concrete construction: T-beams & slabs

T sections
• two areas of compression in moment possible
• one-way joists
• effective flange width

Systems
• beams separate from slab
• beams integral with slab
  – close spaced
• continuous beams
• no beams

T sections
• negative bending: \( \min A_s \), larger of:
  \[
  A_s = \frac{6f^t_c}{f_y} (b_w d) \quad A_s = \frac{3f^t_c}{f_y} (b_f d)
  \]
• effective width (interior)
  – \( L/4 \)
  – \( b_w + 16t \)
  – center-to-center of beams

Figure 9.3.1 Actual and equivalent stress distribution over flange width.
**T sections**

- usual analysis steps
  1. assume no compression in web
  2. design like a rectangular beam
  3. needs reinforcement in slab too
  4. also analyze for negative moment, if any

**One-Way**

- Joists
  - wide pans
  - 5', 6' up
  - light loads & long spans
  - one-leg stirrups

**Compression Reinforcement**

- doubly reinforced
- negative bending
- two compression forces
- bigger $M_n$
- control deflection
- increase ductility
- needs ties because of buckling
Compression Reinforcement

- analysis
  - $A_s$ & $A_s'$
  - $T = C_c + C_s$
  - $T = A_s f_y$
  - $C_s = A_s'(f_s' - 0.85f_c')$
  - $C_c = 0.85f_c' ba$ with $a = \beta c$
  - $f_s'$ not known, so solve for $c$ (n.a.)
  - $f_s' < f_y$?
  - $M_n = T(d-a/2)+C_s(d-d')$

Slabs

- one way behavior – like beams
- two way behavior – more complex

Slab Design

- one unit wide “strip”
- with uniform loads
  - like “wide” beams
  - moment / unit width
  - uniform curvature
- with point loads
  - resisted by stiffness of adjacent strips
  - more curvature in middle

Slab Design

- min thickness by code
- reinforcement
  - bars, welded wire mesh
  - cover
  - minimum by steel grade
  - 40-50: $\rho = \frac{A_s}{bt} = 0.002$
  - 60: $\rho = \frac{A_s}{bt} = 0.0018$

Table 12.4.1—Minimum thickness of solid non-prestressed one-way slabs

<table>
<thead>
<tr>
<th>Support condition</th>
<th>Minimum thickness ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simply supported</td>
<td>$t_{50}$</td>
</tr>
<tr>
<td>One-end restrained</td>
<td>$t_{24}$</td>
</tr>
<tr>
<td>Both-end restrained</td>
<td>$t_{26}$</td>
</tr>
</tbody>
</table>

1.00 = $f_y$ in $0.85$ ksi, $f_y$ in the range of 30 to 112 (lb/ft$^2$), the exemptions in Table 12.4.1.1 shall be multiplied by the greater of (a) and (b).

(c) 3.00 - 8.000w c
(d) 1.89
One-Way Slabs

- $A_s$ tables
- max spacing
  - $\leq 3(t)$ and 18”
  - $\leq 5(t)$ and 18” – temp & shrinkage steel
- no room for stirrups

![Diagram of one-way slab](image)

<table>
<thead>
<tr>
<th>Bar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar spacing (in.)</td>
</tr>
<tr>
<td>45</td>
</tr>
<tr>
<td>44</td>
</tr>
<tr>
<td>43</td>
</tr>
<tr>
<td>42</td>
</tr>
<tr>
<td>41</td>
</tr>
</tbody>
</table>

Precast

- prestressed
  - PCI Design Handbook
  - double T’s
  - hollow core
  - L’s
- topping
- load tables

![Diagram of precast elements](image)