論文 / 著書情報
Article / Book Information

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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	建築学 系 都市・環境学 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of （ 工学 ）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

In this thesis, the study comprehensively validated and discussed the effect of large-scale velocity fluctuations simulated using a modified ε-equation with URANS on concentration dispersion around buildings and conducted an application on the real urban district pollutant dispersion problem. The thesis was consisted by totally 8 chapters.

In **Chapter 1**, an introduction of the air pollution problem and the previous computational fluid dynamics (CFD) study on solving the pollutant dispersion problems. According to the background, the research purpose and the structure of the study were listed in the last section of this chapter. In **Chapter 2**, the governing equations and the modification of the turbulence model for the URANS simulation was introduced. And in **Chapter 3**, the numerical methods for solving the CFD simulations was introduced.

In **Chapter 4**, verified the current URANS method, which included modifications to the ε-equation and codes. These adjustments enabled the method to replicate results nearly identical to those of the source code from the original study. The current model and code were able to replicate nearly identical results to those of the source code in original study, that could be applied to validating their use for dispersion on 3D simulations.

Chapter 5 reveals several key conclusions: 1).URANS method successfully reproduced large-scale periodic fluctuations in the wake of the isolated building, capturing specific time scales and corresponding frequencies closely matching LES results. 2) Significant lateral dispersion of concentrations was observed, which SRANS computations could not replicate. 3) There was a notable improvement in the vertical concentration predictions compared to SRANS. 4) However, due to the model's focus on large-scale variations, its ability to capture lateral dispersion along wake fluctuations was limited, leading to overestimation of concentrations in localized areas. Additionally, URANS showed insensitivity to grid resolution, allowing for fewer grid cells to be used, and since only large-scale variations were reproduced, the required statistical time was reduced, significantly decreasing computational time and resources. Overall, in this chapter I validated the URANS method and demonstrated its ability to successfully reproduce large-scale periodic fluctuations in the wake of a 1:1:2 isolated building. The lateral and vertical dispersion of concentration was significantly improved compared to SRANS. However, URANS had a limitation: it overestimated the concentration near the ground surface in the wake region when the concentration source was located near the building's leeward wall.

Chapter 6 optimizes computational conditions and discusses the potential effects of modeled periodic time scale corresponding to large-scale fluctuations within the YZM $k-\varepsilon$ model on simplified 3D building array model. The main conclusion include: 1) Considering only the time derivative term of total kinetic energy fails to reproduce large-scale flow variations, differing significantly from the modeling in 2D computations, leading to unreasonable convergence and unsuitability for 3D flow and concentration fields calculations in building array. 2) To avoid singular points causing computational crashes, the original method used total kinetic energy instead of large-scale kinetic energy, which had insignificant impact on dispersion in the building array model. 3) However, the reproduction of large-scale fluctuations and their ratio within the total turbulent kinetic energy distribution in the flow field may have some potential impacts.

In Chapter 7, the original YZM model is further applied to simulate pollutant concentration dispersion in actual urban models, supported by corresponding wind tunnel experiments for comparative and supportive analysis. URANS demonstrates better predictive capability for concentration dispersion, specifically: 1) Large-scale periodic variations are successfully reproduced by URANS, though areas with significant periodic wind speed variations are more limited compared to single or simplified building group models. 2) Concentration distributions around high-rise buildings on the upwind side are observed, similar to WTE measurements, indicating successful prediction of upstream diffusion. 3) Overall, URANS can more reasonably reproduce concentration dispersion compared to SRANS, although concentrations at probe points are generally about one order of magnitude lower than WTE, except near the source point. This may be due to the weaker effects of large-scale periodic variations on dispersion effectiveness. 4) The concentration near surface ground could be more effected by the smaller-scale of the fluctuation, however, URANS method is challenging on predicting them.

In conclusion (**Chapter 8**), this study demonstrates that the YZM $k-\varepsilon$ model integrated with URANS effectively captures large-scale velocity fluctuations and improves concentration dispersion predictions around buildings, outperforming SRANS in accuracy. The URANS simulation successfully reproduced the fluctuations that SRANS failed to capture, demonstrating that URANS performs better in situations where: 1.Periodic fluctuations dominate the entire flow field, such as in the dispersion of concentrations around a high-rise building. 2.Predictions focus on the boundaries of the pollutant dispersion range, where URANS outperform SRANS simulations. However, it also identifies challenges in lateral dispersion and highlights the need for further optimization in complex urban environments.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).