Assessment of Anchorage Capacity of Naturally Corroded Reinforcement

Mohammad TAHERSHAMSI
M.Sc.
Chalmers University of Technology
Gothenburg, Sweden
mohammad.tahershamsi@chalmers.se

Kamyab ZANDI HANJARI
Ph.D.
CBI Swedish Cement and Concrete Institute
Borås, Sweden
kamyab.zandi@cbi.se

Karin LUNDGREN
Professor
Chalmers University of Technology
Gothenburg, Sweden
karin.lundgren@chalmers.se

Mario PLOS
Associate Professor
Chalmers University of Technology
Gothenburg, Sweden
mario.plos@chalmers.se

Summary

In this study, the anchorage capacity of naturally corroded reinforcement was investigated. Fourteen specimens with different degrees of corrosion-induced damage were taken from northern edge beams of Stallbacka Bridge in Sweden. All damage including cracking and cover spalling were carefully documented before testing. A four point bending test with suspension hangers at the supports was utilized. In all experiments, diagonal shear cracks preceded the expected splitting-induced pull-out failure. The anchorage behaviour was monitored through measurements of the applied loads, deflections and main bar slips. Combined with the authors' previous findings, these results increase the knowledge regarding the structural behaviour of corroded reinforced concrete.

Keywords: Natural corrosion, anchorage, bond, reinforced concrete beam test, structural behaviour.

1. Introduction

Deterioration of concrete members caused by reinforcement corrosion has always been a major issue in existing structures. Embedding steel reinforcement bars in concrete enhances both strength and ductility if the bond and anchorage are sufficient [1]. However, the initiation of corrosion in steel bars can lead to reduction of load-carrying capacity [2], so models are needed for estimation of remaining bond and anchorage capacity. Existing analytical and numerical models have been mostly developed based on experimental investigations of artificially corroded samples. Experimental evidence in the literature shows that common methods of accelerated induced corrosion may influence the bond capacity [3, 4]. Creating the corrosion at a fast rate is a rather strong justification for using artificially corroded samples. Therefore, in this work, the anchorage capacity of naturally corroded steel reinforcement was investigated experimentally using fourteen specimens with varying degrees of corrosion.

2. Experiments

Naturally corroded specimens were obtained from the northern edge beams of Stallbacka Bridge in Sweden. Due to poor structural design of the slabs and the edge beams, large cracks had propagated that allowed the penetration of de-icing salt chlorides which facilitated the corrosion mechanisms. The edge beams showed different degrees of corrosion-induced damage, from no corrosion to extensive concrete cover cracking resulting in cover spalling. Based on the damage patterns; the test specimens were classified into three different groups: Reference (R) specimens with no visible cracks; Medium (M) with corrosion-induced cracks and Highly (H) damaged specimens with concrete cover spalling. Dimensions of the specimens and the test set-up are shown in Fig.1. Discussion of the test set-up configuration is provided in the full version of the paper.

https://doi.org/10.2749/222137813806521450

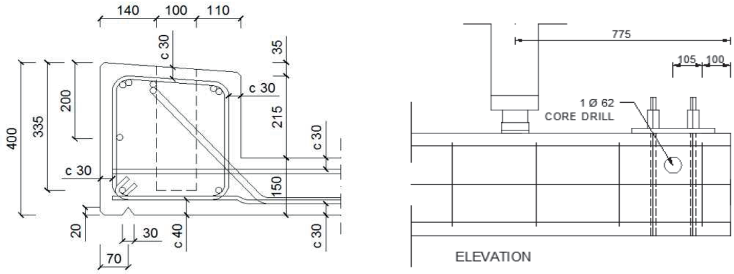

Fig. 1: (a) Cross-section of the edge beams (b) details of the test set-up and the strengthening bars.

3. Results

The fourteen test beams all showed similar behaviour in terms of crack development and failure mode. After the propagation of the flexural and inclined flexural-shear cracks, the anchorage was effectively loaded and the bond capacity came to play an important role. The free-end sections of the tensile bars began to slip at load levels of 190-210 kN obtained from each of the hydraulic jacks. The final anchorage failure took place, on average, at a load level of 281,1 kN for the reference beams (R), 257,2 kN for the medium damaged beams (M) and 265,9 kN for the highly damaged beams (H), see Table 1. More results are provided in the full version of the paper.

Table 1. Maximum failure loads obtained in the experiments.

Beam	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	Avg.	S D
Units						kN					
(R)	240,1	-	322,0	-	-	-	-	-	-	281,1	57,9
(M)	263,0	280,9	178,5	243,3	326,8	234,2	264,9	263,2	259,9	257,2	39,5
(H)	-	307,6	234,9	255,3	-	-	-	-	-	265,9	37,5

4. Conclusions

Fourteen indirectly supported beams with different levels of natural corrosion damage were tested in four-point bending. In all tests, diagonal shear cracks preceded a splitting-induced pull-out failure; i.e. anchorage failure was achieved as intended. The preliminary results show around 7% lower load-carrying capacity for the corroded specimens than for the reference ones. Since the available anchorage lengths varied, more thorough evaluations of the test results are needed to draw further conclusions regarding the anchorage capacities in different categories. The average values of the maximum failure loads for the medium and highly damaged beams were similar. Since quite large scatter was found in this work with test specimens taken from the existing bridge, more detailed analysis is planned. The tests will be evaluated with detailed nonlinear finite element modelling, using earlier developed bond and corrosion models.

5. References

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