Principles First

Fritz Leonhardt and Prestressed Concrete

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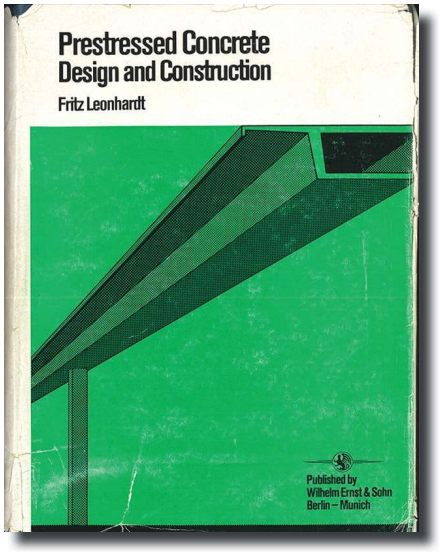

Prestressed Concrete Design and Construction[1], Fritz Leonhardt, English/Second Edition, November 1964. Photo: scan by Oguzhan Bayrak.

Structural engineering is an old profession and prestressed concrete is not new. Since the inception of prestressed concrete, there have been many great engineers, researchers, professors, and pretensioning and post-tensioning professionals who contributed to our understanding and practice of this technology. In this regard, there is much to learn from past research and the fabrication and construction experience.

In an effort to do so, I would like to cover a few things that one can learn from Professor Fritz Leonhardt's book titled, *Prestressed Concrete Design and Construction*.[1] Among other classic prestressed concrete texts, we are fortunate to have the second edition of this book in our library at the Phil M. Ferguson Structural Engineering Laboratory (FSEL). With its 19 chapters, this book covers many topics ranging from fundamental concepts to material properties and spans from structural design to fabrication and construction. To give the readers a concise summary of the most important technical issues, this book includes a section titled "Ten Commandments for the Prestressed Concrete Engineer" that precedes the formal chapters. Five of these ten principles are aimed at providing guidance to structural engineers in a design office and the other five are directed toward construction professionals.

The recommendations for designers are:

1. Being mindful of short-term and long-term deformations associated with prestressing effects and considering those effects in design.
2. Being mindful of reinforcing bar details to handle forces that stem from the directional changes in prestressing force.
3. Not pushing structural designs to their limit to where compressive stress limits are fully exploited. In this way, constructability issues that may stem from the use of an excessive number of strands can be avoided.
4. Avoiding tensile stresses under dead loads.
5. Providing ordinary reinforcing bars transverse to the direction of prestressing force within the transfer length.

The recommendations for the construction professionals are:

6. Protecting prestressing material in fabrication plants to prevent mechanical (cuts, kinks, and the like) and chemical (for example, corrosion) damage to the prestressing strands.
7. Understanding the need for high-quality, properly-consolidated concrete in constructing prestressed concrete elements.
8. Allowing room for prestressed members to deform and experience volume changes without introducing secondary stresses to the structure.
9. Understanding the advantages of post-tensioning structural components in several stages to deal with different load effects that may exist at various stages of the construction.
10. Understanding the need to follow the technical guidance for grouting post-tensioning tendons.

These principles exemplify an industry belief that has existed since the early days of prestressed concrete: A thorough understanding of fabrication/construction processes and fundamental steps in structural design are essential to the design and the fabrication/construction professionals. In other words, it is not possible to be a good prestressed concrete designer without understanding the fabrication and construction processes. Conversely, it is not possible to fabricate prestressed concrete beams without having an appreciation for the supporting engineering principles.

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What does this mean for the structural engineers in the making? Hands-on experience, including time spent in fabrication plants and/or on jobsites, is invaluable. In this context, students who take prestressed concrete design at the University of Texas typically participate in PCI's Big Beam Contest. This exercise gives them a chance to

go through all aspects of the design and fabrication processes. In addition, those students test the beams they design and observe the structural consequences of their design decisions. This is an exercise greatly valued by many.

Since the inception of prestressed concrete, the constraints under which a prestressed concrete engineer works have changed. The industry now works with higher-strength, better performing materials. There have been significant innovations in construction materials (concrete, reinforcing bar, and strand) and beam fabrication and construction technologies. Alongside the technological and scientific advances that have taken place since the inception of prestressed concrete, other changes have also occurred over the past half a century. The industry now faces significant resource constraints. Everyone is being pushed to do more with less. We have to be mindful of our resource consumption in view of future generations. Rightfully, we have a growing concern for our environment and all of us would like to be better stewards of our environment.

What do these observations add up to? Better design optimization and a renewed emphasis on durability and sustainability. If we are to refine or optimize our designs to a greater extent, we need to fully understand the fabrication, construction, and design implications of our decisions. Given the age of our profession and that of prestressed concrete, we have more to read and digest. In an increasingly digital world, this implies more time spent on search engines and an increased effort to take advantage of resources that strike a balance between fabrication and construction issues alongside theory and design. With that said, we must all appreciate the fact that first principles are first.

References:

1. Leonhardt, Fritz. 1964. *Prestressed Concrete Design and Construction,* 2nd Ed., Berlin: Wilhelm Ernst & Sohn.