Slab Form Design

Temporary Structures

Slab Formwork

Parts of typical slab formwork

Slab Formwork

Design Steps:
- **Step 1:** Estimate design loads
- **Step 2:** Sheathing thickness and spacing of its supports (joist spacing)
- **Step 3:** Joist size and spacing of supports (stringer spacing)
- **Step 4:** Stringer size and span (shore spacing)
- **Step 5:** Shore design to support stringers
- **Step 6:** Check bearing stresses
- **Step 7:** Design lateral bracing
Slab Form Design Example

- **Design forms to support a flat slab floor 8 in. thick of normal weight concrete, using construction grade Douglas Fir-Larch forming members and steel shoring. Ceiling height is 8 ft. and bays are 15x15 ft. Since forms will have continuing reuse, do not adjust base design values for short term load.**

**STEP 1: ESTIMATE LOADS:**
- Dead load, concrete and rebar, \( \frac{8 \text{ in.}}{12 \text{ in.}} \times 150 \text{ pcf} = 100 \text{ psf} \)
- Minimum construction live load on forms 50 psf (refer to lecture #1)
- Weight of forms, estimated \( 8 \text{ psf} \)

Total form design load
\[ 100 + 50 + 8 = 158 \text{ psf} \]

**STEP 2: SHEATHING DESIGN:**
- Assuming 3/4-in. form grade plywood sheathing, from Tables 4-2 and 4-3:
  - \( F_b = 1545 \text{ psi} \)
  - \( F_S = 57 \text{ psi} \)
  - \( E = 1,500,000 \text{ psi} \)
  - \( S = 0.412 \text{ in.}^3 \)
  - \( I = 0.197 \text{ in.}^4 \)
  - \( Ib/Q = 6.762 \text{ in.}^2 \)
Slab Form Design

**Slab form Design Example**

- **STEP 2: SHEATHING DESIGN:**
- Tables 4-2 and 4-3, for plywood:

  **CHECK BENDING**
  - For design purposes, consider a 1-foot-wide strip of plywood. Then:
  
  \[ w = \text{design load of 158 psf } \times 1 \text{ ft. } = 158 \text{ lb/lf} \]

  \[ l = 10.95 \sqrt{\frac{f_S}{w}} \]

  - Substituting in the equation:
  
  \[ l = 10.95 \sqrt{\frac{1545 \times 0.412}{158}} = 22.0 \text{ in.} \]

- **CHECK DEFLECTION**
  - For \( \Delta = l/360: \)
  
  \[ l = 1.69 \sqrt{\frac{EI}{w}} = 1.69 \sqrt{\frac{1500000 \times 0.197}{158}} = 1.69 \sqrt{1870} = 20.8 \text{ in.} \]

  - For \( \Delta = 1/16": \)
  
  \[ l = 3.23 \sqrt{\frac{EI}{w}} = 3.23 \sqrt{\frac{1500000 \times 0.197}{158}} = 3.23 \sqrt{1870} = 21.2 \text{ in.} \]
Slab Form Design Example

- **CHECK ROLLING SHEAR**
  - For design purposes, consider a 1-foot-wide strip of plywood. Then:
    \[ F_s = \frac{VQ}{Ib} \]
  - since \( V_{max} = 0.6wL \), so:
    \[ F_s = \frac{VQ}{Ib} = 0.6wL \times \frac{Q}{Ib} \]
    or: \[ L = \frac{F_s}{0.6w} \times \frac{Ib}{Q} \]
  - Substituting in above equation:
    \[ L = \frac{60}{0.6} \times \frac{48}{6.762} = 4.0 \text{ ft or 48 inches} \]

- **Slab Form Design Example**
  - From the above calculations, \( l = 20.8 \text{ in.} \)
  - meaning that joist supports *cannot* be more than 20.8 inches apart.
  - HOWEVER, in order to select the span, we must consider the size of the plywood sheets and equal spacing of supports.
  - In this case, 5 equal spaces of 19.2 inches on an 8-ft. wide plywood sheet will be appropriate.

- **Slab Form Design Example**
  - **STEP 3: JOIST SIZE AND SPACING OF STRINGERS TO SUPPORT THE JOISTS:**
    - Check 2x4 construction grade Douglas-Fir-Larch as joist (forms are used repeatedly, so there is no short-term load adjustment).
    - From Table 4-2: \( F_v = 1000 \text{ psi} \) and \( F_r = 95 \text{ psi} \) and should be adjusted for horizontal shear by a factor of 2. \( E = 1,500,000 \text{ psi} \)
    \[ F_v' = 2.0 \times 95 = 190 \text{ psi} \]
Temporary Structures

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Slab form Design Example

- **CHECK BENDING**
  \[ l = 10.95 \text{ ft} \]
  \[ \frac{F'S}{w} = 10.95 \]
  \[ \frac{1000 \times 3.06}{253} = 38.1 \text{ in.} \]

- **CHECK DEFLECTION**
  - For \( \Delta = \frac{wL^4}{EI} \)
  \[ l = 1.69 \text{ ft} \]
  \[ \frac{F'I}{w} = 1.69 \]
  \[ \frac{150 \times 5.36 \times 10^3}{253} = 1.69 \times 5177.8 = 1.69 \times 31.67 = 53.5 \text{ in.} \]

- **CHECK SHEAR**
  - Using the horizontal shear stress formula for a uniformly loaded continuous beam:
    \[ f_v = \frac{0.9w(2d)}{bd(L - 2d)} \]
    \[ f_v = 190 \times \frac{0.9 \times 253}{5.25} \times \frac{L - 2 \times 3.5}{12} \]
    \[ 190 = 43.37L - 25.3 \implies L = 4.69 \text{ ft.} \]
  - Or \( L = 4.69 \times 12 \text{ in./ft.} = 59.5 \text{ inches} \)
**Slab Form Design Example**

- Comparing the three spans calculated above, \( l = 38.1 \) inches governs.
- Considering 15x15 feet bays and desire for uniform spacing, 36 inch spacing is a reasonable number.
- This means that the spacing of stringers will be at 5 equal spaces per bay.

\[
(5 \times 36" = 180 \text{ inches} = 15 \text{ feet})
\]

**STEP 4: STRINGER SIZE AND SPAN:**

- Use 4x4 Construction grade Douglas-Fir-Larch stringers. From Table 4-1B for S4S 4x4s: \( bd = 12.25 \text{ in.}^2 \), \( l = 12.50 \text{ in.}^3 \), \( S = 7.15 \text{ in.}^3 \); and \( d = 3.5 \text{ in.} \)
- **CHECK BENDING**

\[
I = \frac{10.95}{w} \sqrt{\frac{P^2}{S}} \cdot \frac{1000 \times 7.15}{474} = 42.5 \text{ in.}
\]

**CHECK DEFLECTION**

- For \( \Delta = \frac{l}{360} \)

\[
I = 1.69 \times \frac{E}{w} = 1.69 \times \frac{1500000 \times 12.50}{474} = 1.69 \times 339357 = 1.69 \times 34.07 = 57.6 \text{ in.}
\]

**CHECK SHEAR**

- Use the horizontal shear stress formula for a uniformly loaded continuous beam:

\[
L = \frac{190 \times 12.25}{0.9 \times 474} + \frac{2 \times 3.5}{12} = 5.45 + 0.58 = 6.03 \text{ ft} = 72.4 \text{ in.}
\]
Slab Form Design Example

From the above calculations, \( l = 42.5 \text{ in.} \) governs.

- Meaning that stringers \textbf{CANNOT} be more than 42.5 inches apart (span of stringers).
- HOWEVER, in order to select an appropriate span, we must consider the dimensions of the bay.
- The 15-ft. bay could be divided into 5 equal spaces of 36 inches \((180/5 = 36")\) which is less than the maximum allowable span of 42.5 inches.

Alternatively, we can check the possibility of using a deeper stringer, i.e. 3x6, in order to increase the shore spacing.

- Since bending is dominant here, we will check bending for a 3x6 member.
- For 3x6s from Table 4-2: \( F_b = 1000 \text{ psf} \), and from Table 4-1B, \( S = 12.60 \text{ in.}^2 \)

\[
l = 10.95 \sqrt{\frac{F_b \times S}{w}} = 10.95 \sqrt{\frac{1000 \times 12.60}{474}} = 10.95 \times 5.16 = 56.4 \text{ in.}
\]

Now we can use 45-in. support spacing for the 3x6 stringers, which will divide the bay into 5 equal spaces.

STEP 5: SHORE DESIGN:

- Stringers are placed 36-inches apart, supported by shores spaced 45 inches apart. The area of support for each shore is:

\[
\text{Area} = \left( \frac{36}{12} \right) \times \left( \frac{45}{12} \right) = 11.25 \text{ ft.}^2
\]

- Then the total load per shore is:

\[
11.25 \text{ ft.}^2 \times 158 \text{ psf} = 1778 \text{ lb.}
\]
**Slab Form Design Example**

- Schematic design:

  2\(\times\)4 S4S Joists
  
  Plyform

  3\(\times\)6 S4S
  
  3'-0" o.c.

  3'-9"

  4x4 shores
  
  @ 45° o.c.

---

**Slab Form Design Example**

- Refer to Table 7-11 for wood shoring material. Both 3x4 and 4x4 are more than adequate to carry 1778 lbs for an effective length of 8 ft.

<table>
<thead>
<tr>
<th>Nominal lumber size in</th>
<th>Safe load</th>
<th>Safe load</th>
<th>Safe load</th>
<th>Safe load</th>
<th>Safe load</th>
<th>Safe load</th>
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<th>Safe load</th>
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<th>Safe load</th>
<th>Safe load</th>
<th>Safe load</th>
</tr>
</thead>
</table>

**Effective length:**

- Assume the head piece of the adjustable steel shore is 11\(\frac{1}{2}\) x 3 5/8". The 3x6 stringer is actually 2\(\frac{1}{8}\) in. thick.
Slab Form Design

**Slab form Design Example**

- If the headpiece is placed parallel to the stringer, bearing area is 2½ x 11½ or 28.75 in.². Bearing stress will be:
  \[
  \frac{\text{total shore load}}{\text{bearing area}} = \frac{1778}{28.75} \approx 62 \text{ psi}
  \]

- This is well below the base \( F_{c_L} \), which is obtained from Table 4-2 (the value of compression \perp\) to grain, \( F_{c_L} \) for No. 2 2 x 4 Douglas Fir-Larch is 625 psi.

**Slab form Design Example**

- Joist bearing on Stringers:
  - The two members are 1½ and 2½ in. wide.
  - Contact bearing area = 2½ x 1½ = 3.75 in.²
  - Average load transmitted by joist to stringer is:
    \[
    \text{Joist spacing x joist span x form load} = \frac{19.2}{12} \times \frac{36}{12} \times 158 = 758 \text{ lb.}
    \]
    \[
    \frac{758 \text{ lb}}{3.75 \text{ in.}^2} = 202 \text{ psi}
    \]

Bearing at this point is also low relative to the 625 psi base value for \( F_{c_L} \).