Plain & Reinforced Concrete-1

Sixth Term
Civil Engineering

CE-314

Lecture # 17

Analysis and Design of Slabs

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Slabs

- In reinforced concrete construction, slabs are used to create flat, useful surfaces supported on columns and walls having open spaces underneath.
- A reinforced slab is a broad, flat plate, usually horizontal.
- It may be supported by reinforced concrete beams (and is usually cast monolithically with such beams), by masonry or by reinforced concrete walls, by steel structural members, directly by columns, or continuously by ground.
- A slab panel is defined as a flat slab portion bounded by beams, walls or columns.

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One-Way Slab

"The slab which resists the entire/major part of applied load by bending only in one direction"

- If slab is supported on all four sides and

$$R = \frac{Shorter\ Side}{Longer\ Side} < 0.5$$

it behaves as one-way slab.

- Slabs having supports on less than four sides can be designed as one-way.
- Two edge supported slab is always one-way.
- Cantilever slab is always one-way.

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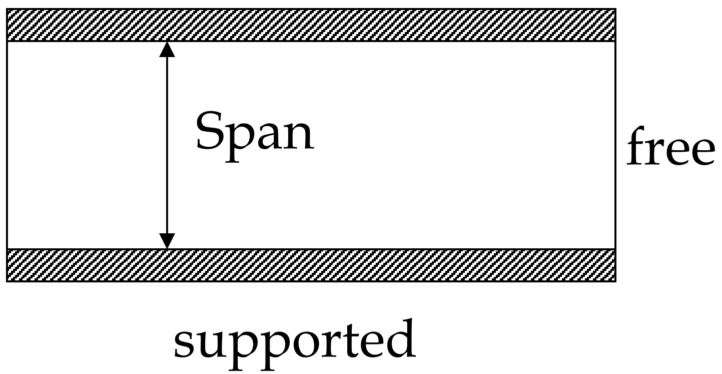
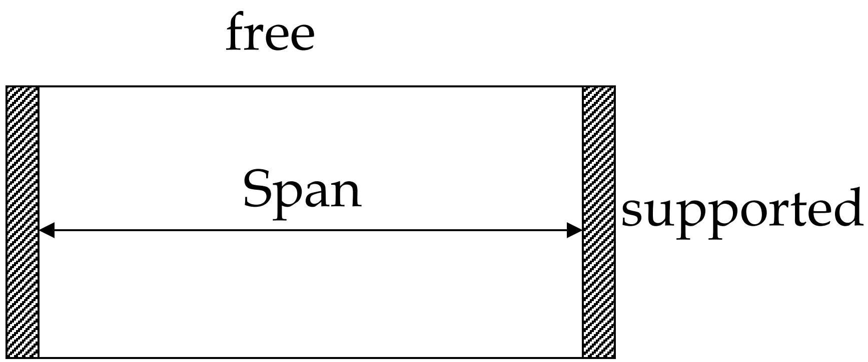
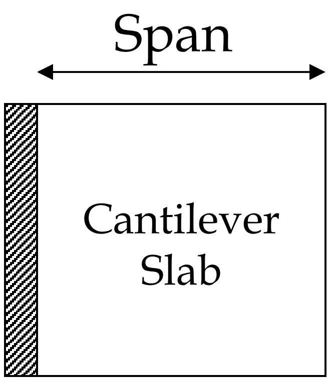




R < 0.5



One-Way Slabs

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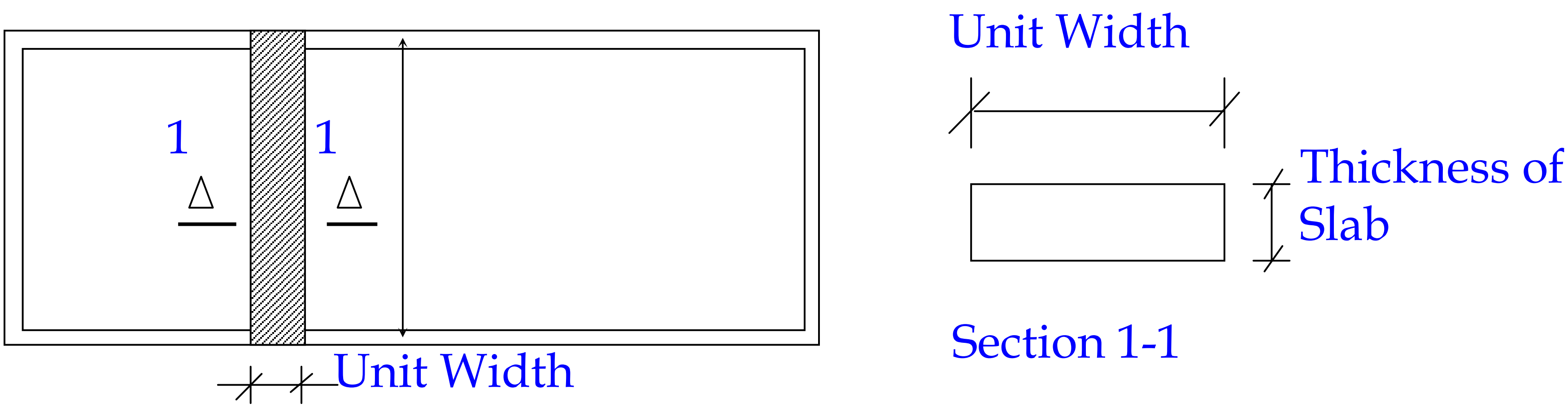
- Main steel is only provided parallel to span
- A strip of one-way slab is designed as singly reinforced rectangular section having unit width.
- The unit width is considered equal to 1mm or 1 m.
- h_{min} for the slab is different compared with the beams.

End Conditions	Steel Grades		
	280 or 300	420	f_y
Simply Supported	L/25	L/20	$\frac{L}{20}\left(0.4+\frac{f_y}{690}\right)$
One end continuous	L/30	L/24	$\frac{L}{24}\left(0.4+\frac{f_y}{690}\right)$
Both ends continuous	L/35	L/28	$\frac{L}{28}\left(0.4+\frac{f_y}{690}\right)$
Cantilever	L/12	L/10	$\frac{L}{10}\left(0.4+\frac{f_y}{690}\right)$



Design Strip for One-Way Slabs.

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One-Way Slab (contd…)

The Effective Span (L) is taken lesser of the following:

$L = L_n + h/2 \text{ (left)} + h/2 \text{(right)}$

$\quad = L_n + h$

$h = \text{depth of slab}$

and

$L_n = \text{clear distance between supports.}$

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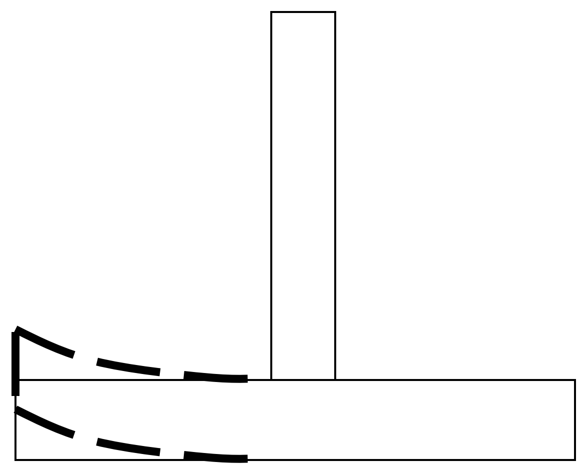
Examples of One-Way Slab (contd…)

- Shades in the roofing system (cantilevers).
- Slab of stairs.
- Cantilever retaining walls.
- Footings.

Slab of stair



Footing

Minimum Clear Cover

According to the ACI Code, the minimum clear cover required for slabs not directly exposed to weather or in contact with soil is to be 20 mm.

Provision of Slab Steel

The steel calculated for the unit width strip is to be provided all along the slab width. This is done by providing bars at a regular spacing (s). If A_b is the area of a single bar effective for a width equal to s and A_s is the area of steel required for a 1m wide strip, the following may be written:

$$\frac{A_s}{1000} = \frac{A_b}{s} \qquad \Rightarrow \qquad s = \frac{1000\,A_b}{A_s}$$

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Maximum Bar Spacing For Main Steel of Slabs

s_{max} will be least of following.

1. 3 x h (local practice is **2 x h**)
2. 450 mm (local practice is **300 mm**)
3. $(159,600/f_y) - 2.5c_c$
4. $126,000/f_y$

c_c = Clear Cover

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Distribution, Temperature & Shrinkage Steel For Slabs **(ACI-318)**

- Shrinkage and temperature reinforcement is required at right angle to main reinforcement to minimize cracking and to tie the structure together to ensure its acting as assumed in design.
- Top and bottom reinforcements are both effective in controlling the cracks.

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Distribution, Temperature & Shrinkage Steel For Slabs **(ACI-318) (contd…)**

For Grade 280 …0.2% of b x h…$\rho = 0.002$ ……$A_s = 0.002bh$

For Grade 420 …0.18% of b x h… $\rho = 0.0018$ ..$A_s = 0.0018bh$

For other grades …..$\rho = \dfrac{0.0018 \times 420}{f_y} \geq 0.0014$

Temperature steel in no case will be less than 0.0014

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Distribution, Temperature & Shrinkage Steel For Slabs **(ACI-318) (contd…)**

s_{max} shall be lesser of following

1- 5 x h (field practice is 2 x h)

2- 450 mm (field practice is usually 300mm)

Minimum Steel For Slabs

Same as the distribution steel

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Check For Shear

$$\text{If } \phi_v V_c \geq V_u \quad \textbf{O.K.}$$

Shear check in slabs is normally satisfied so no shear reinforcement is provided.

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Design Procedure for One-Way Slab

1. Check whether the slab is one-way or two-way.
2. Calculate h_{min} and round it to higher 10mm (or 5mm) multiple.
   i. Not less than 110 mm for rooms
   ii. Not less than 75 mm for sunshades.
3. Calculate dead load acting on the slab.
   Dead Load = Load per unit area x 1m width.
4. Calculate live load acting on the slab.
   Live load = Load per unit area x 1m width.

5. Calculate total factored load per unit strip. (kN/m)
6. Calculate the moments either directly (simply supported) or by using coefficient for continuous slabs.

Moment coefficients for continuous slabs are same as for continuous beams except when slab span is less than 3.0m:

1. Negative moments at all supports, integrally built with beams.	$w_u \ell_n^2/12$
2. Positive moment in end panel.	$w_u \ell_n^2/14$
3. Positive moment in central panels.	$w_u \ell_n^2/16$

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7. Calculate effective depth.

$$d = h - (20 + 0.5d_b) = h - 26$$

$$d_b = 10,\ 13 \text{ or } 15 \text{ (generally)}$$

8. Check that

$$d \geq d_{min}$$

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Design Procedure for One-Way Slab (contd…)

9. Calculate 'A_s' required for 1m width.
10. Calculate minimum/distribution/temperature & shrinkage steel.
11. Select diameter and spacing for main and steel.
12. Check the spacing for max. and min. spacing.

$$s_{min} \approx 90mm$$

if spacing is less than minimum increase the diameter of bar.

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Design Procedure for One-Way Slab (contd…)

13. For continuous slabs, curtail or bend up the +ve steel. For -ve steel see how much steel is already available. Provide remaining amount of steel.
14. Calculate the amount of distribution steel. Decide its diameter & spacing like main steel.
15. Check the slab for shear.

$$\phi_v V_c \geq V_u$$

16. Carry out detailing and show results on the drawings.
17. Prepare bar bending schedule, if required.

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Approximate of Steel for Estimate

Approximate amount of steel in slab

$= 0.07\ kg/mm/m^2 = 70\ kg/m^3$

If slab thickness = 150 mm

Approx. steel = $0.07 \times 150 = 10.5 kg/m^2$

Continued in next file