GUIDELINES FOR EXECUTION OF ADAPT-PT

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The guidelines presented will assist you in the selection of design values that are deemed to result in serviceable, safe and economical post-tensioned floor systems and beam frames, using the ADAPT-PT software. Unlike nonprestressed floors, where for a given geometry and loading there will be a unique minimum rebar design solution, for prestressed members there is always a multitude of acceptable designs. The economy of design depends on the selection by the design engineer of a number of parameters, such as the level of precompression and tendon profile. ADAPT-PT is tailored to provide you with the hints you need to achieve optimum solutions in your designs. The following summarizes the considerations. In addition, several details included in this writing make sure that your design are in line with good construction practice

If you have not been using the program before, it is strongly recommended that you go through the tutorials that are provided in the program CDs, or on ADAPT’s website. There are several well described tutorials that walk you through the design of beam or wall-supported one-way slabs, column supported slabs, beam frames, and nonprismatic members.

The detailed recommendations are based on experience gathered in design of common buildings and parking structures. They reflect the common practice and lead to economical designs. For unusual conditions, however, values other than recommended may apply.

AVERAGE PRECOMPRESSION

- Minimum 125 psi (0.85 MPa), except for the roof, where 150 to 200 psi (1.0 to 1.4 MPa) is recommended, if water tightness of the roof slab is a concern.
- Maximum 275 (2.0 MPa) for slabs; 350 (2.50 MPa) for beams without flange. Lesser values are recommended for flanged beams.

PERCENTAGE OF DEAD LOAD TO BALANCE

Dead load consists of selfweight plus superimposed quasi permanent loading. The percentage of dead load is calculated as the total uplift of a tendon divided by the dead load of the same span. For example in Fig. 1 this value is: \[100(W2 + W3)/DL\], where DL is the dead load of the span. The program automatically calculates this percentage for each span and each profile and reports it to you.

- For critical span (generally longest span)
  - Slabs 60 – 80 percent
  - Beams 70 – 100 percent

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For other spans (non-critical spans)

- Generally balance the load to a lesser amount for the span next to the critical
- First choice is to keep the tendon profile at its maximum drape and reduce the force (number of strands) if practical
- If the above is not practical, reduce the tendon drape.

**FIGURE 1**

The concept of “proportional balancing,” whereby all spans are balanced to the same percentage of dead load is convenient, but it is not economical where spans are not all of the same length and loading. Figure 2 shows a condition, where an economical design is obtained by balancing the first span to the maximum percentage, the second span to a smaller percentage and zero percentage for the last span (straight tendon).

**FIGURE 2**

Example of tendon profile for unequal spans.
TENDON LAYOUT

- For unbonded tendons, use minimum of two tendons over each support in each direction. Each tendon has typically one strand.
  For bonded tendons, if it is not practical to pass a tendon over a support, use a minimum of one tendon on each side of the support within a distance “d” from the face of support. Where, “d” is the slab’s effective depth. A bonded tendon may contain one or more strands.
- Use banded tendons in one direction and distributed in the orthogonal direction.

TENDON PROFILE

Shape
- Use reversed parabola with inflexion points at 0.1 for beams and distributed tendons (Fig. 2).
- In the banded direction, use partial parabola with a straight length of about 4’ – 0” (1200 mm) over the columns (Fig. 3). The straight profile over the support permits the tendon to maintain a high point over the top reinforcement in the orthogonal direction. The straight length specified is intended to clear the extent of top bars below the banded tendons.
Select the midspan as low point of tendon (Figs. 2 and 3). This is primarily for the convenience of construction crew. For slab construction, its adverse impact on the economy of design is not significant. For beam design, it is more advantageous to select a low point 0.4 times the span at end spans and midpoint at interior spans.

Drape

“Drape” is generally interpreted to be a measure between the distance of a tendon’s high and low points in a given span. A higher drape provides a larger uplift.

- Bring the tendon over the support to the highest point permissible for cover and practical for placement.
- At bottom, bring the tendon as close to the soffit of the member as permissible or practical. If the uplift proves to be excessive, reduce the prestressing force. If this is not practical for stressing reasons, raise the tendon at its low point. Use intervals of 0.25 inch (5mm) when adjusting tendon height.
- Lay tendons straight and at high point along and over the interior wall (Fig. 4). For modeling of walls in direction of the frame being analyzed refer to “Modeling of Slabs With Interior Wall Supports” (ADAPT Technical Note 118).
- Along and adjacent to exterior walls, place tendons straight and at mid-depth. Tendons along exterior walls are generally designed by inspection. The force selected is to provide an average precompression over the tributary of an exterior wall equal to that used for other parts of the floor design. Since the slab is supported on the wall, these tendons are not required for the strength check of the code.
- At slab edge, anchor tendons at the height of the first span’s centroid (Fig. 5). Disregard the impact of drop caps/panels and transverse beams at the slab edge in the determination of the anchorage position. Base the position of the anchorage on the level of the centroid at midspan of the member.
- For isolated beams in direction of the frames being analyzed, anchor tendon at the centroid of the beam.
- For flanged beams in direction of frame being analyzed, anchor tendon at the centroid of the combined beam and its tributary. Note that the tendon is to be anchored at the centroid of the beam’s “tributary,” and not the centroid of the beam stem and its “effective width” which may have been considered for the flexural response of the beam.
- For equal performance of exterior and interior spans in resisting fire, provide a higher CGS (distance between soffit to centroid of tendon) for low point of exterior spans, where a slab edge is not tied to a wall, nor is it supported by an edge beam. For normal construction and two hour fire
rating, the cover to prestressing required for exterior spans can be as much as twice of the value of interior spans\(^2\).

- Where tendons do not extend over the entire length of a member, terminate them at one-fifth of the span and at the centroidal axis (Fig. 2).

PRESTRESSING LOSSES

In using ADAPT-PT, you can either ask the program to determine the immediate and long-term stress losses for you and account them in the calculations, or you can specify the stress losses yourself. If you choose the second option, you declare the effective force in strand after all stress losses. The second option is referred to “effective force” method.

If in design of prestressing a constant “effective force” is assumed, select the following:

- For unbonded tendons: 175 ksi (1200 MPa). This translates to an effective 26.8 k for a ½ inch (120 kN for 13 mm) strand. For bonded tendons assume 165 ksi (1140 MPa). This corresponds to 25.2 k for ½ inch strand (112 kN for 13 mm). The effective stress values suggested are for common building structure slabs and are based on the following:

\(^2\) This is a requirement of the International Building Code (IBC 2003), and may not apply when design is based on other building codes.
• When a tendon is less than 125 ft (38.1 m), stress at one end.
• When a tendon is longer than 125 ft (38.1 m), but less than 250 ft (76.2 m) stress at both ends.
• For tendons longer than 250 ft (76.2 m) lower values apply. Use the stress loss calculation of the program to obtain the applicable value. Alternatively, you can use the friction and stress loss program ADAPT-FELT to determine the effective force.

NONPRESTRESS (PASSIVE) REINFORCEMENT
• Limit the area of top reinforcement over columns to 6.25 sq inch (4000 sq mm). This translates to 20 #5 (25 – 16mm) bars, when unbonded tendons are used. For grouted tendons, larger diameter bars may be more appropriate.
• For unbonded tendons use #5 (16mm ) bars for top and #6 (20 mm) bars for bottom. For grouted tendons, larger diameter bars may be used, since tendon thickness is typically larger (3/4 inch; 20 mm).
• For beams use #8 (25 mm) bars top and bottom

TEMPERATURE AND SHRINKAGE REINFORCEMENT
• Temperature and shrinkage reinforcement are generally not required for post-tensioned members, since to conform with building codes the design should provide a minimum of 125 psi (0.85 MPa) precompression. This exceeds the precompression required for temperature and shrinkage (100 psi; 0.70 MPa). Where banded tendons are used, it is possible that in direction of the bands precompression at slab edge is less than the required minimum [2]. Provide local reinforcement equal to 0.0018 times the slab cross-section. Do not provide continuous tendons along the entire length and between the bands or along and in between the beam stems. In the general case, this practice is not beneficial to the performance of the slab.

REFERENCES


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1 International Building Code (IBC 2003); ACI-318-05