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学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Mechanical behavior of reinforced concrete beams with locally corroded shear reinforcement
(局所的に腐食したせん断補強鉄筋を有する鉄筋コンクリートはりの力学特性)

Corrosion of steel reinforcement is one of the major causes of damage of reinforced concrete structures. Corrosion products formed have a volume six times more than the steel, which exerts pressures on the surrounding concrete. The pressure leads to cracking and spalling of cover concrete, deteriorates the bond between the steel reinforcement and concrete, and finally reduces the ultimate strength which sometimes result in brittle failure. A lot of research have been carried out to understand the detrimental effects of corrosion of flexural reinforcement in reinforced concrete beams. A large number of experimental studies have shown that the corrosion of flexural reinforcement considerably reduces load-carrying capacity and ductility. However, shear reinforcement (stirrup) has not been given much consideration and there is not much literature available on the effects of corrosion of stirrup. Therefore, in this study, a detailed experimental research has been conducted to observe the behavior of reinforced concrete beams with locally corroded stirrup.

Thirty-nine beams of 1800 mm long, 100 mm wide and 150 mm high were casted, and corrosion of stirrup was electro-chemically accelerated. The beams before suffering from stirrup corrosion were designed to show the flexural failure mode or the shear failure mode. For this purpose, three kinds of flexural reinforcement were used; two D10, two D13 and two D16 mm, all of which were epoxy-coated to avoid corrosion. The stirrup was 6 mm in diameter with the spacing of 80 mm, 120 mm and 160 mm. The location of stirrup corrosion is also a significant factor in this research; accordingly, stirrup was locally corroded in the shear span, in the middle span, or the full span while using 120 mm stirrup spacing. Mild and severe corrosion levels were prepared, mass loss of which were 10% and 20%, respectively. After the corrosion accelerating treatment, corrosion cracks were marked and their widths were measured to observe their distributions and influences on flexural cracking in the bending test. Four-points bending test was applied to observe the ultimate strength of the corroded beams. Finally, the stirrup was taken out to check the degree of corrosion.

It was found that the most of the corrosion cracks lie in the crack width range of 0.03-0.059 mm, which is the narrowest crack width range. The corrosion cracks in the severely corroded beams were more, and wider cracks were observed as compared with the mildly corroded beams. At the critical locations, the corrosion cracks acted as the pre-defined failure paths and the flexural or shear cracks followed the corrosion cracks during the bending test. The flexural or shear cracks were wider in the corroded beams than those generated in the control beams.

Although stirrup is not responsible for flexural capacity but the results showed reduction in the flexural capacity after corrosion of stirrup. In all cases, the beams with stirrup corrosion showed more flexural capacity than the control beams did. The reduction in the flexural capacity observed was more

in the beams where the stirrups were corroded in the full span and the shear span for mild and severe corrosion. The stirrup in the middle span did not contribute to flexural capacity of beams, as there is zero shear force in the middle span. However, the stirrup corrosion induced the corrosion cracks in the middle span, and was mainly responsible for reducing the flexural capacity of the corroded beams. It was also observed that the strength loss of corroded beams was more for the closely spaced stirrup. When the stirrups were closely spaced, the strength contribution from the stirrups was more and once they got corroded, the strength loss observed was also more.

The failure modes of the corroded beams were also changed particularly when the stirrup was severely corroded. Depending on the location of corrosion, most of the severely corroded beams failed in shear despite having yielding of flexural reinforcement for the control beams. The beams failed in shear had higher capacity loss than those failed in flexure. The flexural stiffness of beams with D16 flexural reinforcement was more affected due to stirrup corrosion. Hence, the stirrup corrosion strongly influences the capacity of the beams, which depends on the location and the amount of corrosion. The results show that the stirrup spacing and the locations of stirrup provided should be chosen carefully when the steel reinforcement is prone to corrosion. The stirrup corrosion has a strong tendency to change the failure mode and even to reduce flexural capacity of reinforced concrete beams.