第Ｖ部門　　Experimental Study on Prestressing Force of Corroded Prestressed Concrete Steel Strands

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1. Introduction

Prestressed concrete (PC) steel strands have high tensile strength and are widely used in important structural members of PC bridges (Lee, 2020). Many scholars have studied the properties of corroded steel strand (Wang et al., 2014, Zhang et al., 2017a) However, there are few researches on how corrosion affects prestress and the law of its effect. The effect of corrosion on prestress in PC strand needs to be further studied.

2. Experimental program

2.1 Details of specimens

Specimens were fifteen 15.2 mm diameter 7-wire steel strands. The material performances of strand are given in **Table 1**.

Table 1　Material properties of steel strand.

Type	Nominal diameter	Cross-section area	The weight per meter	Tensile strength	Range of ultimate tensile capacity	Elongation
1×7	15.2 mm	140 mm^2	1101 g/m	1860 MPa	260-288 kN	≥ 3.5%

2.2 Accelerated corrosion test

In order to measure the change of prestressing force and elastic modulus of PC steel strand in the corrosion process under working condition, the relaxation testing machine and electrochemically accelerated corrosion device were combined in the test. The test setup is shown in **Fig.1**.

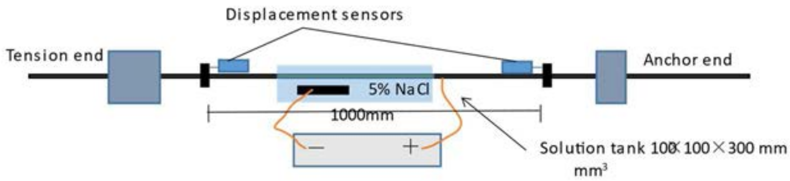


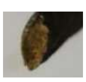
Fig. 1　Outlines of corrosion test under sustain tensile loading

3. Results and discussion in corrosion tests

3.1 Failure mode

The failure modes of the ruptured PC strand during the corrosion test were analyzed. The failure conditions of the 9 wires in the 6 corroded strands are summarized in **Table 2**. The necking phenomenon appeared near both the cup and cone fracture type and the milling cutter fracture type, which showed ductile failure. There is no obvious necking phenomenon near the split type and split-milling cutter type, which showed brittle failure. It can be found from **Table 2** that the fracture types of 50-10-1, 50-10-2, and 50-10-5 are all the milling cutter type, with a more obvious necking phenomenon belonging to ductile failure.

Table 2 Fracture type and results of the corrosion tests

Specimen No	50-7-5-3	50-10-1-1	50-10-1-2	50-10-2-5	50-10-3-1	50-10-3-2	50-10-4-6	50-10-5-4	50-10-5-5
Fracture									
Fracture type	S	S	M	M	S	S	S	M	M

Note: Fracture types are S: Split type, M: Milling cutter type

3.2 Effect of corrosion on prestressing force

According to the Faraday's first law, the Eq. (1) can be obtained.

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$$n = a\frac{M}{NFm_0}IT \quad (1)$$

where, $\boldsymbol{I}$ is current intensity; $\boldsymbol{T}$ is corrosion time; a is a variable parameter for each specimen and obtained as the measured mass loss; $\boldsymbol{M}$ is atomic mass of metal; $\boldsymbol{N}$ is the number of valence electrons lost by oxidation of a metal; $\boldsymbol{F}$ is Faraday constant, $1\boldsymbol{F} = 96485$.

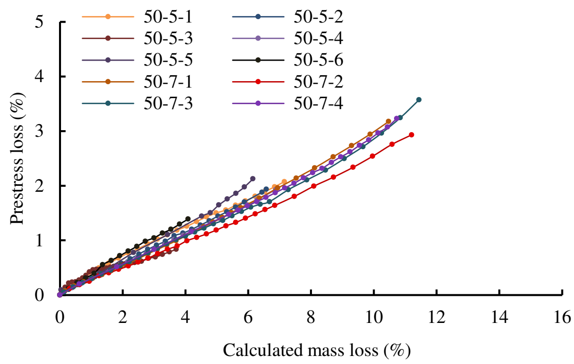
The relationship between corrosion degree calculated by Eq. (1) and prestressing force are shown in **Fig. 2**. According to **Fig. 2(b)**, it can be found that the specimens with higher corrosion degree its deterioration process of prestressing force with increasing corrosion degree can be divided into two stages. In the first stage, the prestress decreased linearly with the increase of the overall corrosion level of the strand with increasing the corrosion degree. After this condition, the second stage started in which the strand indicated the plastic deformation, and the prestressing force was rapidly reduced until the specimen was ruptured.

3.3. A model for predict prestressing force of corroded PC strands

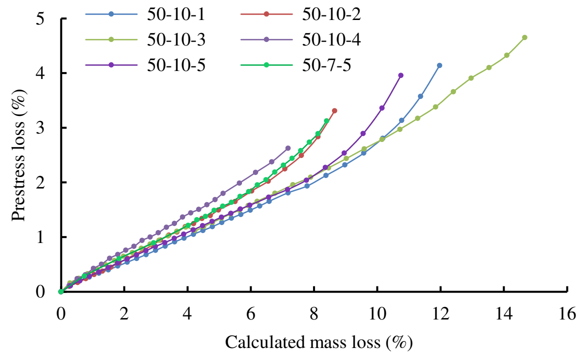
This paper mainly studies the linear relationship between the first stage of prestressing force and the corrosion degree. Test data of first stage are summarized in **Fig. 3.** According to the figure, the model of prestressing force and corrosion degree relationship is assumed to be a liner equation.

$$\boldsymbol{P_c}/\boldsymbol{P_0}=0.27\boldsymbol{n} \quad (2)$$

where, $\boldsymbol{P_c}$ is the prestressing force of the steel strand after corrosion; $\boldsymbol{n}$ is the corrosion degree of the steel strand; $\boldsymbol{P_0}$ is the prestress load at before corrosion



(a) Series of 5 and 7



(b) series of 10

Fig.2 Calculated mass loss versus prestress loss

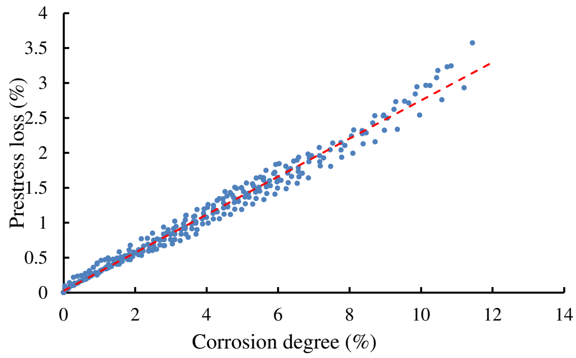


Fig.3 Relationship between prestressing force and corrosion degree

4. Conclusions

The corrosion test for fifteen 1×7 PC steel strands sustaining prestressing levels of 50% tensile strength of PC strands were carried out to study the prestressing force of the corroded steel strand. The following conclusions were drawn:

1. The fracture of the steel strand in the prestressed state may occur either ductile failure or brittle failure due to corrosion.
2. The prestress of steel strand decreases continuously with the increase of corrosion degree, and the reduction process can be divided into two stages; in first stage prstress decrease linearly, in the second stage, the steel strand has a large plastic deformation at the corrosion pitting, and prestressing force drops rapidly.

Reference

Lee, Y. J., (2020). "Probabilistic prediction of mechanical characteristics of corroded strands." ***Engineering structures***, 203, 0141-0296.

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