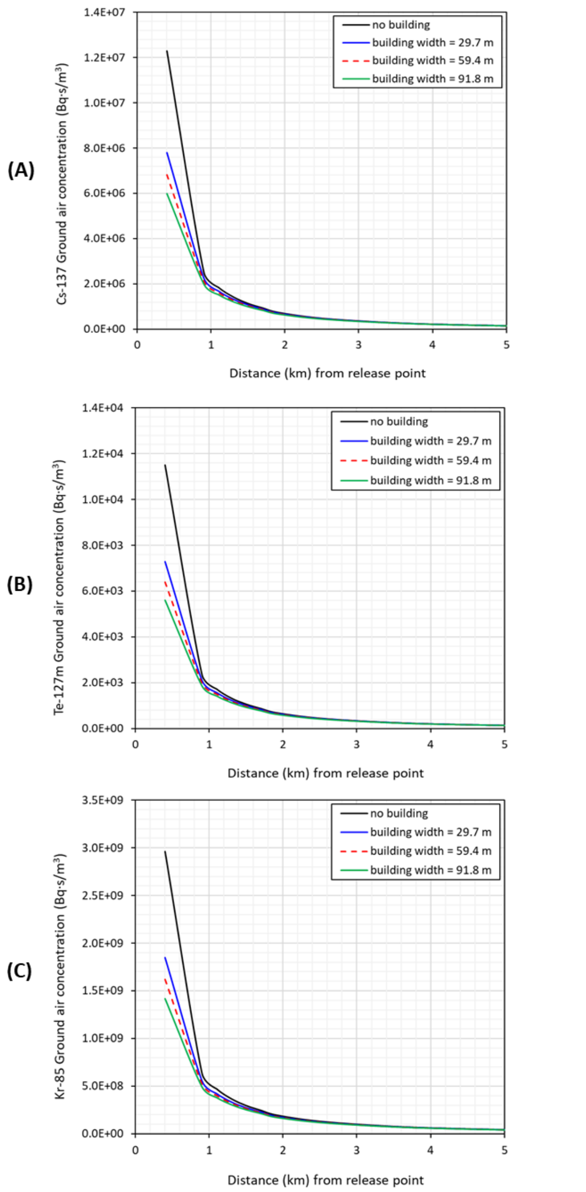

Fig.1. Ground air concentrations (Bq·s/m^3) of (A) Cs-137 (B) Te-127m, and (C) Kr-85 for the four building wake cases (mean value)

When considering the building wake effect, it was confirmed that the centerline ground level air concentration was lowered in the near distance of the release point. In the 0~0.8 km area, when the building widths of 29.7, 59.4, and 91.8 m were applied, the concentrations of radionuclides were estimated to be about 0.63, 0.56, and 0.49 times lower than when the building wake effect was not considered.

Figure 2 shows centerline ground concentrations of Cs-137 and Te-127m for the four building dimensions in PIEF accident case. Since dry and wet depositions are not considered in the noble gas group, there is no results of ground concentration for Kr-85. The ground concentrations also showed results of a tendency that was not significantly different from the air concentration.

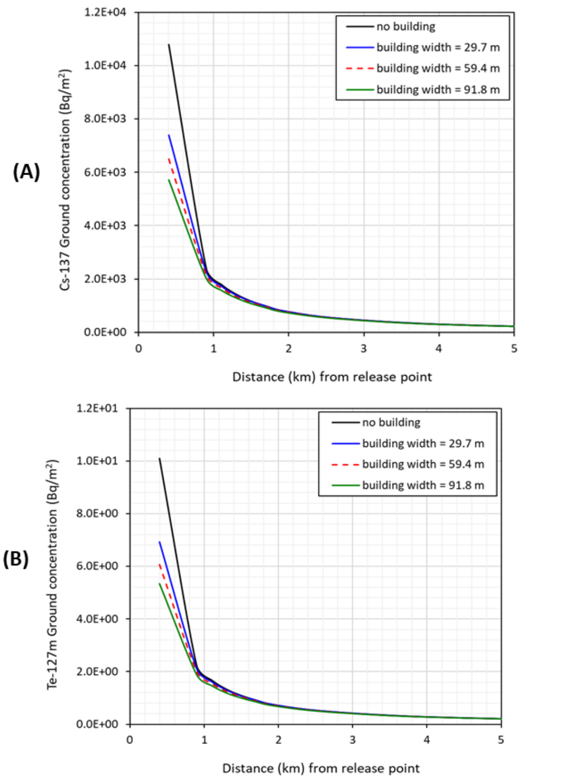

Fig.2. Centerline ground concentrations (Bq/m^2) of (A) Cs-137 and (B) Te-127m for the four building wake cases (mean value)

This difference between the results for the building wake cases decreased as the distance from release point increased. In the 2~4 km distance from release point, the radionuclide concentration results showed a difference of less than 5% compared to the case in which the building wake was not considered under all calculation conditions considering the building wake effect.

This study was conducted to select the PIEF building dimension input value of MACCS2 to consider the building wake effect when performing the off-site consequence analysis of the hypothetical accident at PIEF. Based on the calculation results, 29.7m, which showed the highest centerline concentration result among the building width values, was selected as the input value. In the case of population weighted risk of cancer fatality, a slight difference of about 0.5% or less was shown in all of the 0-1.8, 0-5, 0-20, and 0-30 km areas for the three cases considering building wake effect. It can be interpreted that there is almost no difference in the population weighted cancer fatality risk of residents living within each radius range because radionuclides reduced in the plume centerline are dispersed in the horizontal direction of the plume in consideration of the building wake effect. In the calculation conditions for the PIEF accident scenario, it was confirmed that the difference in the building width input conditions did not significantly affect the results on the off-site consequence.

4. Conclusion

This study was conducted to select the input value for PIEF building dimension to consider the building wake effect in the atmospheric dispersion model of MACCS2 when performing the off-site consequence analysis of the hypothetical accident at PIEF. These results should not be generalized for every case of the nuclear accidents, since only the limited calculations were performed for the hypothetical accident at PIEF with KAERI-specific data. This work will be used as basic material for our research project.

ACKNOWLEGEMENT

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