Development of Korean Off-site Consequence Analysis Code Package, KOSCA-MACCS2

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1. Introduction

In the process of the risk-informed decision-making, the reactor-specific risk surrogates such as the core damage frequency (CDF) and large early release frequency (LERF) have been used instead of the direct risk measures for prompt and the latent cancer fatality risk quantitative health objectives (QHOs). After the Fukushima accident, however, concern about a comprehensive site-specific Level 3 PSA has been raised for some compelling reasons, especially misconception of the risk surrogate and attention to the domestic multi-unit site risk effect including other site radiological sources, e.g., spent fuel pool. Recently, authors have developed an integrated platform for a domestic-specific Level 3 PSA, so-called KOSCA-MACCS2[1] (Korea Off-Site Consequence Analysis based on MACCS2 [2]). Simply speaking, it is similar to WinMACCS [3] in the point that it provides user interface to perform a Level 3 PSA with MACCS2[1] code. In particular, it provides the pre-processing modules to automatically generate MACCS2 input from diverse types of the domestic-specific raw data including numerical map data, e.g., meteorological data, numerical population map, digital land use map, economic statistics and so on.

The paper is on the extension of the KOSCA-MACCS2. In particular, it contains the addition of two modules newly developed, KOSCA-SOURCE and KOSCA-OUTPUT. The former is a pre-processing module to automatically convert MAAP5[2] source-term output to MACCS2 input, the latter is a post-processing module to provide graphic solutions of the MACCS2 text outputs. They facilitate the preparation of MACCS2 input for a domestic site-specific Level 3 PSA as well as the interpretation and documentation of the MACCS2 outputs. Further functions should be still developed and added on it, e.g., network evacuation simulation module using digital road map and so on.

2. Overview of the Current KOSCA-MACCS2

KOSCA-MACCS2 is specialized to enable site-specific consequence analysis for Korean nuclear power plant, based on MACCS2 code. As shown in Figure 1, KOSCA-MACCS2 largely consists of three parts; 1) pre-processing modules, 2) MACCS2 execution (including base and sensitivity case generation module), 3) post-processing module.

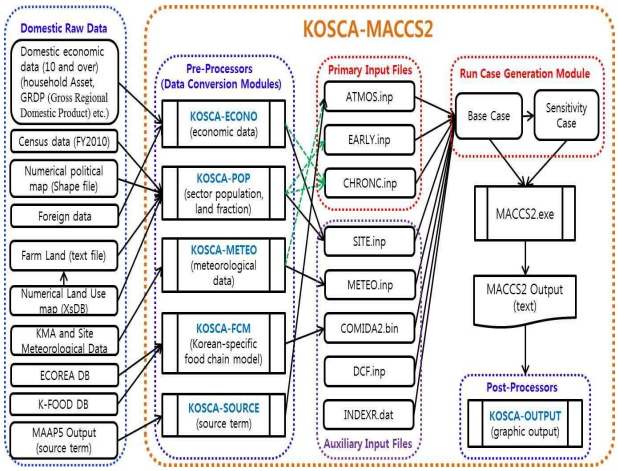

Fig. 1. Overview of KOSCA-MACCS2 code package

KOSCA-MACCS2 has some useful pre-processors to facilitate the generation of domestic site-specific MACCS2 input files as well as a post-processing module (KOSCA-OUTPUT) to convert MACCS2 text outputs to graphic report forms. As preprocessors, there are the following data conversion modules.

1) KOSCA-POP [1]: preprocessor to automatically convert site-specific sector population and land fraction into MACCS2 input, given the polar-coordinate spatial grid specified by user. Its functionality is similar to SECPOP [4] for MACCS2.
2) KOSCA-METEO [1]: preprocessor to convert site-specific meteorological data for MACCS2 input.
3) KOSCA-FCM [6]: COMIDA2[3] input file for domestic-specific food chain model (FCM).
4) KOSCA-ECONO [7]: preprocessor to generate domestic-specific economic cost data for MACCS2, similar to economic estimation part of the SECPOP preprocessor.
5) KOSCA-SOURCE: preprocessor to convert MAAP5 source term output into MACCS2 source term group

[1] MACCS2 (MELCOR Accident Consequence Code System Version 2)
[2] MAAP5 (Modular Accident Analysis Program Version 5)
[3] A food-chain processor interfacing between COMIDA[5] and MACCS2 code.

More details of other pre-processing modules except for KOSCA-SOURCE are provided by the references ([1],[6],[7],[5]). The development environment and system requirement of KOSCA-MACCS2 are given in table 1 [1].

Table 1. Development Environment and System Requirements of KOSCA-MACCS2

Type	Environment and Requirements
OS	Windows XP and over
Hardware	CPU: Intel® Pentium 4 RAM : 2GB and over
Software used	Environment: Microsoft .Net 3.5 and over Language: C#

3. Preprocessor for Source Term Conversion, KOSCA-SOURCE

Even though MACCS2 code uses directly the results of the MELCOR source term (ST), ST analyses for PSA are usually performed by MAAP code in Korea. Owing to the differences in ST categorization of both codes (15 ST groups for MAAP5, 9 for MACCS2), the PSA practitioner has to convert MAAP ST outputs according to the MACCS2 input format. KOSCA-SOURCE module automatically converts ST from MAAP5 output file specified by the user with its execution, and then provides user interface to generate plumes written in MACCS2 ATMOS input file from the STs converted. The method for specifying the plumes analyzed (e.g., selection of the number of plume, release time, release duration, etc.) depends on the MACCS2 code (e.g., max. number of plumes ≤ 4, etc.). Fig. 2 is an illustration of the KOSCA-SOURCE display.

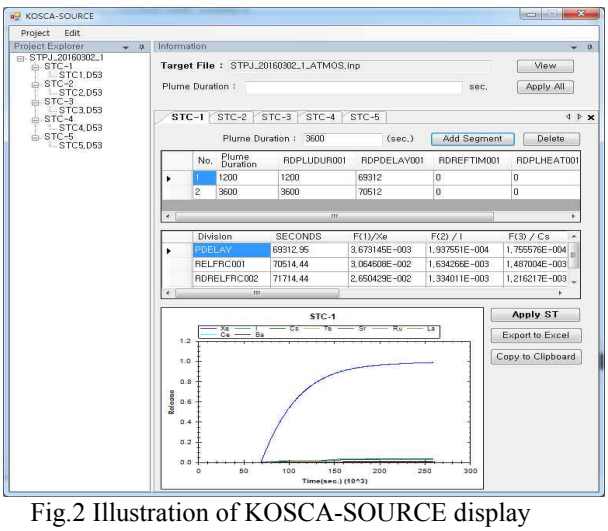

Fig.2 Illustration of KOSCA-SOURCE display

4. Post-processor, KOSCA-OUTPUT

Basically results generated by MACCS2 are written to binary files, which are then processed in order to generate complementary cumulative density functions (CCDFs). If the option CCDF is not specified in the input files, MACCS2 reports the representative statistics (e.g., mean, mode and quantiles (50^{th}, 90^{th}, 95^{th}, etc.)) of the distribution for the result types selected by user [2].

- Type 0: atmospheric results at specified downwind distances
- Type 1: cases of specified health effect
- Type 2: early fatality radius
- Type 3: population exceeding dose threshold
- Type 4: average individual risk of health effects
- Type 5: total collective dose from material deposited within region
- Type 6: centerline dose versus distance
- Type 7: centerline risk versus distance
- Type 8: population-weighted safety goal risk
- Type A: max. observed dose at a specified distance ring (r) (direction-independent dose)
- Type B: max. observed dose at a specified (r,θ) location (direction-independent dose)
- Type 9: breakdown of CHRONC population dose by pathway
- Type 10: economic costs of mitigative actions
- Type 11: max. distance for the various mitigative actions
- Type 12: impacted area/population results
- Type 13: maximum individual dose from COMIDA2 food-chain model

KOSCA-OUTPUT module provides user interface to automatically generate two types of graphs, scatter diagram and CCDF, from MACCS2 text output specified by user. It has the auto-search function for the result types that user can select form the specified MACCS2 output file, and then automatically draw the graphs for the result type selected by user. If necessary, the user can provide the frequency of the cases (e.g., ST categories) related to the result type. Fig.3 and Fig.4 illustrate scatter diagram and CCDF, respectively, for population-weighted risk (Type 8) of the example problem.

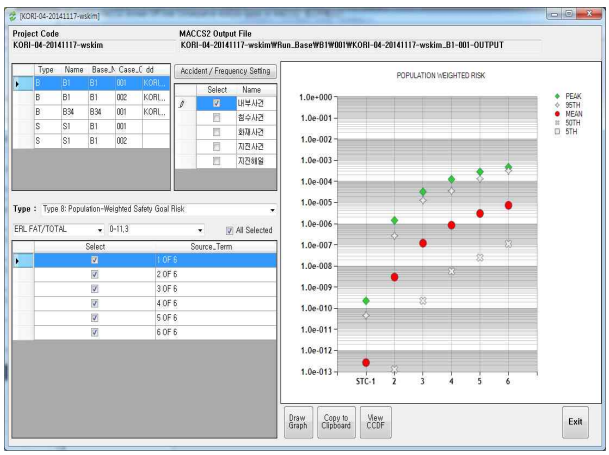

Fig.3 Illustration of the scatter diagram for Type 8 result

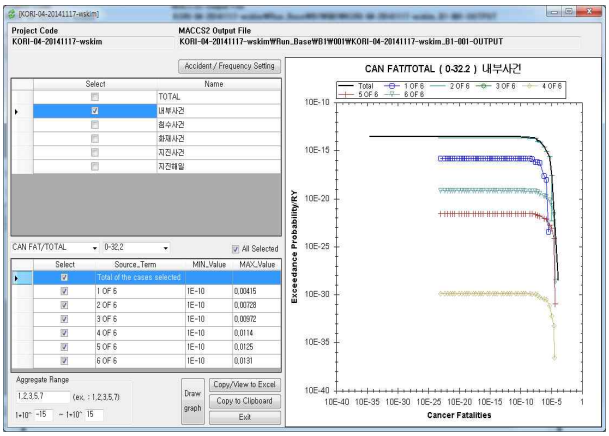

Fig.4 Illustration of the CCDF for Type 8 result

5. Conclusions

A code package for domestic site-specific Level 3 PSA based MACCS2, KOSCA-MACCS2 (Korea Off-Site Consequence Analysis based in MACCS2), was developed including two new processors, KOSCA-SOURCE and KOSCA-OUTPUT. It can serve as an integrated platform for a site-specific Level 3 PSA. The pre-processors involved in KOSCA-MACCS2 facilitate the preparation of MACCS2 input files for a domestic plant-specific Level 3 PSA. Also, the post-processor (KOSCA-OUTPUT) can be helpful in the interpretation and documentation for the results of the Level 3 PSA. In the near future, some functions need to be developed and added on it, e.g., network evacuation simulation module using digital road map, etc.

Acknowledgements

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