論文の内容の要旨

論文題目 Application of Meta-Modeling to Bridge Structure for Consistent Seismic Response Analysis
(整合する地震応答解析を行うためのメタモデリングの橋梁構造への適用)
氏名　　ジャヤシンヘ　アチラチゲ　スプン　チャマラ　ジャヤシンヘ

For earthquake disaster estimation of an urban area, numerical simulation of the seismic response analysis of various structures that exist in the area is an alternative of the current estimation method that makes use of empirical relations of structure damage probability and certain seismic indices. Since a variety of numerical methods of the seismic response analysis and high performance computing are available, construction of a suitable analysis model is a bottle neck to realize simulation-based earthquake hazard estimation.

In view of quality and quantity of available urban area data, this study is proposing a systematic methodology of automated model construction, based on a meta-modeling theory that produces an analysis model consistent with a continuum mechanics model or a solid element finite element model. This theory regards an analysis model as genuinely mathematical approximation of a continuum mechanics model. That is, each model solves the same physical problem but applies distinct mathematical approximations.

Using a bridge structure as a specific example, this study is aimed at developing the following three modelings: 1) consistent data conversion from a solid element solution to a beam element solution or vise versa; 2) construction of a simple consistent analysis model which share the fundamental dynamic properties with a continuum mechanics model; and 3) the module that automatically de-codes and interprets a set of digital data of a structure and constructs a suitable consistent model for it. As a vivid example of automated model construction, this study investigates a possibility of making a few models for a large-scale bridge structure which consists of around 20 piers and decks with curved configuration.

The consistent data conversion is made by converting displacement and stress functions of a target structure, when a solid element solution is converted to a beam element solution. The use of stress function is a key in order to make a beam element model (which does not need Poisson's ratio) consistent with a solid element model (which needs Poisson's ration). Cross sectional forces of a solid element model are accurately computed by converting its solution to the beam element solution that accounts for the stress function.

According to the meta-modeling theory, a single or multi-mass spring model is constructed

for a bridge structure. The construction is made mathematically, so that the single or multi-mass spring model shares the natural frequency and mode with a continuum mechanics model. Numerical experiments verify this agreement. It is found that a multi-mass spring model has extra mass or spring which an ordinary model does not have; such mass or spring is deduced according to the meta-modeling theory.

A prototype automated model construction module is developed. This module is able to use two sets of digital data of a bridge structure, and to generate a solid element model, a beam element model, or a single/multi-mass spring model. The quality of these models of distinct fidelity is assured by comparing the fundamental properties and the synthesized response. It is shown that proposed method of automated model construction is able to generate a set of analysis models for seismic structural response analysis, which share more or less common dynamic properties.