CRIMSON PUBLISHERS
Wings to the Research

Evolutions in Mechanical Engineering

ISSN: 2640-9690

Mini Review

Challenge in Structural Behaviours of Corroded Pre-stressed Concrete Beams

Lei Wang*

Changsha University of Science and Technology, China

***Corresponding author:** Lei Wang, Changsha University of Science and Technology, No. 960 Wanjiali Road, 410114, Changsha, Hunan, China

Submission: August 01, 2018; **Published:** August 13, 2018

Abstract

Strand corrosion is one of the main causes for the deterioration of Pre-stressed concrete structures. Corrosion decreases strand cross-section, causes material deterioration, induces concrete cracking, degrades bond strength and deteriorates the capacity of PC beams. As the high-stress level of pre-stressing strand, strand corrosion causes a brittle failure of PC beams without warnings. The potential dangers of corrosion in PC beams would be much more severe than that in reinforced concrete members. The structural behaviors should be thoroughly investigated to insure the serviceability and safety of corroded PC beams.

Keywords: Pre-stressed concrete beams; Strand corrosion; Concrete cracking; Bond strength; Structural behaviors

Mini Review

Pre-stressed concrete (PC) has been widely used in engineering structures due to its superior performances and high durability. Unfortunately, some failure cases raise concerns over the safety of existing PC structures. For example, the Ynys-Y-G was Bridge in the United Kingdom collapsed in 1985 due to corrosion of post-tensioning tendons after only 32 years of service. Italy's Saint Stefano Bridge failed in 1999, after 40 years of service, due to pitting corrosion of the pre-stressing steel [1,2]. Strand corrosion is one of the main causes for the deterioration of PC structures. Corrosion decreases strand cross-section, causes material deterioration, induces concrete cracking, degrades bond strength and deteriorates the capacity of PC beams [3-5], as shown in Figure 1. AS the high-stress level of pre-stressing strand, strand corrosion can cause a brittle failure of PC beams without warnings. The potential dangers of corrosion in PC beams would be much more severe than that in reinforced concrete members. The structural behaviors should be thoroughly investigated to insure the serviceability and safety of corroded PC beams.

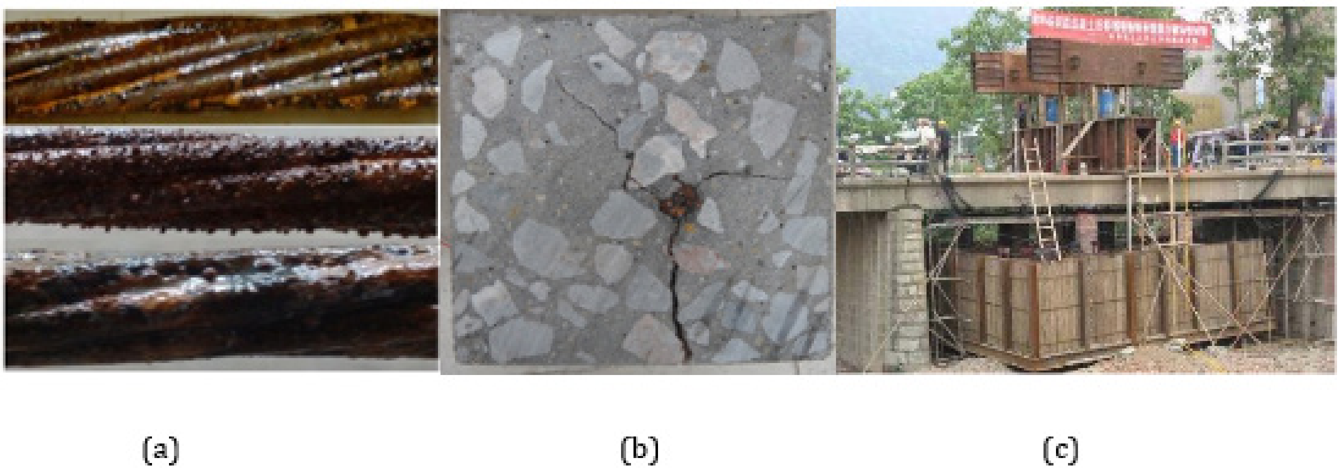

Figure 1: Bridge deterioration caused by strand corrosion: (a) Strand corrosion; (b) Corrosion-induced cracking; (c) Loading test.

Strand corrosion can induce concrete cracking. A considerable number of studies have been undertaken on corrosion-induced cracking in reinforced concrete (RC) structures [6-8]. However, very few works have been reported on corrosion-induced cracking in PC structures. Concrete around the strand would be under a biaxial stress state during the corrosion process; horizontal expansive pressure, and pre-stress in a longitudinal direction [9]. Additionally, a strand consists of several outer wires spiraled around a core wire and has a flower-like cross-section. The high stress level and geometric properties of the strand may lead to the corrosion-induced cracking process in PC structures different from that in RC structures [10]. The strand corrosion-induced cracking mechanism in PC structures has not been clarified, which needs to be investigated further.

Corrosion leads to the cracking of the concrete cover and decreases the cross section of strand. These changes deteriorate the bond strength between strand and concrete. For pre-tensioned concrete structures, the effective bond strength is particularly important as compared to other structures. Many studies have been performed to investigate corrosion's effects on the bond strength between steel reinforcements and concrete in the past few decades [11,12]. However, the material and shape of the pre-stressing strand are very different than those of the steel reinforcements [13]. Thus, corrosion's effects and the existing bond strength models for steel bars may not be suitable for the twisted pre-stressing strand.

Strand corrosion expansion can induce concrete cracking and degrade bond strength, which would further cause the pre-stress loss in corroded PC beams. Numerous studies have been undertaken to assess the effects of concrete creep and shrinkage, and the stress relaxation of pre-stressed strands on long-term pre-stress losses [14,15]. As compared with researches on long-term pre-stress losses, studies regarding corrosion-induced pre-stress loss have been afforded little attention. The evaluation of corrosion-induced pre-stress loss is a complicated issue. Except for the cross-section reduction of corroded strand, concrete cracking and bond degradation can also cause pre-stress loss. Additionally, post-tensioned concrete beams use the anchorage systems to transmit the pre-stress, while the pre-stress in pre-tensioned concrete beams is built through the bond stress at the strand-concrete interface. The pre-stress loss in pre-tensioned concrete beams may be different from that in post-tensioned concrete beams. How to evaluate the pre-stress loss in PC beams caused by corrosive cracking still needs to be studied further.

Corrosion can deteriorate the flexural capacity of PC beams by decreasing strand cross-section, causing material deterioration, inducing concrete cracking and degrading bond strength [16]. Some experimental studies have been undertaken to investigate the flexural behaviors of corroded PC beams [17-19]. Based on the load testing, corrosion effects on concrete cracking, stiffness, ultimate strength, ductility and failure mode of PC beams have been evaluated. However, very few analytical studies have been undertaken to predict the flexural capacity of corroded PC beams. Cavell et al. [20] neglected the effect of bond degradation, and used a strain compatibility theory to study the residual flexural capacity of deteriorating PC beams caused by tendon failure. Wang et al. [21] proposed a strain-incompatibility analysis method to evaluate the flexural capacity of corroded PC members, but it failed to consider the effect of concrete cracking. The effect of strand corrosion on structural behaviors has not been clarified. More studies are needed to explore the capacity deterioration mechanism in corroded PC beams. The structural behaviors of corroded PC beams are the complicated issues. This paper is intended to provide a brief summary of information needed by researchers to understand the challenge in the structural behaviors of corroded PC beams. Hopefully, much effort will be made to identify this topic and to find better solutions to address the existing issues.

References

1. Woodward RJ (1988) Collapse of ynys-y-gwas bridge, west glamorgan. Proceedings of Institution of Civil Engineers 1(6): 1177-1191.
2. Proverbio E, Longo P (2003) Failure mechanisms of high strength steels in bicarbonate solutions under anodic polarization. Corrosion Science 45(9): 2017-2030.
3. Zhang W, Liu,X, Gu X (2016) Fatigue behavior of corroded prestressed concrete beams. Construction and Building Materials 106: 198-208.
4. Li F, Yuan Y, Li CQ (2011) Corrosion propagation of prestressing steel strands in concrete subject to chloride attack. Construction and Building Materials 25(10): 3878-3885.
5. Harries KA (2009) Structural testing of prestressed concrete girders from the lake view drive bridge. Journal of Bridge Engineering 14(2): 78-92.
6. Bazant ZP (1979) Physical model for steel corrosion in concrete sea structures-application. Journal of Structural Divison 105(6): 1155-1166.
7. Bhargava K, Ghosh AK, Mori Y, Ramanujam S (2005) Modeling of time to corrosion-induced cover cracking in reinforced concrete structures. Journal of Building Structures 35(11): 2203-2218.
8. Li CQ, Melchers RE (2006) Analytical model for corrosion-induced crack width in reinforced concrete structures. ACI Structural Journal 103(4): 479-487.
9. Dai L, Wang L, Zhang J, Zhang X (2016) A global model for corrosion-induced cracking in prestressed concrete structures. Engineering Failure Analysis 62: 263-275.
10. Vu NA, Castel A, François R (2010) Response of post-tensioned concrete beams with unbonded tendons including serviceability and ultimate state. Engineering Structures 32(2): 556-569.
11. Coronelli D (2002) Corrosion cracking and bond strength modeling for corroded bars in reinforced concrete. ACI Structural Journal 99(3): 267-276.
12. Chen HP, Nepal J (2016) Analytical model for residual bond strength of corroded reinforcement in concrete structures. Journal of Engineering Mechanics 142(2): 04015079.
13. Wang L, Zhang X, Zhang J, Yi J, Liu Y (2016) Simplified model for corrosion-induced bond degradation between steel strand and concrete. Journal of Materials in Civil Engineering 29(4): 04016257.
14. Osborn GP, Barr PJ, Petty DA, Halling MW, Brackus TR (2012) Residual prestress forces and shear capacity of salvaged prestressed concrete bridge girders. Journal of Bridge Engineering 17(2): 302-309.

15. Kottari AK, Shing PB (2014) Estimation of long-term prestress losses in post-tensioned girders. ACI Structural Journal 111(5): 1091-1100.

16. Wang L, Zhang X, Zhang J, Ma Y, Xiang Y, et al. (2014) Effect of insufficient grouting and strand corrosion on flexural behavior of PC beams. Construction and Building Materials 53(0): 213-224.

17. Rinaldi Z, Imperatore S, Valente C (2010) Experimental evaluation of the flexural behavior of corroded P/C beams. Construction and Building Materials 24(11): 2267-2278.

18. Zhang X, Wang L, Zhang J, Ma Y, Liu Y (2017) Flexural behavior of bonded post-tensioned concrete beams under strand corrosion. Nuclear Engineering and Design 313: 414-424.

19. Coronelli D, Castel A, Vu NA, François R (2009) Corroded post-tensioned beams with bonded tendons and wire failure. Engineering Structures 31(8): 1687-1697.

20. Cavell DG, Waldron P (2001) A residual strength model for deteriorating post-tensioned concrete bridges. Computers and Structures 79(4): 361-373.

21. Wang L, Zhang X, Zhang J, Dai L, Liu Y (2017) Failure analysis of corroded PC beams under flexural load considering bond degradation. Engineering Failure Analysis 73: 11-24.

How to cite this article: Reza M. Implementation of Non-Linear Energy Sink in Damping and Harvesting of Acoustic power. Evolutions Mech Eng . 1(2). EME.000506.2018. DOI: 10.31031/EME.2018.01.000507