concrete construction:
flat spanning systems
Reinforced Concrete Design

- economical & common
- resist lateral loads
Reinforced Concrete Design

- **flat plate**
  - 5”-10” thick
  - simple formwork
  - lower story heights

- **flat slab**
  - same as plate
  - 2 ¼”–8” drop panels
Reinforced Concrete Design

- **beam supported**
  - slab depth ~ $L/20$
  - 8”–60” deep

- **one-way joists**
  - 3”–5” slab
  - 8”–20” stems
  - 5”-7” webs
Reinforced Concrete Design

• **two-way joist**
  - “waffle slab”
  - 3”-5” slab
  - 8”-24” stems
  - 6”-8” webs

• **beam supported slab**
  - 5”-10” slabs
  - taller story heights
Reinforced Concrete Design

• simplified frame analysis
  – strips, like continuous beams

• moments require flexural reinforcement
  – top & bottom
  – both directions of slab
  – continuous, bent or discontinuous
Reinforced Concrete Design

- one-way slabs (wide beam design)
  - approximate analysis for moment & shear coefficients
  - two or more spans
  - ~ same lengths
  - \(w_u\) from combos
  - uniform loads with \(L/D \leq 3\)
  - \(l_n\) is clear span (+M) or average of adjacent clear spans (-M)

*Figure 2-2 Conditions for Analysis by Coefficients (ACI 8.3.3)*
Reinforced Concrete Design

**Figure 2-3 Positive Moments—All Cases**

**Figure 2-4 Negative Moments—Beams and Slabs**
Shear in Concrete

- at columns
- want to avoid stirrups
- can use shear studs or heads
Shear in Concrete

- critical section at $d/2$ from
  - column face, column capital or drop panel
Shear in Concrete

- at columns with waffle slabs
Openings in Slabs

- careful placement of holes
- shear strength reduced
- bending & deflection can increase
General Beam Design

- $f'_c$ & $f_y$ needed
- usually size just $b$ & $h$
  - even inches typical (forms)
  - similar joist to beam depth
  - $b:h$ of 1:1.5-1:2.5
  - $b_w$ & $b_f$ for $T$
  - to fit reinforcement + stirrups

- slab design, $t$
  - deflection control & shear

\[
S = \frac{bh^2}{6}
\]
General Beam Design (cont’d)

• custom design:
  – longitudinal steel
  – shear reinforcement
  – detailing

![Diagram of beam design with labels for longitudinal steel, shear reinforcement, and detailing.]