別紙４－１（課程博士（英文））

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Abstract（Doctor）

Title of Thesis	**Seismic Performance and Vulnerability Assessment of Reinforced Concrete Structures with Infill Masonry Walls in Afghanistan**

Approx. 800 words

Afghanistan, a seismically active region characterized by frequent and severe earthquakes, faces substantial risks to its built environment. The vulnerability of reinforced concrete (RC) buildings, which constitute a significant portion of the country's infrastructure, is heightened by the absence of standardized seismic design codes, comprehensive seismic analysis methodologies, and systematic damage evaluations. Furthermore, the prevalent use of non-structural infill walls, often disregarded in structural analysis, poses additional challenges. Although not considered in conventional design practices, these walls have the potential to enhance and impair seismic performance due to their complex interaction with RC frames during seismic events. This research addresses these gaps by investigating the seismic performance of RC buildings and the damage probability associated with such structures in Afghanistan.

The study begins with a problem statement highlighting the critical issues facing Afghanistan's construction industry: the lack of standardized seismic design codes, inadequate seismic analysis, insufficient damage evaluation frameworks, and the widespread use of non-structural infill walls that are not accounted for in the design process. These factors contribute to the significant vulnerability of RC buildings to seismic damage, as evidenced by past earthquake events that have resulted in extensive loss of life, property damage, and economic disruption. The research, with its potential to revolutionize seismic design practices, aims to provide a comprehensive understanding of the seismic behavior of RC buildings, considering the contribution of infill masonry walls, and to develop tools and methodologies that can enhance the resilience of urban infrastructure in the region.

To achieve these objectives, the study employs a robust research methodology that integrates both analytical and empirical approaches. The nonlinear earthquake response analysis is conducted using STERA 3D software to evaluate the seismic performance of RC buildings with and without infill masonry walls. Incremental dynamic analysis (IDA) is utilized to develop fragility curves that assess the damage probability of RC structures under varying seismic intensities. Additionally, a comprehensive database of low-rise RC buildings constructed between 2001 and 2022 across different regions of Afghanistan is compiled and analyzed. This database, with its thoroughness, includes diverse structural and architectural characteristics, such as varying materials, construction years, and geographic locations. A modified version of the Japanese Is Index method is adapted to local conditions, leading to the development of the Afghanistan Seismic Index (ASI), a tailored tool for assessing

seismic vulnerability and guiding future construction standards.

The findings of this research are significant as they provide valuable insights into the seismic behavior of RC buildings in Afghanistan. The study demonstrates that the presence and configuration of infill masonry walls significantly affect the seismic performance of RC structures. Contrary to the traditional assumption that these walls are non-structural, the results reveal that infill walls can enhance or impair the seismic response, depending on their design and integration with the RC frame. Buildings with well-integrated infill walls show reduced inter-story drift, lower damage indices, and improved overall performance under seismic loads. Conversely, buildings with inadequately designed or poorly integrated infill walls may experience localized damage, such as shear failures and out-of-plane collapses, which compromise the structural integrity and increase the risk of collapse. These findings can potentially inform future policy developments and engineering practices, fostering a culture of seismic resilience in Afghanistan's construction sector.

Second, the research uncovers significant variations in the damage conditions of RC structures across different geological regions in Afghanistan. The damage probability assessment reveals that buildings located in high seismic zones, such as those near active fault lines in the Hindu Kush Mountain range, are more susceptible to severe damage. The fragility curves developed from the IDA indicate that newer RC buildings, designed with enhanced seismic considerations, generally exhibit lower damage probabilities compared to older structures. However, the study also highlights that even recent constructions may be vulnerable if they do not adequately account for local seismic conditions and fail to incorporate the benefits of properly designed infill walls.

Based on these findings, several key recommendations are proposed to improve the seismic resilience of RC buildings in Afghanistan. First, it is suggested that the seismic contribution of infill masonry walls be explicitly considered in the structural design process. This includes developing new design guidelines incorporating infill walls' stiffness, strength, and energy dissipation characteristics to optimize their beneficial effects while minimizing potential risks. Second, the study advocates adopting the Afghanistan Seismic Index (ASI) as a standard tool for evaluating the seismic vulnerability of buildings. The ASI, tailored to local conditions and validated through empirical data, offers a comprehensive metric for assessing structural performance and guiding retrofitting and strengthening efforts.

Furthermore, the research emphasizes the urgent need for establishing standardized seismic design codes and damage evaluation frameworks specific to Afghanistan’s unique seismic environment. This involves integrating global best practices with local knowledge to develop a resilient and context-sensitive approach to earthquake-resistant design. The implementation of these recommendations is expected to significantly enhance building safety, reduce economic losses, and protect human lives in Afghanistan’s earthquake-prone areas.

In conclusion, this dissertation significantly contributes to knowledge on seismic performance and damage probability assessment of RC buildings in seismically active regions. By addressing the current gaps in design standards, analysis methodologies, and damage evaluation practices, the study provides a comprehensive framework for improving the resilience of RC structures in Afghanistan. The proposed ASI and the integration of infill masonry walls into the design process represent significant advancements in mitigating seismic risks and enhancing the safety and durability of the built environment. These findings are anticipated to profoundly impact future policy developments, guide engineering practices, and foster a culture of seismic resilience in Afghanistan’s construction sector.