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Study on Ductile Property of Corroded Reinforced Concrete Beam

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ABSTRACT

Ductility of corroded doubly reinforced concrete beam sections with a range of reinforcement corrosion and concrete degradation was studied. The ductility of reinforced concrete beams corroded by sulfate (SCRCB), in which the normal assumptions of plane section behavior held true, and chloride (CCRCB), in which the normal assumptions of plane section behavior did not hold true, was discussed. Based on mechanical tests on the corroded beams, the section analysis method and fractal theory were applied to study the ductility of corroded beams. A simplified expression is proposed to predict the ductility factor for corroded beams. A relationship between the fractal dimension and the ductility factor of the beam was found.

KEY WORDS: corrosion; sulfate; chloride; ductility; yield curvature; ultimate curvature; fractal dimension

INTRODUCTION

To survive severe earthquakes, structures designed to the level of seismic loading recommended by codes need to be capable of ductile behavior at the critical sections while undergoing horizontal displacements in the inelastic range (Park, 1988). Reinforced concrete is one of the most durable construction materials. However, field surveys indicated that owing to various corrosion effects, many reinforced concrete structures exposed to aggressive environments (e.g. marine environment, chemical environment, etc.) have shown early deterioration including sudden failures. This indicates that corrosion will result in the degradation of the ductility of the RC member, and the failure mode of the corroded reinforced concrete (CRC) member will change from ductile to brittle. Such brittle failures will affect the load capacity of the structure, leading to possible casualties and huge financial loss. With the gradual increase of corrosion loss worldwide, the durability of RC structures in aggressive environments has become and will long be a research concern. Recently, large numbers of experiments have been performed to study the mechanical properties of CRC members (including CRC beams and columns) (Ballim, 2003; Yoon 2000). Based on the experimental results, load carrying capacities for the CRC beams were studied. Some simplified models were put forward for strength capacity prediction. From the experimental results, it can also be concluded that the ductility of CRC members would degrade.

For structural design and the constructive measurement, ductility of the structure is the accordance to establish the reliability index. Therefore, some studies have focused on the ductility of reinforced concrete beams. Assuming the concrete to be unconfined, the ductility of doubly reinforced concrete beam sections with a range of tension and compressive steel ratios and strength of steel and concrete were investigated (Park and Dai, 1988). Fukumoto (2000) analyzed the reduction of ductility factors due to difference between actual yield stress and nominal design value for the compact plate element. Based on the beam tests conducted by various authors, the influence of lateral confinement by stirrups, longitudinal strain gradient, size effects, concrete strength and nature of loading on the ductility rectangle reinforced concrete beams were studied (Kemp, 1998). Modeling the material properties as random variables and assessing their effect on section behavior through fibre modeling and the Response Surface Methodology, the ductility of reinforced concrete beam cross-sections with varying geometries and levels of confinement was investigated (Kappos,1999). Taking the effects of concrete confinement and spalling of the concrete cover into consideration, an algorithm and simplified formulas for estimating the relationship between the tension reinforcement and ductility of RC beams are presented (Lee, 2003). Lee (2004) investigated the load capacity, ductility and energy absorption aspects of reinforced concrete beams retrofitted with sprayed fiber-reinforced polymer composites (SFRP).

DUCTILITY OF RC BEAM CORRODED BY SULFATE

Comprehensive tests (including tests on mechanical properties of materials, tests on bond strength between reinforcement and concrete and tests on the load carrying capacity of the beams) were performed on the CRC beams, which had been corroded by sulfate for more than 10 years (Yoon, 2000). Experimental results showed that, for the SCRCB, expansive internal stress in concrete occurred and compressive strength of concrete had degraded, reinforcement in the concrete was corroded to some degree, bond strength between reinforcement and concrete was degraded slightly, and little slip