Design of One-way Slab

Slab – One-way and Two-way

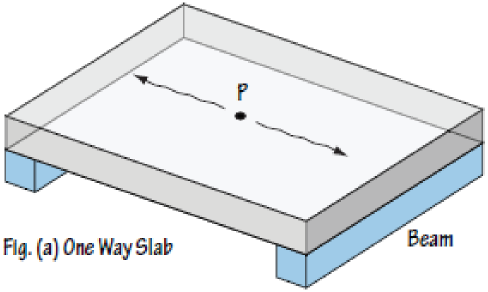


Fig. (a) One Way Slab

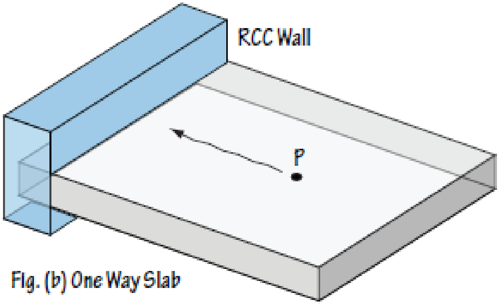


Fig. (b) One Way Slab

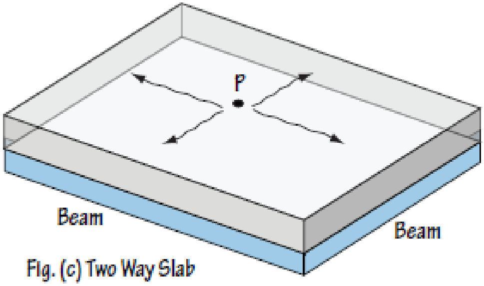


Fig. (c) Two Way Slab

- Concrete slabs are plate structures that are reinforced to span either one or both directions of a structural bay.
- Slab must transfer loads that are placed on it to the support(s). Loads are always transferred to the directions of supports.
- Based on the number of directions of load transfer (flow or propagation), slab could be classified as **one-way** or **two-way**.

- **Fig.** (a): This simply supported slab is carried by two beams from two opposite sides. Any load placed on point *P* will propagate to the direction of the beams. It is a one-way slab because load propagates only in one direction (one axis). Load cannot propagate to the free edges because there are no beams to carry that load.
- **Fig.** (b): A cantilever slab, embedded in a wall, is a one-way slab too. Any load placed on point *P* will propagate to the direction of the wall because it is the only direction where load can go. Load cannot propagate to the three free edges because there are no beams to carry that load.
- **Fig.** (c): This simply supported slab is supported by four beams on all four edges. Since there are beams on all four sides, any load placed on *P* will propagate to the all four beams. It is a two-way slab because load can flow into two different directions (two different axes).
- Thus, support condition plays an important role to classify slab as one-way or two-way.

Slab – One-Way and Two-Way

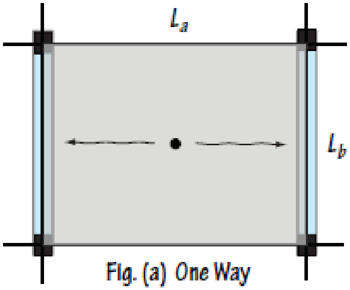


Fig. (a) One Way

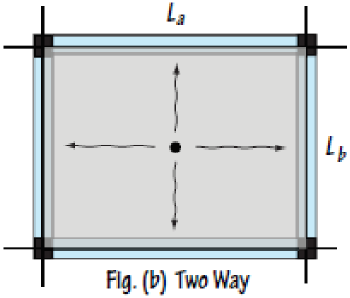


Fig. (b) Two Way

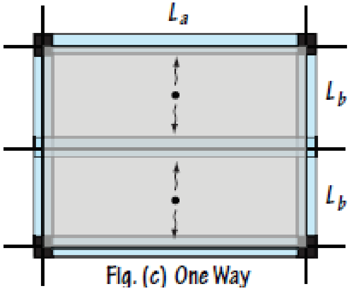


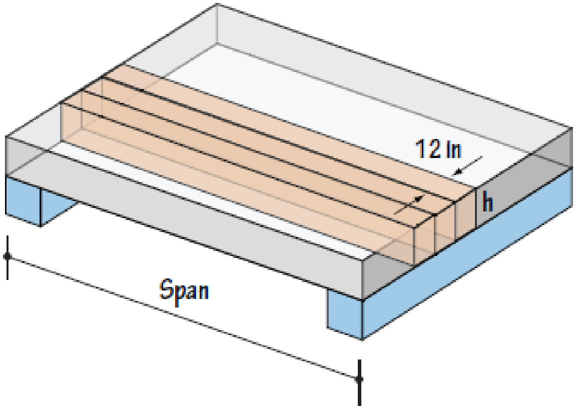
Fig. (c) One Way

- But only the support conditions cannot alone classify a slab correctly.
- The lengths of slab, L_a and L_b, should be considered too if it is supported on all four sides.
- If a rectangular slab is supported on all four sides, but the long side is *two or more times* as long as the short side, for all practical purposes, that slab will act as a one-way slab.
- If the long side is denoted by L_a and short side is denoted by L_b, the following must be true for a two way slab regardless of its support condition.

$$\frac{L_a}{L_b} \leq 2$$

- **Fig. (a):** This simply supported slab is a one way slab because load is transferred only in one direction. The length L_a and L_b are insignificant here.
- **Fig. (b):** Slab is supported from all four edges, therefore the length of sides should be considered. From figure, it seems that both sides are almost equal length, therefore $L_a/L_b < 2$, thus it is a two way slab.
- **Fig. (c):** This slab is supported from all four edges too, therefore the length of sides should be considered. But from figure, it is clearly visible that $L_a/L_b > 2$, therefore it is a one way slab. Actually there are two one-way slabs in this figure.

Design of One Way Slab



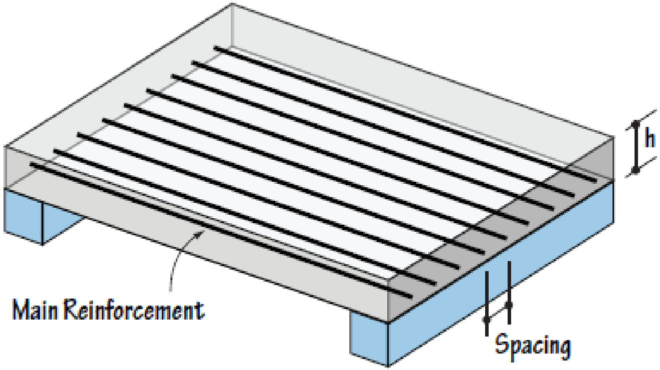
- A one-way slab is assumed to be a very wide rectangular beam.
- To simplify design procedure, a one-way slab is assumed to consist of a series of imaginary beams placed side by side.
- It is customary to consider the width of each of these fictitious beams to be equal to 12 inch.
- Slab depth (*h*) is usually 6 inch for most cases, but ACI-318 suggests to use following table as a guideline for minimum depth for one-way slab.

Simply supported	One end continuous	Both end continuous	Cantilever
$\ell/20$	$\ell/24$	$\ell/28$	$\ell/10$

Span length is denoted by ℓ.

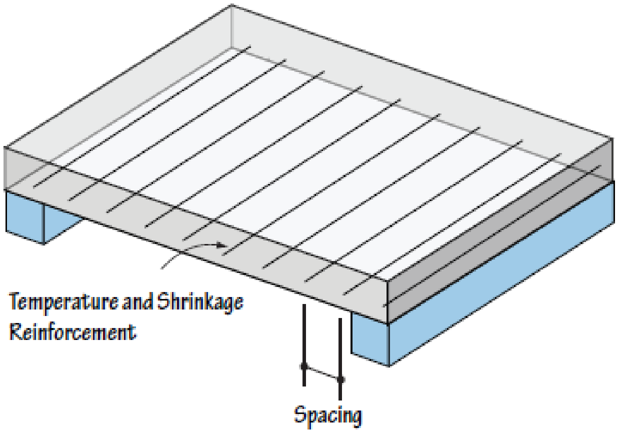
- Slab thicknesses are usually rounded off to the nearest 1/4 inch for slabs of 6 inch or less in thickness and to the nearest 1/2 inch for slabs thicker than 6 inch.
- Span length of one way slabs are typically between 6 ft to 18 ft.

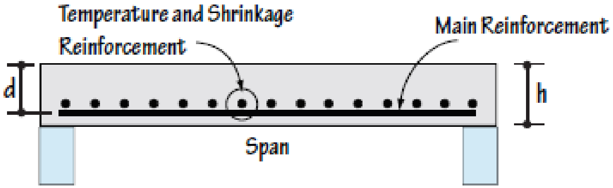
Main Reinforcement



- Main reinforcements are provided to carry the primary loads of one-way slab.
- They are always aligned to the direction of load propagation.
- For simply supported one way slab having beam on two opposite directions, the main reinforcement are always from beam to beam.
- Usually #3 or # 4 bars are provided for main reinforcement.
- Spacing of main reinforcement cannot be greater than 3*h* or 18 inch, where *h* is the depth of slab.

Temperature and Shrinkage Reinforcement





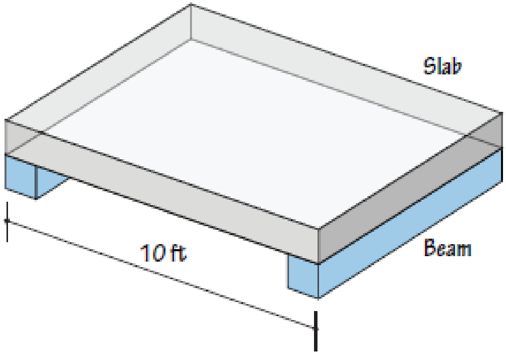
- As concrete hardens, it shrinks. In addition, temperature changes occur that cause expansion and contraction of the concrete.
- The ACI-318 states that shrinkage and temperature reinforcement must be provided in one-way slab otherwise crack will develop.
- It should be provided in the direction perpendicular to the main reinforcement.
- Following is the total amount of temperature and shrinkage reinforcement (A_s), where b is the slab width and h is the slab depth.

$$A_s = 0.0018bh$$

- Usually #3 bars are provided for temperature and shrinkage reinforcement.
- Spacing of temperature and shrinkage reinforcement cannot be greater than $5h$ or 18 inch, where h is the depth of slab.
- Layer of temperature and shrinkage reinforcement is always placed on top of layer of main reinforcement.

Example 1. Simply Supported Slab

Ques. Design a simply supported one-way slab of 10 ft span for 200 psf live load. Given that, $f'_c = 4$ ksi, $f_y = 60$ ksi.



Estimate Slab Thickness For simply supported slab, ACI-318 suggests minimum slab thickness of $\ell/20$.

$$h = \frac{\ell}{20} = \frac{10 \text{ ft}}{20} = 0.5 \text{ ft} = 6 \text{ in}$$

Estimate Effective Depth It is usually one-inch less than slab thickness. Therefore

$$d = h - 1 = 6 - 1 = 5 \text{ in}$$

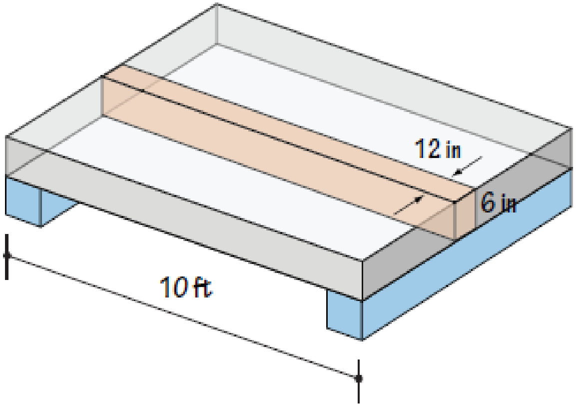
Compute Design Load and Moment

$$w_D = h\gamma_{\text{conc.}} = \left(\frac{6}{12} \text{ ft}\right) 150 \text{ lb/ft}^3 = 75 \text{ psf}$$

$$w_u = 1.2w_D + 1.6w_L = 1.2\times75 + 1.6\times200 = 410 \text{ psf}$$

$$M_u = \frac{w_u L^2}{8} = \frac{0.410\times10^2}{8} = 5.125 \text{ kft/ft}$$

Notice the unit of M_u, it is written as *kft/ft*. The "per feet" (/ft) part is added to the actual unit because we are designing only 1 ft (12 inch) of the slab, not the entire slab.



Now design a simply supported rectangular beam of 12 inch width to carry 5.125 kft moment.

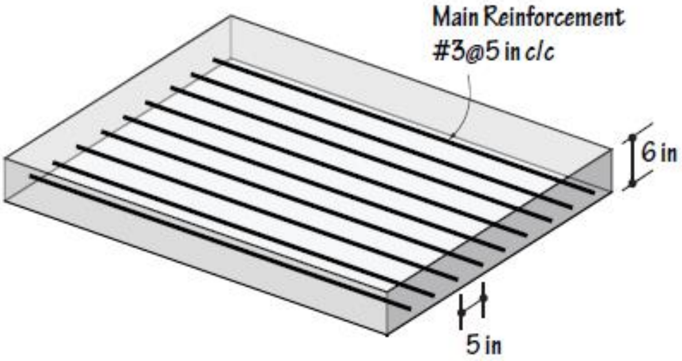
Determine Main (Flexural) Reinforcement

$$R_n = \frac{M_u}{\phi b d^2} = \frac{5.125\times12}{0.9\times12\times5^2} = 0.227 \text{ ksi/ft}$$

$$\rho = \frac{0.85\times4}{60}\left(1 - \sqrt{1 - \frac{2\times0.227}{0.85\times4}}\right) = 0.00393$$

$$A_s = \rho b d = 0.00393\times12\times5 = 0.236 \text{ in}^2/\text{ft}$$

Example 1. Simply Supported Slab



Main Reinforcement

If #3 (0.11 in^2) bar is used, spacing would be,

$$s = \frac{A_{s,provided}}{A_{s,required}} = \frac{0.11}{0.236} \times 12 = 5.59 \text{ in} \approx 5 \text{ in}$$

Check Spacing

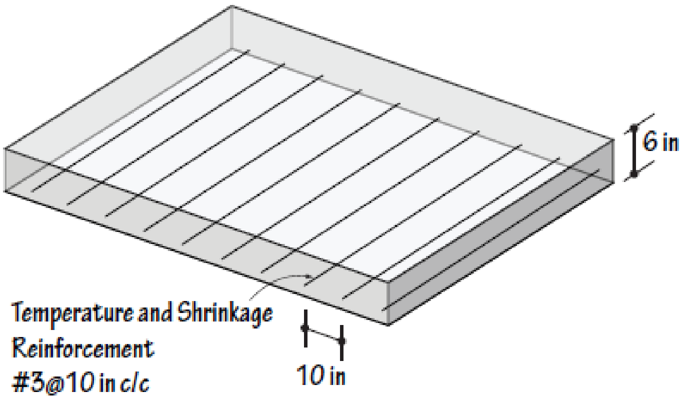
$$s \le \begin{cases} 3h = 3 \times 6 = 18 \text{ in} & \text{(ok)} \\ 18 \text{ in} & \text{(ok)} \end{cases}$$

Therefore, #3 bars could be used as main reinforcement if they are placed 5 inches apart from center to center. More conveniently it is expressed as:

Use #3@ 5 in. c/c

Note: As an alternate option, we could also choose #4 bar, in that case spacing would be 10 inch.

Example 1. Simply Supported Slab



Temperature and Shrinkage Reinforcement

$$A_s = 0.0018bh = 0.0018\times12\times6 = 0.129 \text{ in}^2/\text{ft}$$

If #3 (0.11 in^2) bar is used, spacing would be,

$$s = \frac{A_{s,\text{provided}}}{A_{s,\text{required}}} = \frac{0.11}{0.129}\times12 = 10.23 \text{ in} \approx 10 \text{ in}$$

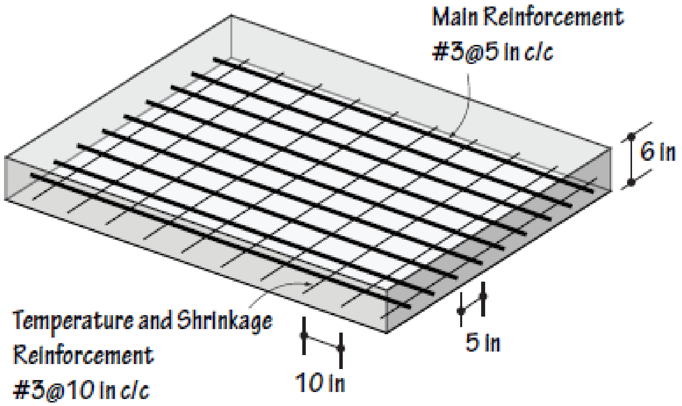
Check Spacing

$$s \le \begin{cases} 5h = 5\times6 = 24 \text{ in} & \text{(ok)} \\ 18 \text{ in} & \text{(ok)} \end{cases}$$

Use #3@ 10 in. c/c

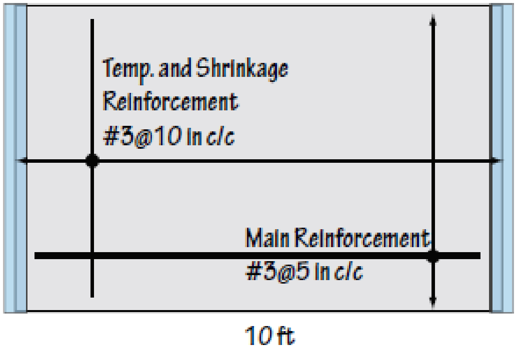
Example 1. Simply Supported Slab

Following figure is the actual reinforcement distribution which looks very congested due to large amount of reinforcement crossing each other.



To simplify the drawing of the actual distribution, the following two figures are usually practiced in construction drawing.

Plan: Only one main reinforcement and one temperature and shrinkage reinforcement are shown. Each of the two reinforcement is attached with a double arrow which shows the direction of distribution of that particular reinforcement.



Longitudinal Section: One main reinforcement and a series of temperature and shrinkage reinforcement on top of it are shown.