Analysis of Technical Standards for Applying HDPE Coated and Greased Tendon System in Reactor Containment Building

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1. Introduction

The post-tensioning system in reactor containment building is installed to secure performance for tensile when the internal pressure occurs. Unbonded post-tensioning system have been adopted for most nuclear power plants. Recently, several experimental studies have been performed to apply HDPE (High Density Polyethylene) coated and greased tendon system with three anti-corrosion concepts (greased steel strand + HDPE sheath + cement grout filling in duct) as an alternative to the existing unbonded post-tensioning system for reactor containment building. Fig. 1 shows the comparison between post-tensioning systems. In this paper, technical standards on the post-tensioning system were analyzed from the perspective of HDPE coated and greased tendon system.

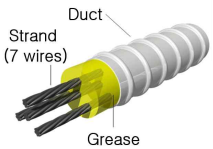
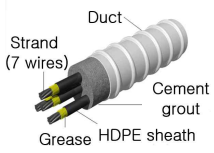
Type	Unbonded post-tensioning system	HDPE coated and greased tendon system
Tendon Composition	Bare strand + Grease filling in duct	HDPE coated and greased strand + Cement grout filling in duct
Concept		
		

Fig. 1. Comparison between post-tensioning systems

2. Technical Standards for Post-tensioning System of Reactor Containment Building

The design and construction on the post-tensioning system in reactor containment building have been performed using references such as ASME Sec. III, Div. 2 [1] and KEPIC SNB [2]. The technical standards consist of the following chapters:

- Introduction (ASME CC-1000 and KEPIC SNB 1000)
- Material (ASME CC-2000 and KEPIC SNB 2000)
- Design (ASME CC-3000 and KEPIC SNB 3000)
- Fabrication and Construction (ASME CC-4000 and KEPIC SNB 4000)
- Construction Testing and Examination (ASME CC-5000 and KEPIC SNB 5000)
- Structure Integrity and Examination (ASME CC-6000 and KEPIC SNB 6000)

In this paper, the technical standards [1, 2] for material of the post-tensioning system were analyzed from the perspective of HDPE coated and greased tendon system, and the items necessary to be revised for applying the system were identified. The chapters reviewed for the analysis are as followed:

- Concrete and Concrete Constituents (ASME CC-2200 and KEPIC SNB 2200)
- Material for Prestressing Systems (ASME CC-2400 and KEPIC SNB 2400)

3. Analysis of Technical Standards

3.1. Concrete and Concrete Constituents (ASME CC-2200 and KEPIC SNB 2200)

For chapters on quality and performance criteria of grout, ASME CC-2243.3 and KEPIC SNB 2243.3, the instructions state that grout mixtures shall be tested for compliance with the testing quality limits. The performance requirements and acceptance criteria presented in the technical standards tend to be requirements for the bonded post-tensioning systems that rely only on grout to prevent corrosion of the bare strands in ducts, and these standards are conservative for HDPE coated and greased tendon system with three anti-corrosion concepts (greased steel strand + HDPE sheath + cement grout filling in duct). It is necessary to be revised based on the technical standards such as EN-445 [3], EN-446 [4], and EN-447 [5] codes that have been widely used for the nuclear power plant structures.

3.2. Material for Prestressing Systems (ASME CC-2400 & KEPIC SNB 2400)

For chapters on types of ducts, ASME CC-2435.1 and KEPIC SNB 2435.1, the instructions state that ducts shall be made from ferrous metal in ASME code, while ducts shall be made from smooth steel in KEPIC code. In the case of ASME code, the instructions had been revised from the smooth steel to the ferrous metal in 2019 edition. The requirements on types of ducts in KEPIC code should be revised from smooth steel to

ferrous metal, because the use of the material such as the corrugated duct can be restricted.

For system pressure field test chapters, ASME CC-2454 and KEPIC SNB 2454, the acceptance criteria on the system pressure field test are presented in ASME code, while the acceptance criteria are not presented in KEPIC code. The acceptance criteria in ASME code state that the assembly of the post-tension system in concrete shall sustain internal pressure of 75 psi to 105 psi for 3 min with on more than 15 psi reduction in pressure. It is necessary to establish the acceptance criteria through the field mock-up test and to be revised in KEPIC code.

For grout field mock-up testing chapters, ASME CC-2454.1 and KEPIC SNB 2454.1, the instructions state that grouted duct work shall be destructively examined for a complete encapsulation of tendons and complete filling of duct cavities per a procedure approved by the designer. As mentioned 3.1, for the HDPE coated and greased tendon system with three anti-corrosion concepts (greased steel strand + HDPE sheath + cement grout filling in duct), the above requirements tend to be conservative. It is necessary to establish the acceptance criteria (e.g. for grout voids and cracks in duct) suitable for that system through the field mock-up test and the chapters should be revised corresponding to the established criteria.

4. Conclusions

In this paper, the technical standards for the material of the post-tensioning system were analyzed from the perspective of HDPE coated and greased tendon system, and the items necessary to be revised for applying the system were identified. Based on these analyses, the following chapters should be revised for applying the HDPE coated and greased tendon system.

- Quality and performance criteria for grout (ASME CC-2243.3 and KEPIC SNB 2243.3)
- Types of ducts (KEPIC SNB 2435.1)
- System pressure field tests (KEPIC SNB 2454)
- Grout field mock-up testing (ASME CC- 2454.1 and KEPIC SNB 2454.1)

REFERENCES

[1] ASME, Code for Concrete Containments, ASME Sec. III, Div. 2, 2023.
[2] KEPIC, Concrete Containments, KEPIC SNB, 2022.
[3] BSI, Grout for Prestressing Tendons – Test Methods, BS EN 445, 2007.
[4] BSI, Grout for Prestressing Tendons – Grouting Procedures, BS EN 446, 2007.
[5] BSI, Grout for Prestressing Tendons – Basic Requirements, BS EN 447, 2007.