PTI JOURNAL

Technical Papers

Review of ACI 318-19 Shrinkage and

Temperature Reinforcement Provisions

and Proposed Code Change

By: Asit Baxi



Authorized reprint from: Issue 1 2023 of the PTI JOURNAL Copyrighted © 2023, Post-Tensioning Institute All rights reserved.

REVIEW OF ACI 318-19 SHRINKAGE AND TEMPERATURE REINFORCEMENT PROVISIONS AND PROPOSED CODE CHANGE

BY ASIT BAXI

INTRODUCTION

Shrinkage and temperature reinforcement Code provisions for monolithic, cast-in-place post-tensioned (PT) beam-and-slab construction were substantially revised in the ACI 318-11 Code.¹ It changed how design engineers and PT suppliers had been detailing temperature tendons for over 40 years.

Prior to the 318-11 Code, the gross concrete area requiring a 100 psi (689 kPa) minimum average compressive stress to resist shrinkage and temperature stresses was defined as the slab section between the effective flange widths of the T-beam sections used in the flexural design, as shown in Fig. 1. Temperature tendons in the slab were proportioned to achieve this average compressive stress within the gross concrete area. The compression from the beam tendons was kept within the T-beam section using an effective flange of $(b_w + 16h)$ or an assumed value used for the beam flexural design. Additionally, the Code specified that an average compressive stress of 100 psi (689 kPa) or minimum shrinkage and

temperature reinforcement be provided under prestress plus service load in the positive moment areas, as shown in Fig. 1. Hence, the required 100 psi (689 kPa) compressive stress on the gross concrete area was calculated exclusively by using the slab temperature tendons and no beam tendons.

In the 318-11 Code, a significant change was made to the overall approach to determining shrinkage and temperature tendons. The definition of the gross concrete area was revised from the slab region between effective flange widths, which had been the standard for many years, to the gross area of slab and beam (orange area) between span centerlines shown in Fig. 2. The primary intent of the change was to include the compression from both beam and slab temperature tendons present within the entire T-beam section between span centerlines, as seen in Fig. 2, in arriving at the minimum 100 psi (689 kPa) average compressive stress required for resisting shrinkage and temperature stresses.

Due to the inclusion of beam tendons and the revised



maintained under prestress plus service dead load.

Fig. 1—*Gross concrete area per ACI* 318-08.² (*Note: 1 psi = 0.00689 MPa.*)



Beam and slab tendons within the orange area must provide 100 psi minimum average compressive stress in the orange area (gross area tributary to each beam).

Section A-A

Fig. 2—*Gross concrete area per ACI* 318-11/14/19.¹ (*Note:* 1 *psi* = 0.00689 MPa.)

definition of the "gross concrete area" introduced in the 318-11 Code, an inadvertent consequence of the Code change occurred. For slabs thicker than 5 in. (127 mm) and depending on the slab spans and slab thickness, even if all the Code provisions in their current form are satisfied, there are cases where in a bay, a large region of the slab with compressive stresses much less than 100 psi (689 kPa) and without any nonprestressed reinforcement in the temperature direction can occur. This unreinforced region of the slab could be susceptible to shrinkage and temperature cracking and could potentially get further exacerbated if thermal and restraint effects are significant.

This paper presents details and results of an analytical investigation of a monolithic cast-in-place parking garage considering varying span lengths and slab thicknesses to study the impact of the aforementioned discrepancy in the Code. The paper concludes with proposed options to resolve this Code discrepancy.

PURPOSE OF INVESTIGATION

The 100 psi (689 kPa) minimum compression requirement on the gross concrete area to resist shrinkage and temperature stresses has been in the 318 Code for over 40 years and has been used successfully on a large number of projects. What has not been investigated or clearly understood is the slab behavior from the slab edge to the location in the slab where the 100 psi (689 kPa) compression has been achieved and the slab is uniformly compressed beyond that point. Furthermore, the exclusion or inclusion of slab temperature tendons and their distribution (quantity and spacing) and the extent of the gross concrete area has not been studied.

Figure 3 shows a schematic diagram of the force dispersion from individual slab tendon anchorages and the approximate line (blue line) of 100 psi (689 kPa) uniform compression, beyond which the slab is uniformly



Fig. 3—Force dispersion of slab temperature tendons at the slab edge based on ACI 318-08. (Note: 1 psi = 0.00689 MPa.)

compressed to a 100 psi (689 kPa) average stress. The image referenced in Fig. 3 is for a slab detailed according to the ACI 318-08 Code.

For a slab detailed based on the 318-08 Code, the approximate line of 100 psi (689 kPa) uniform compression would occur in most instances within a relatively short distance of 2 to 4 ft (0.6 to 1.2 m) from the slab edge, depending on the temperature tendon spacing. Because the "gross concrete area" is defined as the slab section between the effective flanges, and all temperature tendons are concentrated within this section (Fig. 3), the distance required to achieve the uniform compressive stress is short—that is, roughly half the temperature tendon or tendon group spacing.

Figure 4 shows the approximate 100 psi (689 kPa) line (blue line) of compression for a slab detailed per $318-11^1/14^3/19^4$ Code. Due to the revised definition of the "gross concrete area" and the inclusion of beam tendons in the calculation of the 100 psi (689 kPa) compressive stress, this line has moved further inward from the slab edge. Because the beam tendons carry the bulk of the total prestressing force (beam plus slab temperature tendons) and the beams are spaced much farther than the slab temperature tendons, the distance required to achieve the uniform compressive stress is greater and is intuitively slightly less than half the span length, as seen in Fig. 4.

Due to the inclusion of beam tendons and the revised definition of the "gross concrete area" introduced in the 318-11 Code, it has become evident that for slabs thicker than 5 in. (127 mm), and depending on the slab spans and slab thickness, the approximate line (blue line) of 100 psi (689 kPa) uniform compression could be anywhere from 5 to 12 ft (1.5 to 3.7 m) or more, creating large regions of a slab with compressive stresses less than 100 psi (689 kPa) and without any Code-required nonprestressed reinforcement. For slabs where thermal effects and restraint are significant, this region of the slab could be further vulnerable to cracking.

Hence, an analytical investigation of a typical onebay garage structure with multiple spans of varying length and slab thicknesses was performed using the finite element method to study the overall slab stress distribution and dispersion of forces close to the slab edge for shrinkage and temperature Code provisions based on the ACI 318-08 and 318-11 Codes.

ANALYTICAL INVESTIGATION

A monolithic cast-in-place PT parking garage deck with a typical 60 ft (18.3 m) bay and seven spans of varying



Fig. 4—Force dispersion of slab temperature tendons at slab edge based on ACI 318-11/14/19. (Note: 1 ft = 0.3048 m.)

lengths—18, 27, and 36 ft (5.5, 8.2, and 11.0 m)—and corresponding slab thicknesses of 5.5, 7.5 and 12 in. (140, 191, and 305 mm) was analyzed for different temperature tendon detailing configurations using the finite element (FE) method. The focus of the analysis was to study the dispersion of the prestressing forces from beam and slab temperature tendons into the floor slab and the overall compressive stress distribution across the gross concrete area in the region close to the slab edges.

A plan view and a three-dimensional (3-D) view of a typical FE model analyzed are shown in Fig. 5 and 6, respectively. The garage loads considered for each case were self-weight plus a superimposed dead load (SDL) = 5 lb/ft^2 (0.24 kPa) and live load (LL) = 40 lb/ft² (1.9 kPa). Concrete strength at stressing and at 28 days was assumed to be 3000 and 5000 psi (20.7 and 34.5 MPa), respectively. The assumed final effective force per tendon was 27 kip (1/2 in. [13 mm] diameter Grade 270 ksi [1860 MPa] low-relaxation unbonded tendon). All beam and uniform slab tendon forces in the deck were proportioned to keep the member design stresses just under 7.5 $\sqrt{f'}$.

The various cases analyzed based on the different temperature tendon configurations are as follows:

- CASE-A: No temperature tendons. Compression from beam tendons only (Fig. 7 and 8)
- CASE-B: Temperature tendons detailed per ACI 318-08 (Fig. 9 and 10)
- CASE-C: Temperature tendons detailed per ACI 318-11/14/19 (Fig. 11 and 12)
- CASE-D: Temperature tendons detailed per ACI 318-11/14/19 and proposed Code change option with continuous added tendons (Fig. 13 and 14)
- CASE-E: Temperature tendons detailed per ACI 318-11/14/19 and proposed Code change option with short added tendons (Fig. 15 and 16)



Fig. 5—Plan view of garage floor structure analyzed. (Note: 1 in. = 25.4 mm; 1 ft = 0.3048 m.)



Fig. 6—Typical 3-D view of FE model showing beam and slab (distributed plus temperature) tendons (nonprestressed reinforcement is not shown for clarity).

- CASE-F: Temperature tendons detailed per ACI 318-11/14/19 and proposed Code change option with added nonprestressed reinforcement (Fig. 17)
- CASE-G: Revert back to temperature tendons detailed per ACI 318-08 with minor modifications (Fig. 18)

PRESENTATION AND DISCUSSION OF RESULTS

CASE-A: The first case analyzed was with the intent of getting a basic understanding of the dispersion

of the prestressing forces from the beam tendons only; hence, no temperature tendons were considered in the analysis. Figure 7 shows the overall tendon layout based on the flexural analysis of the floor slab. The beam and distributed tendon forces were determined based on keeping the flexural stress close to the modulus of rupture value of $7.5\sqrt{f_c'}$. Even without any temperature tendons, the 100 psi (689 kPa) average compression requirement on the gross concrete area, as defined in ACI 318-11/14/19, is provided by the beam tendons.



CASE-A: FE ANALYSIS ASSUMING NO TEMPERATURE TENDONS

Fig. 7—Tendon layout for CASE-A: no temperature tendons. (Note: 1 in. = 25.4 mm; 1 psi = 0.00689 MPa.)



CASE-A: FE ANALYSIS ASSUMING NO TEMPERATURE TENDONS

Fig. 8— σ_{yy} stress contour distribution for CASE-A: no temperature tendons. (Note: 1 in. = 25.4 mm; 1 psi = 0.00689 MPa.)

Figure 8 shows the axial compressive stress (σ_{yy}) contour distribution across the floor slab. The angle of dispersion of the prestressing forces from the beams varies between 28 degrees for the 18 ft (5.5 m) span (5.5 in.

[140 mm] slab) and 38 degrees for the 36 ft (11.0 m) span (12 in. [305 mm] slab). The approximate line of 100 psi (689 kPa) uniform compression varies from 4.9 ft (1.5 m) for the 18 ft (5.5 m) span (5.5 in. [140 mm] slab) to 14.2 ft

(4.3 m) for the 36 ft (11.0 m) span (12 in. [305 mm] slab).

The stress contour plot clearly shows that there are large regions of the slab in the 27 and 36 ft (8.2 and 11.0 m) spans that have a compressive stress of less than 100 psi (689 kPa) and hence must be reinforced with either nonprestressed shrinkage and temperature reinforcement (0.0018 A_g) in accordance with Section 24.4.3 of ACI 318-19 or an appropriate amount of temperature tendons in the slab to achieve the 100 psi (689 kPa) compressive stress.

CASE-B: This case was analyzed with the intent of understanding how the compressive stress distribution would be if temperature tendons were provided and detailed per ACI 318-08—that is, prior to the Code change in 2011. Figure 9 shows the overall tendon layout with the temperature tendons providing the 100 psi (689 kPa) average compression requirement on the gross concrete area as defined in ACI 318-08. The temperature tendon spacing provided did not exceed 4.5 ft (1.4 m) so as not to trigger the requirement for additional nonprestressed reinforcement between the tendons at the slab edge.

Figure 10 shows the axial compressive stress (σ_{yy}) contour distribution across the floor slab. The approximate line of 100 psi (689 kPa) uniform compression

varies from 2 ft (0.6 m) for the 18 ft (5.5 m) span (5.5 in. [140 mm] slab), 2.4 to 4.4 ft (0.7 to 1.3 m) for the 27 ft (8.2 m) interior and exterior spans (7.5 in [191 mm] slabs), and 2.7 to 4.9 ft (0.8 to 1.5 m) for the 36 ft (11.0 m) span (12 in. [305 mm] slab).

The analysis of this case shows that for temperature tendons provided per the 318-08 Code, the distance in which the 100 psi (689 kPa) compressive stress becomes effective in the concrete is less than 4.5 ft (1.4 m) in most instances along the slab edge.

CASE-C: The analysis of this case is the basis of this study. This case provides the compressive stress distribution in the slab for temperature tendons that are provided and detailed per ACI 318-11/14/19—that is, the current Code. Figure 11 shows the overall tendon layout with the temperature tendons providing the 100 psi (689 kPa) average compression requirement on the gross concrete area as defined in ACI 318-11/14/19. The temperature tendon spacing provided was kept at 4.5 ft (1.4 m) or less to ensure that the Code requirement for additional nonprestressed reinforcement along the slab edge if this spacing was exceeded did not apply. Also, as permitted in the current Code and to illustrate the Code discrepancy, single-temperature tendons were provided across the gross concrete area regardless of the slab thickness



Fig. 9—Tendon layout for CASE-B: temperature tendons detailed per ACI 318-08. (Note: 1 in. = 25.4 mm; 1 psi = 0.00689 MPa.)

in each span. The combination of beam and slab tendons still met the 100 psi (689 kPa) compression requirement in each span. Figure 12 shows the axial compressive stress (σ_{yy}) contour distribution across the floor slab. The angle of dispersion of the prestressing forces from the beam and





Fig. 10— σ_{yy} stress contour distribution for CASE-B: temperature tendons detailed per ACI 318-08. (Note: 1 in. = 25.4 mm; 1 psi = 0.00689 MPa.)



Fig. 11—Tendon layout for CASE-C: temperature tendons detailed per ACI 318-11/14/19. (Note: 1 in. = 25.4 mm; 1 psi = 0.00689 MPa.)



Fig. 12— σ_{yy} stress contour distribution for CASE-C: temperature tendons detailed per ACI 318-11/14/19. (Note: 1 in. = 25.4 mm; 1 psi = 0.00689 MPa.)

slab tendons flattened slightly compared to CASE-A from 38 to 31 degrees for the 36 ft (11.0 m) span (12 in. [305 mm] slab). The approximate line of 100 psi (689 kPa) uniform compression varies from 1.8 ft (0.55 m) for the 18 ft (5.5 m) span (5.5 in [140 mm] slab), 4.2 to 5.8 ft (1.3 to 1.8 m) for the 27 ft (8.2 m) interior and exterior spans (7.5 in. [191 mm] slabs), and 10.7 ft (3.2 m) for the 36 ft (11.0 m) span (12 in. [305 mm] slab).

The stress contour plot shows that there are large regions of the slab in the 27 and 36 ft (8.2 and 11.0 m) spans that have a compressive stress of less than 100 psi (689 kPa), although the slab is detailed in compliance with the current ACI Code. Moreover, the Code does not require additional nonprestressed reinforcement in these regions. This appears to be an inadvertent discrepancy when the Code was revised in 2011.

The size of the region with a compressive stress of less than 100 psi (689 kPa) increases with the slab thickness. For one-way slabs where restraint to shortening and thermal effects are significant, these unreinforced slab regions could be further vulnerable to unanticipated cracking.

This discrepancy can be addressed by one or more of the following Code change options:

1. Provide additional continuous temperature tendons (from slab edge to slab edge) to achieve 100 psi (689 kPa) compression. This option was analyzed as CASE-D.

- 2. Provide additional short temperature tendons (in the region close to the slab edge) to achieve 100 psi (689 kPa) compression. This option was analyzed as CASE-E.
- 3. Provide additional nonprestressed temperature and shrinkage reinforcement. This option is presented as CASE-F.
- 4. Revise the Code provisions back to the ACI 318-08 Code with minor adjustments. This option is presented as CASE-G.

CASE-D: The Code discrepancy illustrated in CASE-C can be solved by providing additional temperature tendons in the slab. It is practical to provide tendons that extend from slab edge to slab edge to enable stressing, facilitate installation, prevent problems related to broken tendons, and aid in tendon replacement if necessary. The other advantage of using continuous tendons is the overall superior uniform compressive stresses across the floor slab.

Figure 13 shows the overall tendon layout with the added continuous temperature tendons. It is proposed that the added continuous tendons to achieve the 100 psi (689 kPa) compression requirement be provided in the region between the effective flange widths of the T-beams where they are most needed.

Figure 14 shows the axial compressive stress (σ_{vv}) contour distribution across the floor slab. The



Fig. 13—Tendon layout for CASE-D: temperature tendons detailed per ACI 318-11/14/19 and proposed Code change option with continuous added tendons. (Note: 1 in. = 25.4 mm; 1 psi = 0.00689 MPa.)

CASE-D: FE ANALYSIS BASED ON TEMP TENDONS DETAILED PER ACI 318-11/14/19(CASE-C) AND PROPOSED CODE CHANGE OPTION WITH CONTINUOUS ADDED TENDONS σ_{yy} STRESS CONTOUR DISTRIBUTION σ_{yy} Stress Contours at Mid-depth in psi



Fig. 14— σ_{yy} stress contour distribution for CASE-D: temperature tendons detailed per ACI 318-11/14/19 and proposed Code change option with continuous added tendons. (Note: 1 in. = 25.4 mm; 1 psi = 0.00689 MPa.)

approximate line of 100 psi (689 kPa) uniform compression has shifted close to the slab edge between 2.2 and 3.8 ft (0.7 and 1.2 m), which provides the desired outcome.

CASE-E: This case is similar to CASE-D except that the added tendons are not continuous, but they are short tendons close to the slab edges which are provided only in the region of the slab where compressive stresses are less than 100 psi (689 kPa). While there can be some economy by providing short added tendons, the savings can be offset by requiring twice the number of anchors for the same tendon line (one additional anchor for each edge of the bay). Moreover, added short tendons may not be as practical as providing continuous tendons if there are broken tendons or if tendon replacement is required. CASE-E was analyzed in this study for the sake of completeness.

Figure 15 shows the overall tendon layout with the added continuous temperature tendons. If added short tendons are to be considered, it is proposed that these tendons be provided in the region between the effective flange widths of the T-beams where they are most needed. The length of the short tendons for this analysis was 15 ft (4.6 m) with the consideration that a meaning-ful final effective force could be achieved since a significant portion of the prestressing force in short tendons is lost due to seating.

Figure 16 shows the axial compressive stress (σ_{yy}) contour distribution across the floor slab. The approximate line of 100 psi (689 kPa) uniform compression has shifted close to the slab edge between 2.2 and 3.8 ft (0.7 and 1.2 m), as with CASE-D. The stress contour plot also shows that there are tensile stresses created behind the anchors, effectively reducing the amount of precompression in the slab.

CASE-F: The Code discrepancy illustrated in CASE-C can also be resolved by providing additional nonprestressed reinforcement $(0.0018A_a)$ in accordance with Section 24.4.3 of ACI 318-19, as shown in Fig. 17. This reinforcement must be provided between the beams and must extend for a distance equal to half the clear distance between the beams or half the span length for simplicity of calculation. While this option is straightforward and economical, the conundrum with this option is, "Who is responsible for showing this reinforcement on the structural drawings?" Since the 2011 Code change, it has been reported on numerous occasions that the responsibility of the entity (licensed design professional [LDP], contractor, or subcontractor) for showing or including the additional reinforcement (or tendons) on the bid documents has created confusion and put an unnecessary burden on all concerned parties.

CASE-G: Additionally, The current Code discrepancy can be resolved by reverting to the ACI 318-08 Code and



CASE-E: FE ANALYSIS BASED ON TEMP TENDONS DETAILED PER ACI 318-11/14/19(CASE-C) AND PROPOSED CODE

Fig. 15—Tendon layout for CASE-E: temperature tendons detailed per ACI 318-11/14/19 and proposed Code change option with short added tendons. (Note: 1 in. = 25.4 mm; 1 psi = 0.00689 MPa.)
16 Issue 1 2023 | PTI JOURNAL

preventing the need for calculating and providing details for the amount of either additional tendons (short or continuous) or nonprestressed reinforcement as presented in CASES-D, -E, and -F. CASE-B stress contour plots show that the 100 psi (689 kPa) compressive stress requirements can be adequately met. Figures 18(a) to 18(c) have been developed based on the ACI 318-08 Code with minor modifications to address the current Code discrepancy.

CASE-E: FE ANALYSIS BASED ON TEMP TENDONS DETAILED PER ACI 318-11/14/19(CASE-C) AND PROPOSED CODE CHANGE OPTION WITH SHORT ADDED TENDONS σ_{yy} STRESS CONTOUR DISTRIBUTION σ_{yy} STRESS CONTOUR DISTRIBUTION



Fig. 16— σ_{yy} stress contour distribution for CASE-E: temperature tendons detailed per ACI 318-11/14/19 and proposed Code change option with short added tendons. (Note: 1 in. = 25.4 mm; 1 psi = 0.00689 MPa.)



Fig. 17—Tendon layout for CASE-F: temperature tendons detailed per ACI 318-11/14/19 and proposed Code change option with added nonprestressed reinforcement. (Note: 1 in. = 25.4 mm; 1 psi = 0.00689 MPa.)

It should be noted that this change will not affect the overall flexural design approach of the beams.

SUMMARY AND CONCLUSIONS

Shrinkage and temperature reinforcement Code provisions for monolithic, cast-in-place post-tensioned



Fig. 18(a)—CASE-G: detail of temperature tendons per ACI 318-08 with proposed modification to existing Code Fig. R7.6.4.2—section in between T-beams. (Note: 1 psi = 0.00689 MPa.)

beam-and-slab construction were substantially revised in the 318-11 Code. Prior to the 318-11 Code, the gross concrete area requiring a 100 psi (689 kPa) minimum average compressive stress to resist shrinkage and temperature stresses was defined as the slab section between the effective flange widths of the T-beams, and



Fig. 18(b)—CASE-G: detail of temperature tendons per ACI 318-08 with proposed modification to existing Code Fig. R7.6.4.2—section in between wall support and T-beam. (Note: 1 psi = 0.00689 MPa.)



Fig. 18(c)—CASE-G: detail of temperature tendons per ACI 318-08 with proposed modification to existing Code Fig. R7.7.6.3.2—plan view at slab edge showing added shrinkage and temperature reinforcement. (Note: 1 ft = 0.3048 m.)

temperature tendons were proportioned to achieve this average compressive stress.

In the 318-11 Code, the definition of the gross concrete area was revised from the slab region between effective flange widths, which had been the standard for many years, to the gross area of the slab and beam between span centerlines in an effort to include the compression from both beam and slab temperature tendons.

The inclusion of beam tendons, the revised definition of the "gross concrete area," and subsequent changes in detailing requirements led to an inadvertent consequence of the Code change. Even if all the current Code provisions were to be satisfied, for slabs thicker than 5 in. (127 mm), there could be cases with large regions of a slab with compressive stresses less than 100 psi (689 kPa) and without any nonprestressed shrinkage and temperature reinforcement required by the Code. This unreinforced region of the slab would not only be susceptible to shrinkage and temperature cracking, but could make the slab further vulnerable to cracking if thermal and restraint effects were significant.

This paper presents details and results of an analytical investigation of a monolithic cast-in-place parking garage considering varying span lengths and slab thicknesses to study the impact of the above discrepancy in the Code. The paper concludes with options to resolve this Code discrepancy which include providing additional short or continuous temperature tendons or additional nonprestressed shrinkage and temperature reinforcement or reverting to the ACI 318-08 Code provisions with some minor modifications and which had been used successfully for many years.

While all the options presented in this paper are viable, this study clearly shows that reverting to the ACI 318-08 Code is the recommended solution to resolve this Code discrepancy. It requires relatively less overall material, prevents the need for additional calculations, and has the benefit of simplicity in the detailing of temperature tendons. Until the Code has been revised, slab regions as described previously without any nonprestressed reinforcement, and particularly in cases with significant thermal and restraint considerations, should be carefully evaluated by the licensed design professional. Any additional tendons or nonprestressed reinforcement if required must be clearly shown on the structural drawings indicating the quantity, spacing, and extent of this reinforcement so that this information is included as a part of the contract documents. This issue is currently being evaluated as a code change proposal in ACI 318.

REFERENCES

- 1. ACI Committee 318, "Building Code Requirements for Structural Concrete (ACI 318-11) and Commentary (ACI 318R-11)," American Concrete Institute, Farmington Hills, MI, 2011, 503 pp.
- 2. ACI Committee 318, "Building Code Requirements for Structural Concrete (ACI 318-08) and Commentary (ACI 318R-08)," American Concrete Institute, Farmington Hills, MI, 2008, 473 pp.
- 3. ACI Committee 318, "Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary (ACI 318R-14)," American Concrete Institute, Farmington Hills, MI, 2014, 524 pp.
- ACI Committee 318, "Building Code Requirements for Structural Concrete (ACI 318-19) and Commentary (ACI 318R-19) (Reapproved 2022)," American Concrete Institute, Farmington Hills, MI, 2019, 624 pp.

Asit N. Baxi is President of Baxi Engineering Inc. He has over 30 years of experience as a structural engineer in the area of prestressed concrete and is recognized as an industry expert on post-tensioned buildings. He owns and runs a full-service post-tensioned concrete specialty engineering firm with specialization in the analysis and design, construction, repair, and forensics of different types of post-tensioned concrete structures using any type of post-tensioning system. Baxi is an ACI and PTI Fellow. He currently serves as Chair of PTI Committee DC-20, Building Design, and is a member of PTI TAB-TG on Code Change Proposals for ACI 318-T and ACI 320; PTI Committee DC-25, Parking Structures; and PTI Subcommittees DC-20A, Building Information Modeling; M-10 TG, Barrier Cable; and M-10 TG, Performance-Based Specifications. He has previously served on the PTI Executive Committee and PTI's Technical Advisory Board for many years. Baxi is also a member of ACI Committee 131, Building Information Modeling of Concrete Structures; ACI Subcommittees 301-I, Post-Tensioned Concrete, and 318-T, Post-Tensioned Concrete; and Joint ACI-ASCE Committee 423, Prestressed Concrete.