



The California State University

OFFICE OF THE CHANCELLOR

CSU GUIDELINES

FOR POST-TENSIONED CONCRETE STRUCTURES

April 27, 2018

<http://www.calstate.edu/cpdc/ae>

California State University Seismic Review Board Technical Guidelines January 9, 2018

The CSU Seismic Policy details requirements for CSU construction projects in addition to those that are contained within the CBC and CEBC. The CSU Seismic Review Board (SRB) maintains guidelines on selected topics that provide the design team additional technical details on issues that are important to the execution of projects and represent areas of concern to the SRB. These are intended to inform the EOR so that when the situation is encountered, the EOR can know what the SRB expects. These are not directions, but express issues that in the experience of the SRB need to be resolved for the project to meet CSU's objectives. They are not intended as direction, but as alerts to important technical performance issues in the design that are likely to be of concern in the peer review. These are intended for use for California State University construction, but may also be used by others.

1. Requirements and Recommendations for Post-Tensioned Concrete Structures

In addition to satisfying all of the requirements listed in the CSU Seismic Policy and the applicable sections of the California Building Code, the design and construction of all post-tensioned concrete structures shall conform to all requirements of:

- American Concrete Institute ACI 318-14 for post-tensioned concrete design,
- Post-Tensioning Institute - 6th Edition's recommendations for post-tensioned structures,
- Additional standard of care and practice for post-tensioned structures described in this document.

A post-tensioned concrete designer shall discuss with the peer reviewer, at a minimum, the recommendations in this document and comply with the intent of these requirements, unless there are good technical reasons for not doing so.

A. American Concrete Institute 318 Requirements

1. All post-tensioning tendons shall be encapsulated in compliance with ACI 318-14 Section 20.6.3.1 through 20.6.3.3. Specifications or details that show or indicate exposed strand are not permitted. Closure strip/pour strip details shall not show tendon tails extending into the delay strip.
2. Integrity tendons at the columns shall be clearly indicated on the structural drawings in compliance with ACI 318-14 Section 8.7.5.6.1.
3. Minimum average of 125 psi for two-way slabs and plates shall be provided in compliance with ACI 318-14 Section 8.6.2.1.
4. Precompression from unbonded prestressing reinforcement, as described in ACI 318-14 Section 12.5.1.4, shall be utilized where possible to resist seismic diaphragm forces to minimize congestion from mild reinforcement in chords and collector elements.
5. In podium structures and post-tensioned mat foundation structures where the balanced load exceeds 100% of the concrete weight, the calculations shall clearly demonstrate that the transfer stresses in ACI 318-14 Table 24.5.3.2 are not exceeded using a concrete compressive strength f'_{ci} not greater than 75% of the 28-day compressive strength.

B. Post-Tensioning Institute Recommendations

6. Lateral curvature in banded groups of tendons should be minimized and should satisfy Section 6.3.1.3.4 and Figure 6.14 of the Post-Tensioning Manual - 6th Edition, except that the minimum extension of straight tendon layout past an opening shall be 4'-0". The maximum lateral curvature for banded tendon groups of 20 tendons or less shall be 1:6, with hairpin reinforcement required for curvatures exceeding 1:12. The maximum lateral curvature for banded tendon groups in excess of 20 tendons shall be 1:12, with hairpin reinforcement required for curvatures exceeding 1:20.

Lateral curvature of banded groups of tendons is prohibited in areas of the slab where the concrete top or bottom cover over the tendons is less than 2".

In general, uniformly spaced tendons should be placed orthogonally to the banded tendons. Lateral curvature of uniform tendons should be minimized and shall satisfy Section 6.3.1.3.4 and Figure 6.14 of the Post-Tensioning Manual - 6th Edition. When curving uniform tendons around openings and other obstructions, tendon layout shall not exceed the maximum tendon spacing of 5'-0" or 8 times the slab thickness, whichever is smaller.

7. The seismic system layout shall adhere to the "favorable" arrangement depicted in Figure 6.2 of the Post-Tensioning Manual - 6th Edition. The schematic layout of the seismic system shall be provided to the seismic peer reviewer at the onset of the project for a compliance review.
8. Closure strips/pour strips shall be provided in structures where significant restraint-to-shortening exists. A minimum pour delay of 30 days from the time of the 2nd pour shall be specified for structures with plan dimensions less than or equal to 250', and 60 days for structures with a larger plan dimension. In structures where the plan dimensions exceed 350' a permanent expansion joint is required.
9. Closure strips/pour strips should be limited to 30"-36" in width as stated in the Post-Tensioning Institute document "Restraint Cracks and Their Mitigation in Unbonded Post-Tensioned Building Structures."
10. Slab and beam thicknesses should meet or exceed the recommendations of Table 9.3 of the Post-Tensioning Manual - 6th Edition.

C. California Building Code

11. Comply with minimum fire cover as required in Table 721.1(1)4. Interior bays may be considered restrained as described in Note k. Exterior bays shall be considered unrestrained.

D. Recommended Standards of Care & Practice

12. When closure strips/pour strips are used, it shall be made clear to the contractor through notes and details that the open pour strip bay is incapable of supporting any load, including its own. Unless a greater number of bays is required by calculation, reshores shall be provided and designed such that for every open pour strip bay, a minimum of four closed and cured bays are required for support below if the shoring does not continue to the ground. It is recommended that all reshores in closure/pour strip bays extend to the foundation level.
13. When closure strips/pour strips and construction joints are used, they should be located to minimize uneven floors, column deformations, and related construction costs. The peer reviewer will want to review the basis for their locations to assure good technical performance of the resulting structure.
14. The average compression in flat plates and flat slabs should be limited to a maximum of 250 psi, with 150-175 psi considered optimum.

15. Calculations shall demonstrate the amount of dead load balanced by the post-tensioning system. A minimum of 65% of the concrete weight shall be balanced. Balanced loads shall not exceed 125% of the concrete weight.
16. Tendons less than 125' in length may be stressed from one end only. Tendons greater than 125' in length shall have a "lift-off" performed at the 2nd stressing end. The maximum length of a two-way pull is 250 ft.
17. Every tendon shall be stressed to their full extent (one occurrence) and never partially stressed and then restressed. This requirement is not intended to prohibit staged stressing.
18. Requiring de-tensioning of tendons should be avoided. This is a very dangerous operation for the contractor and alternate solutions should be thoroughly explored before de-tensioning is proposed.
19. Care should be taken to minimize the amount and diameter of conduit placed in the decks. Congested runs of conduit should be surface mounted below the decks. All conduit shall be independently chaired and not supported by the post-tensioning tendons.
20. Care should be taken to minimize penetrations near column supports and tendon anchorages. Penetrations near post-tensioning anchors shall require Schedule 40 steel sleeves. PVC sleeves are not permitted near anchorages.
21. Shear stud reinforcement should be used at two-way slab banded tendon anchorages in lieu of hairpin reinforcement to minimize congestion near anchorages.
22. In flat plates and two-way slabs, provide a minimum of #4 continuous (lapped) bottom reinforcement, spaced not more than 30" apart each way.
23. Shotpin embedment shall be limited to the cover of the concrete over the tendons.
24. Drilling into the post-tensioned slab is prohibited unless tendon locations are marked in advance, the slab has been x-rayed, or the post-tensioning has been recorded through drone or other photography methods. Cast-in-place non-prestressed reinforcement, bolts, plates, etc. shall be specified in lieu of post-installed items.
25. For structures utilizing moment frames, a thorough analysis of punching shear using the story drifts occurring during the maximum considered earthquake story drifts shall be completed.
26. Slabs 10 inches thick or greater should utilize column caps in lieu of shear studs for punching shear reinforcement.
27. Floor systems shall be required to be stressed within 3-5 days of the concrete pour to minimize shrinkage cracking.
28. Deck forms shall remain in place until the deck is poured and stressed completely. Reshores shall be used in non-pour strip bays to distribute the weight of the wet concrete floor to cured and stressed floors below (3 floors minimum) such that the design live load at any floor is not exceeded. Details reflecting these requirements shall be provided on the structural design drawings.
29. Where significant modifications over the life of the structure are anticipated, the designer should specify a method for locating tendons, such as permanent marking on the slab, digitized photography, etc.

Document history:

First issued: November 16, 2017

Revision Date: January 9, 2018

Revision Date: April 23, 2018

April 23, 2018 Revision to cover page title only.

April 27, 2018 Revision to cover page title only.