concrete construction: flat spanning systems

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

- 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 $L/D \leq 3$
  - $\ell_n$ is clear span (+M) or average of adjacent clear spans (-M)

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

- two-way slabs - Direct Design Method
  - 3 or more spans each way
  - uniform loads with $L/D \leq 2$
  - rectangular panels with long/short span $\leq 2$
  - successive spans can’t differ $> \text{longer}/3$
  - column offset no more than 10% span

Shear in Concrete

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

General Beam Design (cont’d)
• custom design:
  – longitudinal steel
  – shear reinforcement
  – detailing
Space “Frame” Behavior

- handle uniformly distributed loads well
- bending moment
  - tension & compression “couple” with depth
  - member sizes can vary, but difficult

**Folded Plates**

- increased bending stiffness with folding
- lateral buckling avoided

Space “Frame” Behavior

- shear at columns
- support conditions still important
  - point supports not optimal
- fabrication/construction can dominate design

Folded Plates

- common for roofs
- edges need stiffening

http://nisee.berkeley.edu/godden
Folded Plates

– State Farm Center
  (Assembly Hall), University of Illinois
– Harrison & Abramovitz 1963
– Edge-supported dome spanning 400 feet wound
  with 614 miles of one-fifth inch steel wire