別紙４－１（課程博士（英文））

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Abstract（Doctor）

Title of Thesis	Rapid Post-Earthquake Damage Detection of Buildings based on Machine Learning

Approx. 800 words

Currently, the decision-making response to an earthquake is limited by the time since it takes to identify the extent of damage to buildings. This limitation and accuracy rely on various factors, including on-site inspections by professionals, structural analysis from engineering offices, and limited information due to logistical resources. It has been observed in past earthquakes that structural engineering professionals are insufficient to cover the needs of all the affected buildings. Therefore, new technologies such as structural health monitoring and machine learning (ML) can be employed to decrease response time. This research proposes several methodologies to use ML methods and ground and roof sensors to predict damage conditions represented by the maximum ductility ratio, inter-story drift ratio, and absolute acceleration on each floor under earthquake conditions.

Moreover, Incremental Dynamic Analyses of the structures for each case study are carried out to cover elastic and inelastic behavior. Initially, a Lumped Mass Model was used to represent the buildings, and their damage condition was obtained using wavelet spectra as images in the Convolutional Neural Network method. Subsequently, the methodology was improved using Wavelet Power Spectra and a proposed selection of records to increase accuracy. The procedure was applied to three-dimensional frame models of two actual instrumented buildings in Japan and an artificial RC building in order to consider distinct materials, lateral force-resisting systems, and structural configurations. Even though the high accuracy of the previous methodology, it was updated to predict new earthquakes of different characteristics (without a selection methodology), obtain information on the main predicting features, and reduce the bias from splitting training and validation records by using seven ML methods and 27 Intensity Measures (IM) and applied to the two buildings in Japan. Later, a new methodology based on the previous ML and IMs is proposed to predict new buildings and earthquakes. It was applied to 600 buildings of a moment-resisting frame system archetype. The archetype is designed using the virtual work method. For all the methodologies, high accuracy with low splitting dispersion of the predictions is obtained, and the building's post-earthquake condition is possible to detect immediately since the ML is trained and validated beforehand.

The results will be helpful for countermeasures after an earthquake, such as evacuating buildings, resuming economic and social activities, and mitigating future damage by aftershocks.