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（博士課程）
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論 文 要 旨

THESIS SUMMARY

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

Earthquake is a natural disaster characterized by unpredictability and devastation, often causing significant damage to buildings. This makes providing temporary spaces for gathering or staying overnight essential. There are different level of shelters and demands for different evacuation phase, and the challenge is different. In immediate evacuation phase, safety is most concerned, especially with secondary disasters like fire or road blockages occurring. In the mid- to long-term phase, the main issue is the uncertainty of demand versus the limited shelter capacity. We propose two different models to address these two issues, and an extension of these models are made to ensure these models can be used in a wider range.

Chapter 1: Introduction

This chapter will introduce the background of earthquake and secondary disaster, also the challenges in disaster management will be pointed out. The aim of our research is to address two of these challenges: risk during immediate evacuation, and uncertainty in mid- and long-term evacuation. Although many previous studies have done a lot of works on shelter location-allocation problem, they seem to ignore these two points. We review related literatures on shelter planning model, risk assessment during evacuation, model formulation to deal with uncertainty, and show the research gap.

Chapter 2: Study area and data processing

In this chapter, we will introduce the basic situation of study area and explain the reason why we choose it. We will introduce the data source of our study and explain how to use these data to generate the parameters we will use in subsequent chapters, including determinist parameters and uncertain parameters. The most important part is the introduction of earthquake simulation model and its application in the process of the estimation of uncertain demand.

Chapter 3 Short-term shelter planning model: distance-based single-objective vs risk-based multi-objective approach

In this chapter, we propose a multi-objective optimization model with the goal of reducing the risk during the evacuation process, which is called the risk reduction model (RRM). Problem-specific indicators for screening optimal solutions are introduced. The results indicate that, in the case of Ogu, RRM can, in most situations, reduce the risk level during the evacuation process and improve evacuation

efficiency and success rate without significantly increasing the total evacuation distance. It proves to be superior to the traditional distance minimization model (DMM), which prioritizes minimizing the total distance as the objective function.

Chapter 4 Medium- and long-term shelter planning model: a robust and multi-objective approach

This chapter proposes a multi-objective distributionally robust optimization (MODRO) model tailored for shelter location and evacuation allocation. First, an ambiguity set (moment-based or distance-based) is constructed to capture the uncertainty in evacuation demand, reflecting the possible range of outcomes based on demand data from a disaster simulation model. Then, the distributionally robust optimization model considers the “worst-case” distribution within this ambiguity set is proposed. The model aims to ensure that shelters are optimally located, and evacuees are efficiently allocated, even under the most challenging scenarios. In the case study of Ogu, the results demonstrate that the objective value obtained by the DRO model is higher than a stochastic programming model while lower than the worst-case robust model, indicating a more balanced approach to managing uncertainty.

Chapter 5 Extensions: hierarchical approach

In the real world of earthquake, there are many uncertainties which not only influence the demand, connectivity, and supply as we discussed in previous chapters, but also require a flexible arrangement of shelter planning to prepare for the uncertainty. In previous chapters, we made assumptions which are specific for Japan, these assumptions may not be effective in many other countries, therefore, in this chapter, we will discuss the situation when we relax these assumptions on fixed shelter rank and evacuation flow between shelters. The results can provide us with different strategies for shelter planning in different situations.

Chapter 6 Summary and conclusions

This chapter summarizes previous chapters and draws the conclusions, limitations, and future directions of the dissertation.

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).

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