# 論文 / 著書情報
# Article / Book Information

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# 論 文 要 旨

THESIS SUMMARY

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| 系・コース：<br>Department of, Graduate major in | Civil & Env. Engg.<br>Civil Engineering 系<br>コース | 申請学位（専攻分野）：<br>Academic Degree Requested | 博士<br>Doctor of (Philosophy) |
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要旨（和文 2000 字程度）
Thesis Summary（approx.2000 Japanese Characters ）

The steel bar corrosion is considered as the significant degradation issue of reinforced concrete structures, which may lead to premature failure during a seismic event. In a chloride rich environment, chloride ions may locally disrupt the passivating film and cause steel bar corrosion with local or non-uniform distribution. In addition, there might be a difference in ambient environments, consequently, the steel bars in RC structural members might be subjected to the spatial variation of corrosion damage or non-uniform steel bar corrosion. Here, non-uniform corrosion of steel bars is divided into four different categories: (a) non-uniform corrosion without corrosion pit (b) non-uniform corrosion with corrosion pit (c) cross-sectional non-uniform distribution of steel bar corrosion, and (d) one-sided steel bar corrosion. In this study, the coupled effect of non-uniform steel bar corrosion and seismic force on the structural performance of RC structures was investigated by developing a three-dimensional numerical model and experimental program.

The study first examined the effect of non-uniform steel bar corrosion with corrosion pit on the structural performance of RC beams. Seven reinforced concrete beams with identical dimensions and reinforcement layout were tested under static loading. While six RC beams were subjected to different levels of non-uniform steel bar corrosion, and another beam was used as a control specimen without corrosion. The obtained results indicated that non-uniform steel bar corrosion with corrosion pit adversely affects the ductility and load-carrying capacity of the RC beams. In particular, the specimen with 28% steel bar corrosion displayed 57% less

ductility than the specimen with 26% steel bar corrosion. This behaviour can be attributed to the localized yielding and early rupture of the steel bar at the deeper corrosion pit.

A numerical model was developed using the three-dimensional finite element method (FEM) to predict the structural performance of RC beams with non-uniform steel bar corrosion. The numerical model was developed accounting for corrosion-induced cracking, changing the property of concrete and steel, and modifying the bond between steel and concrete. The FE model was validated using the experimental result obtained from this study and the results from experimental tests on corroded RC beams available in the literature, with various average corrosion ratios ranging from initial to severe levels. The obtained results from the proposed numerical model demonstrated an excellent correlation with all the experimental results making it suitable to investigate the seismic behaviour of corrosion-damaged RC beams in terms of stiffness, strength, displacement capacity, and cracking pattern.

The cyclic behaviour of non-uniformly corroded RC members under axial loading was investigated by experimental program. One specimen was subjected to non-uniform steel bar corrosion, and another specimen was kept undamaged. The RC members were subjected to an axial load equivalent to 5% of the capacity. It was observed that cross-sectional and spatial non-uniform distribution of steel bar corrosion results in a significant difference in structural behaviour i.e., yield load, ultimate load, stiffness, cumulative energy dissipation in the negative and positive loading cycle. It was also found that external axial loading might have a positive effect on the ductility of the RC members.

The numerical model for RC beams was modified and extended, and FEM analysis was carried out to understand the coupled influence of corrosion damage and seismic force on the cyclic behaviour of RC columns. In the modified model, corrosion-induced cracking and bond deterioration between steel and concrete was considered depending on the spatial variation of steel bar corrosion. The numerical model was validated using the results obtained

from three different sets of experimental tests available in the literature with various average corrosion ratios ranging from initial to severe levels. After the validation, the numerical model was used to investigate the effect of localized corrosion on the cyclic response of RC columns. The FEM analysis indicated that the formation of a smaller number of corrosion pits results in a shorter plastic hinge length of RC columns and leads to reduced plastic deformation capacity and reduced displacement capacity.

Two simplified approaches were presented to assess the seismic vulnerability of the corrosion-damaged RC bridge piers and RC buildings. For RC bridge piers, non-linear static pushover analysis was carried out by simplifying the numerical model developed in this study. Thereafter, seismic fragility analysis of RC bridge piers was carried out by defining three different damage states. For RC buildings, corrosion damage was modelled using the plastic hinge concept. Seismic fragility analysis of RC buildings was carried out based on the static pushover analysis. Obtained results indicated that steel bar corrosion significantly increases the risk of seismic fragility of the RC structures.

The findings of this study will be useful in assessing the residual structural performance and seismic vulnerability of the RC structures with non-uniform steel bar corrosion and help the infrastructure owners with the optimization of maintenance and repair strategies.