（ 続紙 1 ）

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論文題目	Challenges and Potentials of Retrofitting Masonry Non-Engineered Construction in Indonesia（インドネシアにおけるノンエンジニアド組積造建築の耐震補強の課題および展望に関する研究）		

（論文内容の要旨）

Indonesia has a large stock of non-engineered masonry, which are often without appropriate reinforcement, and consequently become highly vulnerable to earthquakes. The high demand for new masonry houses, together with a limitation on the resources available, including finance, skills, and building materials, resulting in poor workmanship and poor quality of construction. The general tendency has been that the overall standards are decreasing over years. The objective of the study is to find some means and methods to improve the present construction and the quality of related materials with local labor under minimal supervision and most suitable to the local culture, particularly in Indonesia. The main aim is to save human life; and therefore, it is assumed that part of the structures might be damaged when shaken by earthquakes, but the structure do not collapse and kill people.

This dissertation is divided into six chapters. Chapter 1 gives an overview of the dissertation. In this chapter, the background, objective, methodology, and literature study are presented briefly.

In Chapter 2, the earthquake problems in Indonesia are elaborated. It is observed that considerable research and available guidelines regarding non-engineered construction are available since almost 35 years. However, until today, Indonesia is still experiencing damages of non-engineered construction that caused large number casualties and economic losses during destructive earthquakes. The problems are reviewed so that the necessary actions can be taken to prevent and/or reduce damage and casualties caused by the next earthquakes.

Chapter 3 describes the definition, the history and types of non-engineered construction in Indonesia. From this chapter, the dissertation focuses on masonry construction; the type of non-engineered constructions which suffered most damages and collapses due to earthquakes. Earthquake resistant design feature is described, namely half-brick thick masonry buildings with reinforced concrete framing, consisting of the so called “practical columns and beams”. The characteristics of masonry as a composite structure made of masonry units and mortars and some issues that should be considered to build earthquake resistant masonry buildings are also elaborated briefly. Some experiments of non-engineered masonry construction are presented to prove the appropriateness of construction methods. Chapter 3 also describes the general causes of damage and collapse of the masonry buildings during earthquakes; mostly due to poor quality of materials and poor workmanship. At the end, issues related to non-engineered construction in Indonesia are presented.

In Chapter 4, design basis of non-engineered constructions is described. Observations from survey of past earthquake damages of non-engineered constructions serve as a basis on how to design non-engineered constructions.

The investigations of past earthquakes and their effects on various types of structures have contributed to significant information and knowledge on this regard. The causes and typical damages are explained and analyses of the mechanism of damage are performed. The principle loading that causes damages are identified and also elaborated in Chapter 4. Failure mechanism of non-engineered masonry buildings due to seismic shaking is explained. With the vast development of computing technology and the availability of software, mechanism of damage can be confirmed using computer models. Examples of non-engineered construction analysis and the correlation between the observed damages and the results of the analysis are presented at the end of Chapter 4.

Chapter 5 proposes a simple, affordable, and replicable retrofitting method for non-engineered constructions in Indonesia to reduce future casualties. The step-by-step procedures of retrofitting using ferrocement are elaborated. Applications of sandwich theory for the proposed retrofitting method are described briefly. The brick-wall acts as the core and ferrocement on both sides of the wall act as skin facings. Examples of analysis and design utilizing existing commercial software also are shown in Chapter 5, followed by experiments that were conducted in Japan related to the proposed method.

Finally, Chapter 6 serves as the concluding chapter, which describes what still have to be done to make the proposed retrofitting method easier, less costly, and can be applied in other developing countries. Disaster risk reduction training programs should be effective using a multi-sectoral approach. The trainings for disaster risk reduction for each target groups (policy makers, national planners, project staff, community groups, NGOs, and trainers themselves) are explained. Finally, this chapter outlines some recommendations as the way forward to improve disaster risk reduction in Indonesia.

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（論文審査の結果の要旨）

本論文は、開発途上国に多数存在するノンエンジニアド組積造建築の地震脆弱性と耐震補強に関し議論するものである。ケーススタディとして、インドネシアのノンエンジニアド組積造建築物の地震脆弱性と耐震補強にかかる課題を調査・分析し、同様の建築様式を有する他の国でも適用できる低コストの耐震補強技術を提案した。本論文では、１）インドネシアにおけるノンエンジニアド組積造建築の現状と過去の地震による被害の分析、２）ノンエンジニアド組積造建築の地震時の挙動に関する分析、３）ノンエンジニアド組積造建築物の耐震補強の手法および他地域への適用について議論・分析を行った。本論文における評価するべき主な点は次の通りである。

1. インドネシアにおけるノンエンジニアド組積造建築物の施工実態及び過去の地震による被害を分析し、建物の耐震性に建築資材の品質と施工方法、建設労働者の技量が大きく影響していることを明らかにした。建築物の耐震性は、煉瓦の形状の均一性や強度、砂・セメント・水の配合割合、粗骨材の形状、鉄筋の適正な配置及び緊結などと関係していることを詳細な観察と実験により検証した。また、建設労働者の多くは未熟練工で、災害後に収入を求め転職した者も多いため、耐震性の低い建築物が多数存在することも指摘した。
2. ノンエンジニアド組積造建築の適切な施工方法等を示す、技術ガイドラインを提案した。ノンエンジニアド組積造建築の挙動と崩壊メカニズムを実物大試験および三次元分析などの実験により解析し、同ガイドラインで建設された建築物は、耐震性が高いことを検証した。
3. 安価な建築資材と施工、短い施工期間、現地で調達可能な資材の利用、最低限の技術支援で家主が活用できる技術といった条件を満たす、ノンエンジニアド組積造建築物の耐震補強のための実用的な技術を提案した。この技術は同様の建物が多数存在する途上国においても、適用可能である。
4. 他の開発途上国に耐震補強の技術を適用するため、法律の施行、地方自治体の強い意志と動機づけ、建設関連部局の役割の明確化、施工時と施工後の検査、耐震補強技術の検査、建設労働者へのトレーニングおよび家主への啓発に関する提案を行った。

ノンエンジニアド組積造建築の地震に対する脆弱性と耐震補強に関する詳細な研究は限られている。本論文は、資金や技術が限られている開発途上国の状況を踏まえた手法を開発し、実践的な各種試験を行い、低コストの耐震補強技術を提案した。研究成果は、ケーススタディとして取り上げられたインドネシアと同様の状況にある他の地域の問題解決にも参考、適用できるものと考えられる。よって、本論文は博士（地球環境学）の学位論文として価値あるものと認める。また、平成26年4月1日、論文内容とそれに関連した事項について試問を行った結果、合格と認めた。

要旨公開可能日：　　年　　月　　日以降