SELECTING POST-TENSIONING TENDON PROTECTION LEVELS

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Abstract

Post-tensioning is the primary structural element used in many of today's structures. These structures vary from utilitarian to some of the most elegant imaginable. Design lives of the structure also vary, but the constant between them is the necessity to protect post-tensioning tendons from corrosion.

This paper will review and discuss pertinent requirements for post-tensioning tendons contained in Fédération International du Béton (fib) Bulletins. Information on accessing the aggressivity of the environment, exposure of the structure or element, and classifying the protection provided by the structure will be examined. Selecting the proper post-tensioning protection level will be reviewed with examples. Finally, identifying components required of post-tensioning systems for proper tendon protection levels will be presented.

Keywords: Tendons, post-tensioning, protection levels, corrugated plastic duct, monitoring

1 Introduction

Post-tensioning tendon protection level (PL) identifies the degree to which a post-tensioning tendon is protected from corrosion and deterioration over time. There are several documents that refer to tendon PLs such as *fib* Bulletin 33, *Durability of post-tensioning tendons*[1] and draft of PTI/ASBI, *Guide Specification for Grouted Post-Tensioning*[2] along with previous papers by the author *Post-Tensioning Tendon Protection Strategies for Precast Elements*[3] and *Segmental Construction-Protection Internal Post-Tensioning Tendons for 100-Year Service Life*[4] This paper will lead the reader through the process of selecting the correct PL for their structure. *fib* Bulletin 33[1] lays the ground work for selecting PLs; this paper organizes that information into an easy to understand process.

The objective of the process is to select the PL of post-tensioning tendons based on: aggressivity of environment, exposure of structure or element, and protection provided by structure. Combination of the post-tensioning tendons' PL and the protection provided by the structure together provides the resistance against the aggressivity of the environment and particular exposure conditions of the structural element.

2 Identifying Aggressivity of the Environment

In order to provide information on entry points for aggressivity and exposure, *fib* Bulletin 33[1] references EN 206-1[7]. It defines classifications of principal environments to which concrete structures are exposed and the corrosivity of these environments.

For post-tensioned structures, six classes of aggressivity are considered:

1. No risk of corrosion or attack: X0
2. Corrosion induced by carbonation: XC
3. Corrosion induced by chlorides other than from sea water: XD
4. Corrosion induced by chlorides from sea water: XS
5. Freeze/thaw attack with or without de-icing agents: XF
6. Chemical attack: XA

Aggressivity of the environment is used in determining the tendons' PL. Designers should realize that the only areas with "low" aggressivity are when there is no risk of corrosion in a very dry environment (X0) or when corrosion is induced by carbonation and the environment is dry or permanently wet (XC1). There are many more possibilities for classifying an environment's aggressivity as "medium" or "high".

3 Identifying Exposure of Structure or Element

The exposure of a structure or element is critical in determining the correct PL to use for the structure's tendons. In a specific structure there may be multiple exposure classes. The author recommends that the worst case be used in determining the tendon PL.

It is not practical to have various tendon PLs on one structure. Based upon the author's experience, post-tensioning material costs vary slightly from PL1 to PL3 in increments of 5-15% per PL. Labor costs are marginally higher per PL. However, mixing PLs on a structure can cause confusion and add to costs because several systems are used and labor learning curves are not as efficient. Quality control and inspection costs increase for the same reasons. Utilizing the same PL for the entire structure will simplify detailing, installation, and inspection of the post-tensioning system. It will provide the designer with confidence that the design life of the structure will not be compromised by using an incorrect PL for the most critical exposure class.

4 Identifying Protection Provided by the Structure

Designers must identify the protection provided by the structure to the internal post-tensioning tendons as "high", "medium", or "low". Many factors go into this decision including design concept, detailing, material selection, and construction quality. Designers should always keep in mind that corrosion of post-tensioning tendons is increased by means of ingress of chlorides and other deleterious agents through vulnerable areas of tendons such as anchorages, joints, cracks, porous concrete, and inadequate concrete cover.[1]

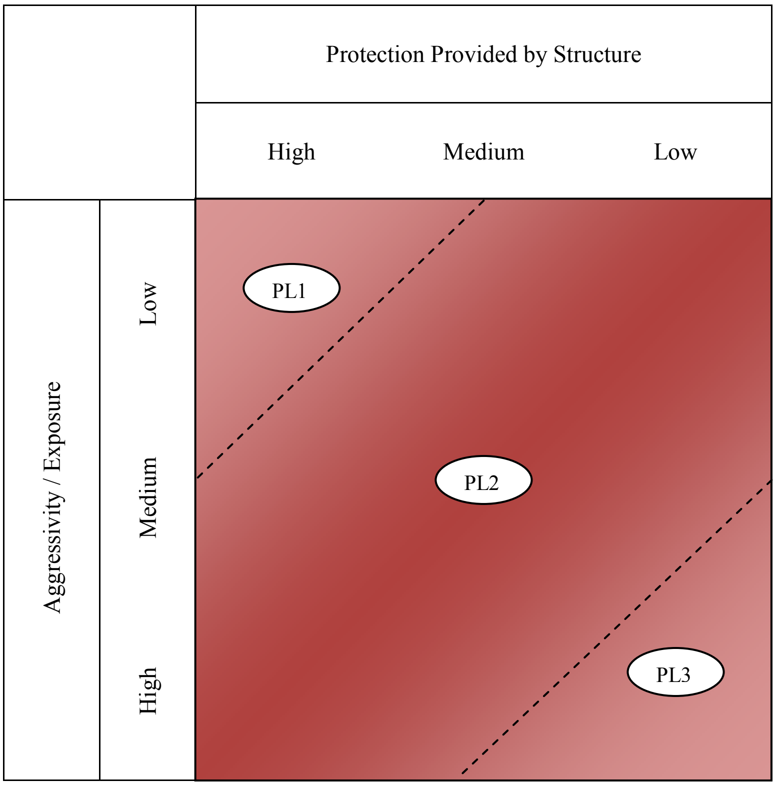
Individual construction details are an integral part of the structure's protection scheme and help to provide protection to tendons. The level of protection provided by construction details can vary from minimal up to the best possible available protection. The designer should consider the following construction details together when identifying protection provided to the structure as noted in *fib* Bulletin 33[1]: concrete quality and cover; concrete cracking; construction and expansion joint details; waterproofing systems and other surface protection systems; drainage system details; and segment joint details.

For an entire structure to qualify for a "high" rating in overall structural protection, all construction details necessary for the project need to have optimum protection schemes. This total structure rating should be used when determining tendon PLs.

5 Selecting the Post-Tensioning Tendon Protection Level

Selecting the tendon's PL for a specific project requires that the aggressivity of the environment attacking the prestressing element ("low" – "high") is identified. Then the protection provided by the structure for the element with the greatest exposure ("low" – "high") is identified. Once these two tasks are completed, the PL for a specific project can be selected by using **Tab. 1**. The combination of the structural protection level and the tendon's PL provide the resistance against the aggressivity of the environment.

Tab. 1 Protection levels for post-tensioning tendons based on aggressivity/exposure versus protection provided by structure.[1]



6 Post-Tensioning Protection Levels (PL) Defined

fib Bulletin 33[1] and PTI/ASBI Guide Specification[2] identify three PLs providing basic parameters for each. PTI/ASBI Guide Specification[2] further splits PL1 into an "A" and "B" section. There are subtle differences in definitions between *fib* and PTI/ASBI, see **Tab. 2**.

Tab. 2 Protection Level (PL) Definitions. [1] [2] [9]

fib Bulletin 33[1]	PTI/ASBI Guide Specification[2]
PL1 is defined as a duct with filling material (grout) providing durable corrosion protection.	PL1A – defined as a duct with grout providing durable corrosion protection.
	PL1B – defined as PL1A plus engineered grout and permanent grout cap.
PL2 is defined as PL1 plus a watertight, impermeable envelope providing a leak tight barrier.	PL2 is defined as PL-1B plus an envelope, enclosing the tensile element bundle over its full length, and providing a permanent leak tight barrier.
PL3 is defined as PL2 plus integrity of tendon or encapsulation to be inspectable or monitorable.	PL3 – defined as PL-2 plus electrical isolation of tendon or encapsulation to be monitorable or inspectable at any time.

7 Conclusions

Protecting post-tensioning tendons from corrosion is paramount to structures remaining durable and fit for use during their design service life. Selecting the correct tendon protection level (PL) revolves around aggressivity of environment, exposure of structure or element, and protection provided by structure. It is the combination of the tendons' PL and protection provided by the structure that determines how durable the post-tensioning system (and the structure) will be.

Once the aggressivity/exposure and protection provided by the structure are determined, the designer uses **Tab. 1** to select the appropriate tendon PL. Post-tensioning tendons in the entire structure should have the same PL; this will provide the designer with confidence that the design life of the structure will not be compromised by an incorrectly placed tendon in a critical exposure location and will have minimal affect on the overall project costs.

Definitions and performance requirements of tendons for a specific PL are identified in both *fib* Bulletin 33[1] and PTI/ASBI Guide Specification[2]. Tendon PLs of these two codes are identified and evaluated; other similar codes may be available. While component requirements are comparable, specific project requirements should rely on which code governs the work.

Initial costs for post-tensioning systems increase from PL1 to PL3. However, this increase in initial overall structure costs is relatively minimal and consistently beneficial when evaluating the life-cycle costs of the structure.[1]

References

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