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Autor: García, Dolores / Gutiérrez, José Pedro / Rodríguez, Jesús
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Mechanical Properties and Bond Behaviour of Corroded Deformed Bars

Dolores GARCÍA
Dr Architect
Inst. of Constr. Science
Madrid, Spain

José Pedro GUTIÉRREZ
Dr Engineer
Inst. of Constr. Science
Madrid, Spain

Jesús RODRÍGUEZ
Dr Engineer
GEOCISA
Madrid, Spain

Summary

An experimental investigation of the effect of corrosion on the mechanical properties and bond behavior of deformed reinforcing bars is presented. Tensile tests on corroded rebars through an accelerated process and bond tests on concrete specimens reinforced in all four corners were carried out. Results indicate that corrosion affects ductility of steel, decreasing bar elongation at maximum load. Too corrosion affects steel-to-concrete bond, but the presence of stirrups improves significantly bond behavior of corroded reinforcing bars.

1. Experimental Program

Fresh and corroded deformed bars with diameters of 12 and 20 mm respectively were tested in tension to determine yield strength, tensile strength and elongation at maximum load. For corroding the samples, a direct current of a 1mA/cm^2 density was impressed on the rebars immersed in 3% weight of NaCl solution or fresh water. These media reproduce, to a certain, the aggresive environment of a completely carbonated concrete and a chloride-contaminated concrete respectively. Several levels of corrosion were examined: no corrosion, corrosion associated to cross section losses from 7% to 20% and corrosion associated to cross section losses higher than 25%.

Pullout bond tests were carried out on 300x350x350 mm concrete specimens with 20 mm diameter bars arranged in the four corners. A cover to diameter ratio of 1.5 was examined and the embedded length was 14ϕ in all cases. The test method used simulates anchorage conditions in a part of a beam submitted to constant shear force, and allows to reproduce the most usual bond failure on reinforced concrete structures: splitting failure in the concrete cover (Fig.1). For corroding the rebars the concrete in which they were embedded was contaminated with 3% calcium chloride by weight of cement and later a direct current of a 0.1 mA/cm^2 density was impressed on each bar embedded in the pullout specimens. Several corrosion levels were reached producing crack widths ranging from 0.1 mm to 0.4 mm and cross section loss up to 5%. Various amounts of transverse reinforcement were also arranged: no stirrups, ϕ6 mm stirrups at 200 mm and ϕ8 mm stirrups at 10 mm.

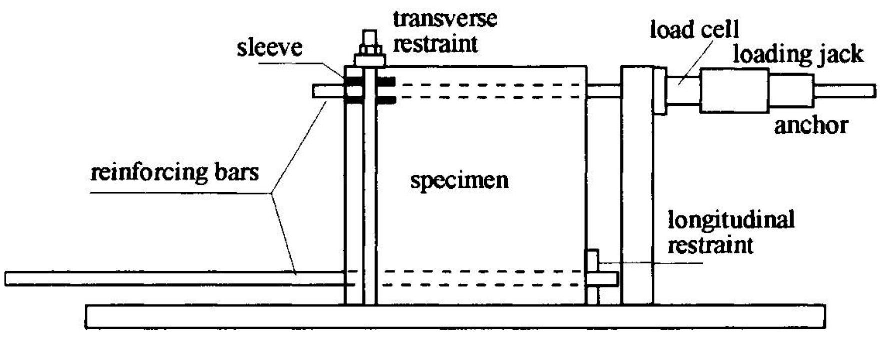

Fig 1. Bond test arrangement

2. Results and Discussion

The results of tensile tests hint yield stress and tensile stress do not decrease for cross section losses lower than 20%, corrosion range that includes the majority of actual cases of generalized corrosion. On the other hand, a systematic and important reduction of elogation at maximum load was observed both for rebars corroded in water with chlorides and those damaged in fresh water (Fig. 2). The results indicate reductions of elongation at maximum load of about 20% for cross section losses of 10%. When corrosion level achieves values about of 25%-30%, elongation at maximum load decreases 40% aproximately.

Pullout bond tests allowed to study the influence of bar cast position (top or bottom) and amount of transverse reinforcement on the bond strength of corroded rebars. As for the influence of the bar position, in noncorroded specimens the average values of bond strength for top bars were about 15%-20% lower than for bottom ones. Nevertheless, in corroded specimens a net diference between bond strength values of bottom and top bars was not observed, with the same specimen shape and corrosion level.

As for the influence of the amount of transverse reinforcement, the tests of specimens with no stirrups confirmed bond stregth is significantly reduced when corrosion takes place. On the other hand, the presence of stirrups improves considerably bond behavior of rebars damaged by corrosion. Thus, the presence of transverse reinforcement allows to count on residual bond strength at least equal to 1,6 Mpa, even for small amounts of stirrups.

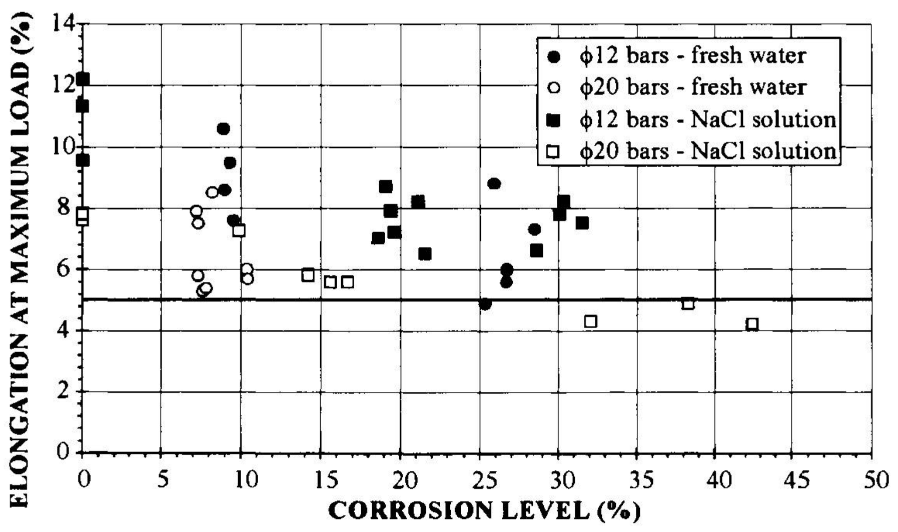

Fig 2. Relationship between elongation at maximum load and corrosion level