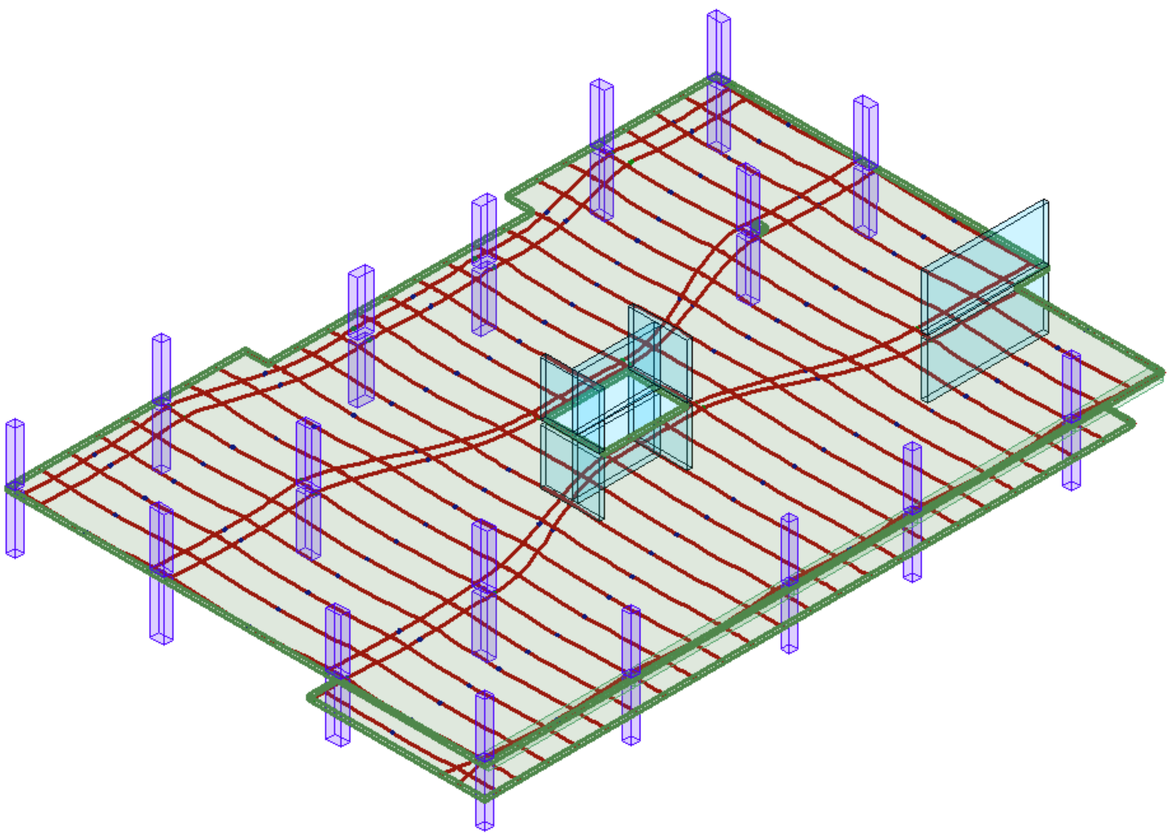
ADAPT-Builder® 22 Quick Start Course

Project Specifications



adaptsupport@risa.com   www.risa.com
RISA Tech, Inc., 26632 Towne Centre Dr. Ste210, Foothill Ranch, California, USA
Tel: +1 (949) 951-5815, Toll Free: +1 (800) 332-RISA

Introduction and Model Description

In this Quick Start Course we will go through the process of modeling, analyzing, and designing a single level two-way post-tensioned slab. The slab will be an unbonded, post-tensioned (PT) concrete flat slab. The model will also include a post-tensioned beam to be designed. The concrete floor being designed is assumed to be a single representative level of a multi-story building. The gravity supports will be square and rectangular concrete columns and walls.

The governing design codes to be used for the tutorial are ACI318-2019/IBC 2021

The following assumptions also apply:

- The structural analysis is limited to gravity load design of the post-tensioned slabs and beams.
- It is assumed that the slabs act as rigid diaphragms which transfer forces through the floor system and are apportioned to resisting frame elements as a function of their individual stiffness as determined by the Finite Element Method.
- For gravity analysis and design, it is assumed that all column-to-slab joints can transfer moment and are not released for rotation in XYZ directions.
- For analyses performed in Single-Level mode, the support conditions are assumed as fixed rollers with translation X and Y stabilization at the slab level.
- The “effective flange” concept does not apply and the design tributaries for beams will consider the entire tributary width associated with a design strip.

Note: Additional “progress models” are included in the Quick Start Kit so that users can make sure that they are following along with the course progress.

Geometry:

FIGURE 1-1 shows the structure geometry for the slab to be designed, the .dwg file used to start the model is included in the Quick Start Kit .zip folder.

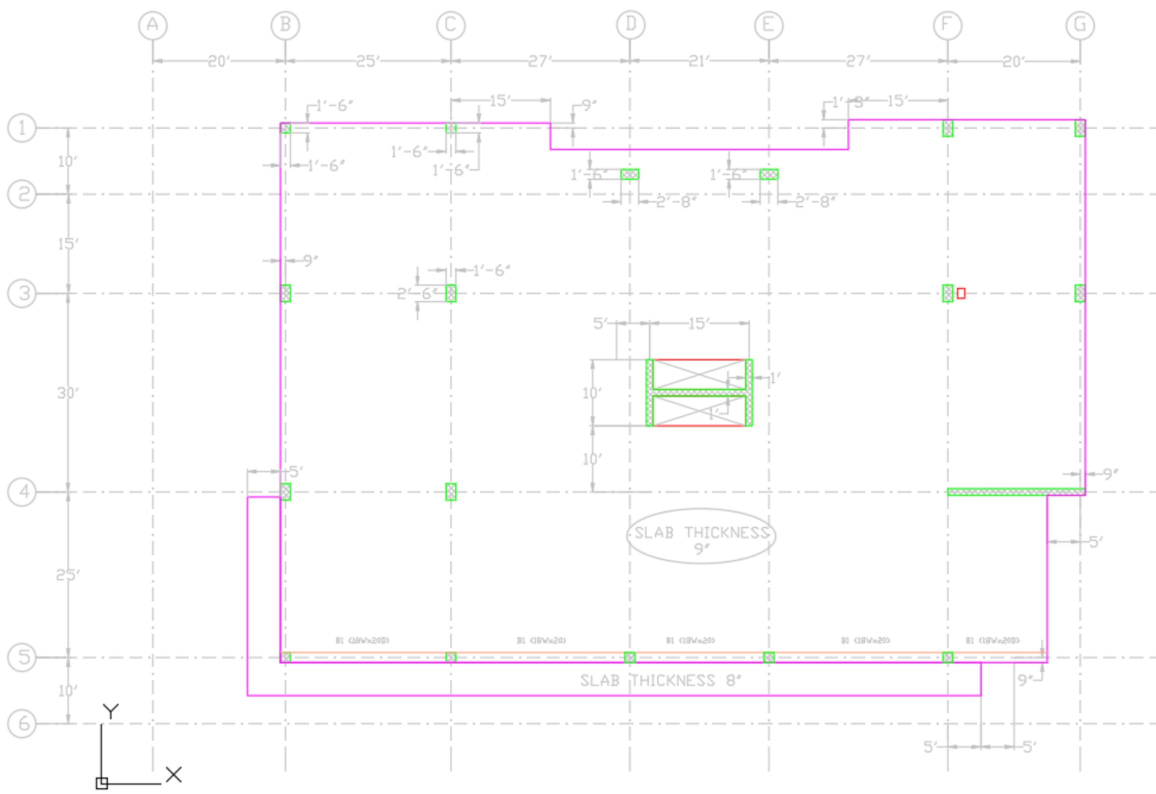


Figure 1-1

The following parameters define the structure geometry, component dimensions, material properties, design criteria, loads and load combinations.

Dimensions:

- Post-tensioned slab thickness = 9”
- Post-tensioned balcony slab thickness = 8”
- Post-tensioned concrete beams = 18”x20”
- Columns = 18” sq., 18”x30”, 32”x18”
- Wall thickness = 12” all levels

Material Properties:

Concrete

- Concrete unit weight = 150lb/ft3
- Cylinder Strength (f’c) at 28 days = 4000 psi (slabs and beams)
- Cylinder Strength (f’c) at 28 days = 5000 psi (walls and columns)
- Modulus of Elasticity (4000psi) = 3835 ksi
- Modulus of Elasticity (5000psi) = 4287 ksi

- Creep Coefficient = 2
- Shrinkage Factor = 0.5
- Curing Type = Moist
- Duration of curing = 7 days.

Post-Tensioning

- Low-relaxation, seven wire strand
- Strand Diameter = 0.5 in nominal
- Strand Area = 0.153 in^2
- Modulus of Elasticity = 28500 ksi
- Ultimate strength (fpu) = 270 ksi
- Yield strength (fpy) = 240 ksi
- Average effective stress (fse) = 175 ksi
- Effective force/strand = 26.7 k
- System type = Unbonded
- Angular friction = 0.07
- Wobble friction = 0.001 rad/ft
- Jacking stress = 0.80fpu = 216 ksi
- Seating loss (draw-in) = 0.25 in.
- Concrete strength at stressing = 0.75 f'c

Non-prestressed Reinforcement

- Yield Strength = 60 ksi
- Modulus of Elasticity = 29000 ksi

Average Pre Compression and Balanced Loading:

- Minimum precompression = 125psi
- Maximum precompression = 300psi
- Minimum balanced loading = 50% (total dead load)
- Maximum balanced loading = 100% (total dead load)

Allowable Stresses for Post-Tensioned Slabs:

Maximum tensile stress due to

- Prestress plus sustained loads = 6*sqrt(f'c)
- Prestress plus total loads = 6*sqrt(f'c)
- Prestress plus self-weight = 3*sqrt(f'ci)

Maximum compressive stress due to

- Prestress plus sustained loads = 0.45*f'c
- Prestress plus total loads = 0.60*f'c
- Prestress plus self-weight = 0.60*f'ci

Tendon Profiles:

- Interior spans - Reversed parabola with inflection point ratio of 0.1
- Exterior spans with no cantilever - Low point at center; exterior half simple parabola; interior half reversed parabola with inflection point at 0.1 ratio
- Exterior spans with cantilever - Same as interior span
- Cantilever - Single simple parabola with center of curvature at bottom

Cover:

Non-prestressed Reinforcement - Slabs

- To top bars (enclosed areas) = 0.75 in
- To bottom bars (enclosed areas) = 0.75 in
- To top bars (exposed area) = 1.5 in
- To bottom bars (exposed areas) = 1.5 in

Non-prestressed Reinforcement - Beams

- To stirrups - top = 1.5 in
- To stirrups - bottom = 1.5 in

Post-Tensioned Slabs

- Top CGS = 1.0 in
- Bottom CGS – Interior spans = 1.0 in
- Bottom CGS – Exterior spans = 1.75 in

Design Loads:

Gravity Loads

- Self-weight = based on unit weight
- Superimposed dead load
    - Residential = 25 psf
    - Corridor = 25 psf
    - Mechanical = 60 psf
- Exterior cladding (dead load) = 300 lb/ft
- Live Load
    - Residential = 40 psf
    - Corridor = 100 psf
    - Mechanical = 40 psf

Load Combinations:

Serviceability Load combinations (SLS) – Gravity

- 1.0*SW + 1.0*SDL + 1.0*LL + 1.0*PT [Total Service]
- 1.0*SW + 1.0*SDL + 0.3*LL + 1.0*PT [Sustained Service]
- 1.0*SW + 1.15*PT [Initial]

Strength Load Combinations (ULS) – Gravity

- 1.2*SW + 1.2*SDL + 1.6*LL + 0.5*RLL + 1.0*HYP
- 1.4*SW + 1.4*SDL + 1.0*HYP

Long-Term Deflection

Load is applied in stages:

Stage 1: Forms removed 20 days after casting, t1=20 days.
Stage 2: Partitions and deflection-sensitive fixtures installed 40 days after casting, t2 = 40 days.
Stage 3: Live load placed on a slab 180 days after casting, t3= 180 days. Part of live load sustained on the structure (30%).

Calculate:

- Defections at 180, 360 and 5000 days after casting.
- Incremental deflection occurring after the installation of nonstructural elements likely to be damaged by large deflections.

Total deflection is calculated as:

$d = d_t + d_l$

Where,

d_t = long term deflection at time t (all sustained loads) dl = immediate deflection due to additional live load (non-sustained portion of live load)

The long-term deflection is calculated as:

$d_t = dm_1 + C_1*dm_1 + dm_2 + C_2*dm_2 + C_3*dm_3$

Where,

dmi= instantaneous deflection due to added sustained load. It is calculated as the difference between deflections at Stage i+1 and Stage i. Deflections are calculated assuming cracked sections.

dmi= (deflection at Stage i+1) - (deflection at Stage i)

Ci = time dependent creep and shrinkage coefficient at day t; Detailed calculations of creep and shrinkage coefficient based on ACI 209R-92

Deflections:

Assuming the hypothetical tensile stresses within the limits stated in the preceding are maintained, the total and live load deflections will be considered based on un-cracked, linear-elastic properties for gravity service evaluation of slab deflections.

For the floor slabs and beams the maximum deflections are maintained below the following values with the understanding that the floor structure is not attached to nonstructural elements likely to be damaged by large deflections of the floor:

- Total Long-Term Deflection = L/240
- Total live load = L/360