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学位論文題目	Investigations on Rupture Mechanism of Stirrups Due to ASR (ASR による鉄筋破断メカニズムの研究)
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学　位　論　文　内　容　の　要　旨

Due to ASR, extensive expansion generated, which induced ruptures in corner stirrups of bridges in Japan. Concerning the stirrup rupture, initiating crack was observed to produce in corner stirrup caused by the bending process. Further, to study how the initiating crack propagated to rupture, the actual stirrup motion and the generation mechanism of it were tried to understand clearly.

The most significant topics were determined as followings:

Topic 1: To find out the real stirrup motion with its influence on propagation of initiating crack, the study for performance of stirrup was carried out.

Topic 2: To learn about the casual factors for deformation condition of stirrup, generation mechanism of circular-arc deformation was evaluated.

This thesis included total 6 chapters:

Chapter 1 introduced the entire research background and objective on rupture of stirrup. The research topics were also introduced.

Chapter 2 gave the literature reviews mainly about the mainstream estimation for rupture mechanism, initiating crack in stirrup, motion of stirrup and progress of initiating crack, respectively.

In Chapter 3, results for 6 simulation specimens (Case 11 to Case 16) were evaluated. Case 11 & 13 were set as the standard case with identical stirrup ratio 0.22% to the actual pier beam, expansion amount as 1444cm2 and size of frame concrete as 150mm. By increasing stirrup ratio to be 0.39%, Case 12 was manufactured. Case 15 adopted the stirrup ratio as 0.31% in the middle level.

Simultaneously, Case 14 applied larger expansion amount as 2019cm2 than the standard. Case 16 used greater size of frame concrete as 230mm.

It was noted that greatest cracking density, strain and deformation amount occurred for Case 14 with stirrup ratio and size of frame concrete in smaller level. Further, brittle rupture surfaces similar to ASR-influential structures mainly generated for rebar with rib in steep slope for Case 13, 14 & 16. Besides, all specimens show the similar longitudinal cracking and circular-arc deformation to ASR-influential structures.

In Chapter 4, experimental results of Case 14 & 16 in greater expansion amount were discussed as representative. For the Topic 1, angular opening of corner stirrup was confirmed as 1.9° to be avg. of 16 corners from Case 16. Besides, initiating cracks were confirmed as 2.56% to the diameter of stirrup in avg. before expansion. Subsequently, caused by the angular opening of corner stirrup, initiating cracks were progressed to 17.7% in avg. of Case 14 & 16. Corresponding to the Topic 2, the entire deformation was classified as circular-arc deformation and uniform elongation, with the max. as 5.0mm and 3.3mm as avg. of Case 14, respectively.

In Chapter 5, FEM analysis was carried out based on Case 14 which suffered the most severe concrete damage. Regarding the Topic 1, increase of angular opening for corner stirrup was also verified with the max. as 2.5°. For the Topic 2, circular-arc deformation of 4.7mm and uniform elongation of 2.6mm was validated, respectively. On the basis of analysis, owing to the effective confinement from stirrup in corner area, expansion is relatively small (avg. increment of element size as 0.12mm, 2.6mm in total for 22 elements). Whereas, owing to the weak confinement from stirrup in central area, max. expansion was resulted (avg. increment of element size as 0.33mm, totaling 7.3mm for 22 elements). Therefore, circular-arc deformation was resulted as the difference value induced by different confinements from stirrup.

In Chapter 6, conclusions drawn based on this study were summarized.

学 位 論 文 審 査 の 結 果 の 要 旨

Accordingly, this study has simulated effects from ASR expansion on stirrup rupture. Regarding the Topic 1, from both experiment and analysis, angular opening of corner stirrup was validated and verified to be very crucial for progress of initiating cracks in stirrup. With respect to the Topic 2, circular-arc deformation was confirmed by both experiment and analysis and was estimated to generate

based on the different confinement of the stirrup in different area. Thereby, this thesis is recognized for having satisfied the requirement for doctoral thesis.

Additionally, comprehension was able to be obtained by appropriately answering the questions from members of the dissertation committee and other attendees in the final examination.

Based on the aforementioned results, this dissertation committee herein approves that this candidate is qualified in the final examination.