Construction and Building Materials 186 (2018) 1005–1015

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Effect of grout conditions and tendon location on corrosion pattern in PS tendon in grout

Yoon Yong-Sik [a], Ryu Hwa-Sung [b], Lim Hee-Seob [a], Koh Kyung-Taek [c], Kim Jeong-Su [d], Kwon Seung-Jun [a,*]

[a] Dept. of Civil and Environmental Engineering, Hannam University, 70, Hannam Ro, Daedeok Gu, Daejeon 34430, South Korea
[b] Hanyang E&C, 55, hanyangdaehak Ro, Sangnok Gu, Ansan, Gyeonggi do 15588, South Korea
[c] Structural Engineering Research Institute, Korea Institute of Civil Engineering and Building Technology, 283, Goyangdae Ro, Ilsanseo Gu, Goyang, Gyeonggi do 10233, South Korea
[d] Hanwha Research Institute of Technology, Hanwha Engineering & Construction, 24, Yeouidae Ro, Yeongdeungpo Gu, Seoul 07320, South Korea

HIGHLIGHTS

- Enhanced durability performance in improved grout with silica fume.
- Quantitative corrosion evaluation with impressed current method.
- Considerations of various tendon corrosion in one tendon-grout system.
- Investigation of bleeding and crack effect on corrosion.
- Evaluation of corrosion in tendon with small cover depth of grout.

ARTICLE INFO

Article history:
Received 6 April 2018
Received in revised form 2 August 2018
Accepted 6 August 2018
Available online 11 August 2018

Keywords:
Corrosion
Tendon
Grout
ICM
Chloride ion
Bleeding ratio

ABSTRACT

Pre-stressed Concrete (PSC) has various engineering advantages like reduction of dead load, enhancement of shear strength, and reducing crack, however tendon corrosion in grout caused by deficient grout and intrusion of chlorides causes a tendon break and the related structural problems. It is important to understand the corrosion pattern varying with grout properties and placement conditions. In the work, TG (Tendon-Grout) systems are prepared considering grout quality, bleeding, tendon location, and crack width. In order to evaluate corrosion pattern in TG systems in a short period, ICM (Impressed Current Method) is adopted for corrosion acceleration for 2 and 4 days of duration. For two types of grout (conventional one and improved grout with reduced water to cement ratio and silica fume), corrosion current and its amounts are evaluated for various conditions. In the TG system with crack, corrosion greatly increases with extension of test duration for both types of grout since crack width on grout is a main channel for ion intrusion. In spite of crack effect, improved grout has better resistance to corrosion considering crack and bleeding condition. When TG system has eccentricity of tendon with small cover depth, no significant differences between conventional and improved grout are measured since cover depth is too small to protect chlorides from outside. Various effects like bleeding, crack, tendon location, and grout quality are discussed in the work. The improved properties in IG like porosity, strength, absorption ratio, and expansion rate are also investigated.

1. Introduction

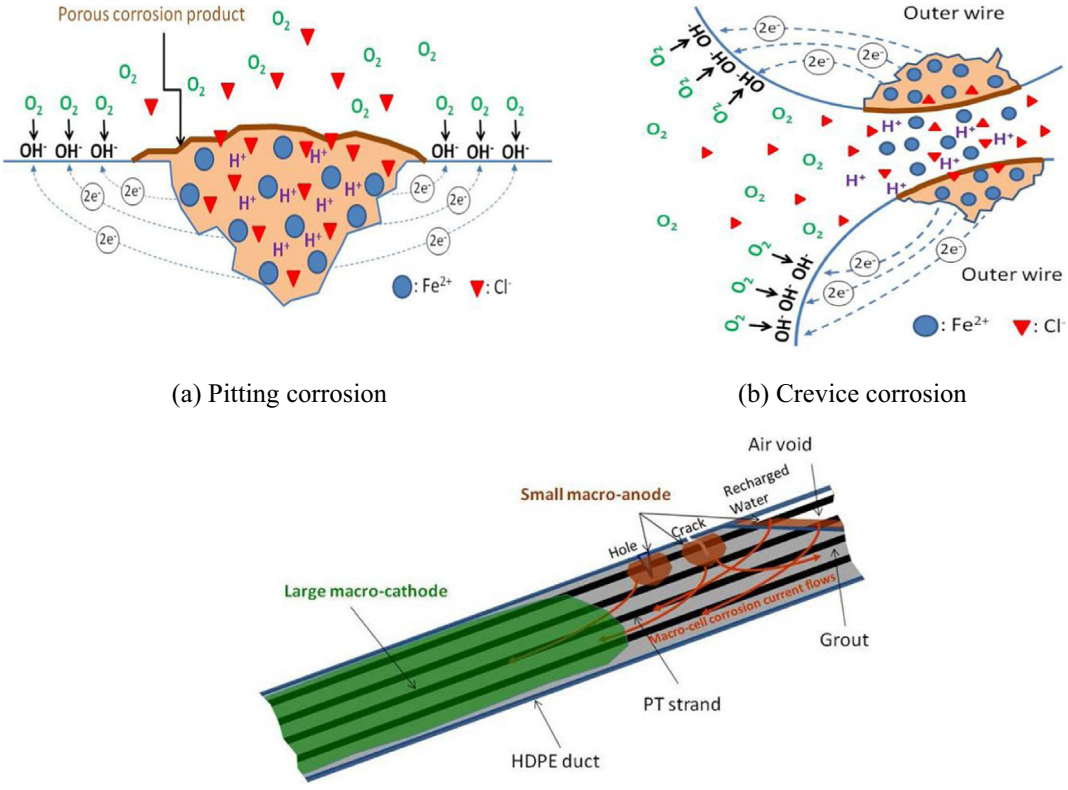
RC (Reinforced Concrete) structures have been constructed and used with various engineering merits like high durability, excellent fire resistance, and cost benefit. Concrete has porosity and its connectivity, and they have clear pros and cons, which can permit pressure escape area and thermal insulation due to low conductivity of air, but also permits intrusion of harmful ions which can accelerate corrosion initiation and matrix disintegration [1,2]. Particularly RC structures exposed to corrosive environment with sufficient oxygen and chloride ions are suffered from corrosion in embedded steel, which causes degradation both in durability and structural performance [3–5].

PSC structures usually contain many internal ducts with PS tendon and grout for structural integrity and resistance to corrosion [6,7], however the tendon inside may break due to corrosion and it becomes social and engineering problem [1,8–10]. Unlike normal

* Corresponding author.
E-mail addresses: rhsung73@hanyang.ac.kr (R. Hwa-Sung), ktgo@kict.re.kr (K. Kyung-Taek), jjuni98@hannam.ac.kr (K. Seung-Jun).

https://doi.org/10.1016/j.conbuildmat.2018.08.023
0950-0618/

Fig. 1. Duct corrosion and the residual grout in PSC member [12].



(a) Pitting corrosion

(b) Crevice corrosion

(c) Micro cell corrosion

Fig. 2. Illustration of corrosion types in tendon with grout [16].

Table 1
Mix proportions for conventional and improved grout type.

Type	W/C	Binder (%)		Admixture (× Binder %)
		OPC*	SF**	
CG	0.45	100	–	
IG	0.30	90	10	Expansion agent 1.0% Super-plasticizer 0.3% Viscosity agent 0.1%

* Ordinary Portland Cement.
** Silica Fume.

reinforcement in RC structures, PS tendons are always subjected to high tensile stress and this causes more higher corrosion current [11]. Many researches have reported the break of corroded tendon due to poor quality and imperfect grout injection [12–15]. They also reported the main causes for tendon corrosion were moisture/O_2 intrusion through coarse structure of grout, de-icing salts from upper anchorage zone, sulfate ions from re-grouting area, and micro-cell due to notch on tendon [13,16].

The grout quality plays an important role in corrosion prevention in normal conditions, so that many researches on grout improvement have been performed [17–20], which reveals that mineral admixture and low permeability in grout can enhance both strength and corrosion protection. The photos of representative corrosion in duct and insufficient grout are shown in Fig. 1.

In the work, a conventional grout (CG) and an improved grout (IG) with lower w/c ratio and chemical admixtures are considered for the accelerated corrosion test. Various TG (Tendon-Grout)