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:
  \[
  A_s = \frac{6}{f_c} f' (b_w d) \quad A_s = \frac{3}{f_y} f_c (b_d d)
  \]
- effective width (interior)
  - $L/4$
  - $b_w + 16t$
  - center-to-center of beams

**Figure 9.5.1** 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
  - standard stems
  - 2.5” to 4.5” slab
  - ~30” widths
  - reusable forms

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
  - $A_s$ & $A_s'$
  - $T = C_c + C_s$
  - $T = A_s f_y$
  - $C_s = A_s (f'_s - 0.85 f'c)$
  - $C_c = 0.85 f'c ba$ with $a = \beta_1 x$
  - $f_s'$ not known, so solve for $x$ (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:
      \[ \rho = \frac{A_s}{bt} = 0.0018 \]
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

<table>
<thead>
<tr>
<th>Bar size</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
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<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar spacing (in)</td>
<td>0.22</td>
<td>0.20</td>
<td>0.17</td>
<td>0.15</td>
<td>0.13</td>
<td>0.11</td>
<td>0.10</td>
<td>0.09</td>
<td>0.08</td>
<td>0.07</td>
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<tr>
<td>$A_s$ (in.$^2$/ft)</td>
<td>0.42</td>
<td>0.40</td>
<td>0.38</td>
<td>0.36</td>
<td>0.34</td>
<td>0.32</td>
<td>0.30</td>
<td>0.29</td>
<td>0.27</td>
<td>0.25</td>
<td>0.23</td>
<td>0.21</td>
<td>0.19</td>
</tr>
</tbody>
</table>

Precast

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