lecture twenty two

concrete construction: T-beams & slabs
Systems

- beams separate from slab
- beams integral with slab
  - close spaced
- continuous beams
- no beams
T sections

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

- **negative bending:** min $A_s$, larger of:

  $$A_s = \frac{6}{f_y} \sqrt{f_c'} (b_w d) \quad A_s = \frac{3}{f_y} \sqrt{f_c'} (b_f d)$$

- **effective width (interior)**
  - $L/4$
  - $b_w + 16t$
  - center-to-center of beams
**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**

![Diagram of T section](image)
One-way

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

FLANGEforms are available in standard 2- and 3-foot modules. These forms are among the most popular because of their flexibility to accommodate various layouts and joist widths where required. They are efficient for projects with heavy superimposed loads and provide a two-hour fire rating by using a 4 1/2-inch hard-rock concrete topping. They are efficient for projects of smaller size and for moderate size projects with irregular layouts or unusual building shapes. They are also efficient for projects where the structure is not required to provide a two-hour fire rating by using 3-inch or 3 1/2-inch top slab.

The varying depths provide flexibility to meet a wide range of spans and loads. Further, they will accommodate in-the-floor raceway electrical and communication distribution systems. Ceco FLANGEforms are capable of producing sound structural concrete, but are incapable of producing tight tolerances and smooth finishes. This form is a segmented steelform and the concrete will have irregular joists, a rough finish, and offsets at both the laps and flanges.

If a higher quality finish is required, you may wish to consider Ceco LONGforms (please see page 6). The additional cost of higher quality forms is often offset by finishing costs. Contact your Ceco representative for assistance.
One-way

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

- doubly reinforced
- negative bending
- two compression forces

- \( T = C_c + C_s \)
- \( T = A_s f_y \)
- \( C_s = A_s' f_y \)
- \( M_n = T(d-a/2) + C_s(d-d') \)
Compression Reinforcement

- needs ties because of buckling
- simplified method in text assumes
  - \( A_s' = 0.3A_s \)
  - \( M_n > M_u/\phi \)
  - \( f'_s = \frac{1}{2}f_y \)
  - \( a = 2d' \)
  - so

\[
A_s = \frac{M_u/\phi}{f_y(d - d')} 
\]
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 9.5(a)—MINIMUM THICKNESS OF NONPRESTRESSED BEAMS OR ONE-WAY SLABS UNLESS DEFLECTIONS ARE COMPUTED

<table>
<thead>
<tr>
<th>Member</th>
<th>Simply supported</th>
<th>One end continuous</th>
<th>Both ends continuous</th>
<th>Cantilever</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid one-way slabs</td>
<td>( \ell/20 )</td>
<td>( \ell/24 )</td>
<td>( \ell/28 )</td>
<td>( \ell/10 )</td>
</tr>
<tr>
<td>Beams or ribbed one-way slabs</td>
<td>( \ell/16 )</td>
<td>( \ell/18.5 )</td>
<td>( \ell/21 )</td>
<td>( \ell/8 )</td>
</tr>
</tbody>
</table>

Notes:
1) Span length \( \ell \) is in inches.
2) Values given shall be used directly for members with normalweight concrete \((w_c = 145 \text{ lb/ft}^3)\) and Grade 60 reinforcement. For other conditions, the values shall be modified as follows:
   a) For structural lightweight concrete having unit weight in the range 90-120 \( \text{lb/ft}^3 \), the values shall be multiplied by \((1.65 - 0.005w_c)\) but not less than 1.05, where \(w_c\) is the unit weight in \(\text{lb/ft}^3\).
   b) For \(f_y\) other than 60,000 psi, the values shall be multiplied by \((0.4 + f_y/100,000)\).
One-way Slabs

- $A_s$ tables
- max spacing
  - $\leq 3(t) \text{ and } 18''$
  - $\leq 5(t) \text{ and } 18''$ – temp & shrinkage steel
- no room for stirrups