Continuity in Building Frames of Reinforced Concrete

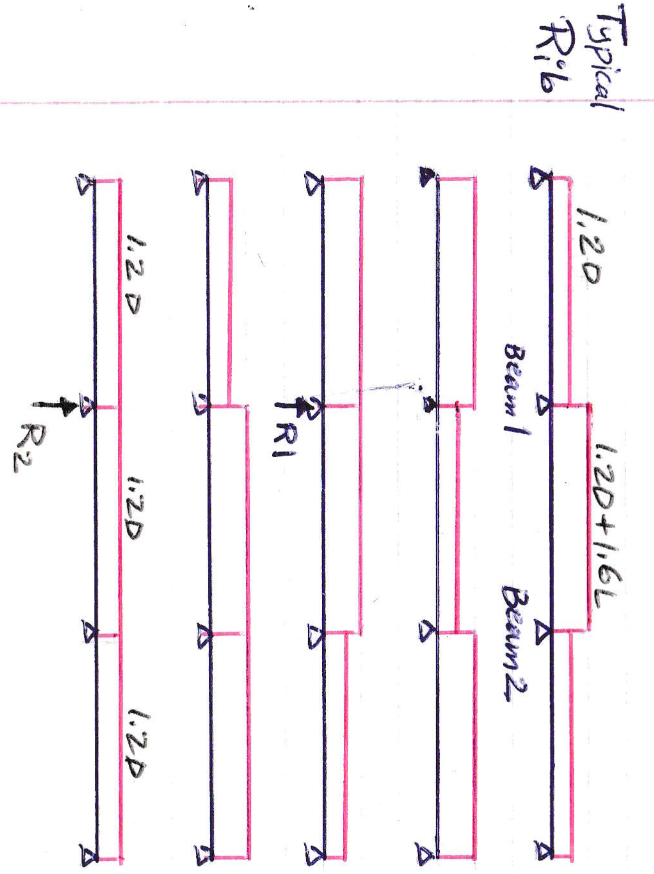
* Review the subject of influence lines.

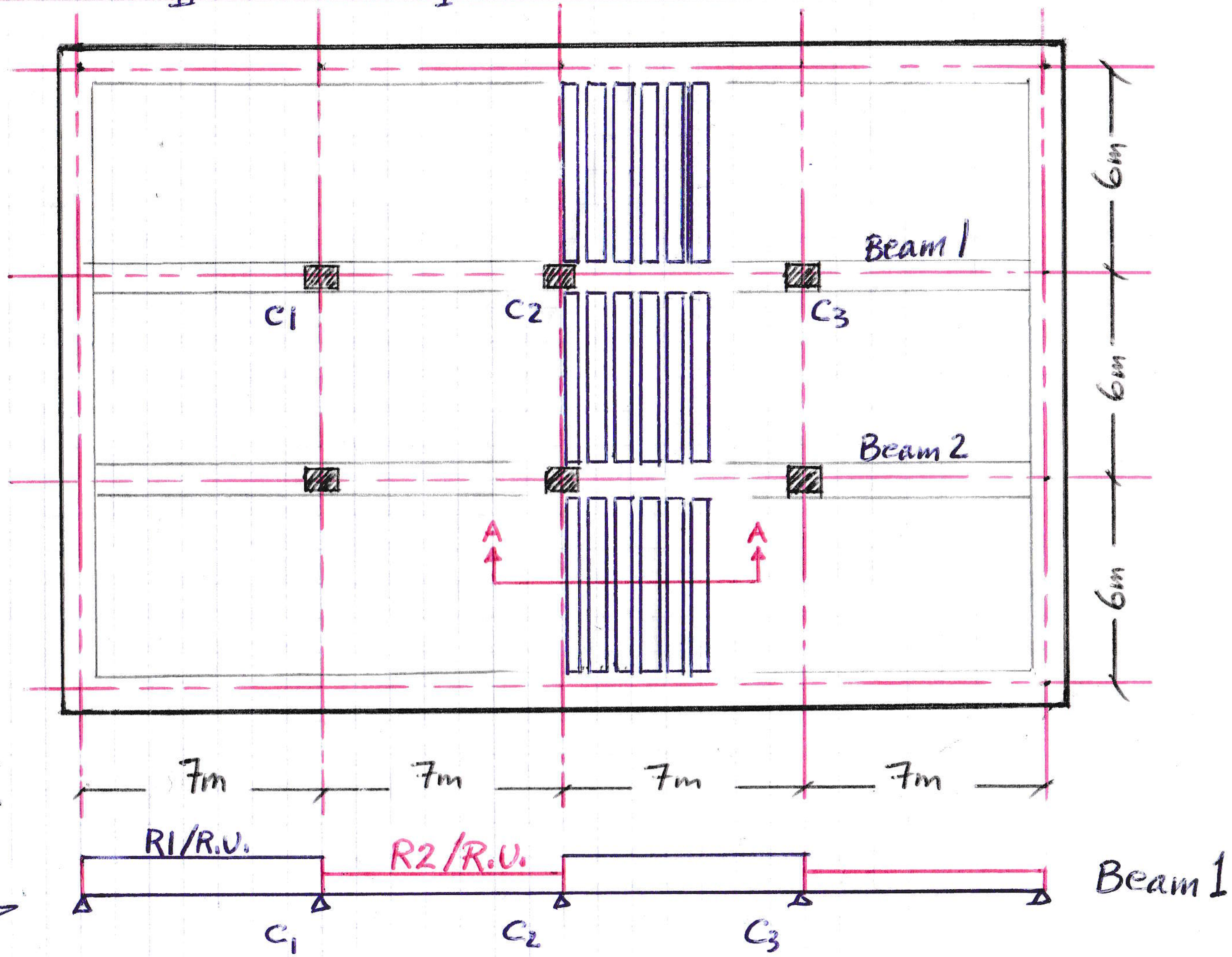
Refer to Fig 7.2.1 and note that:

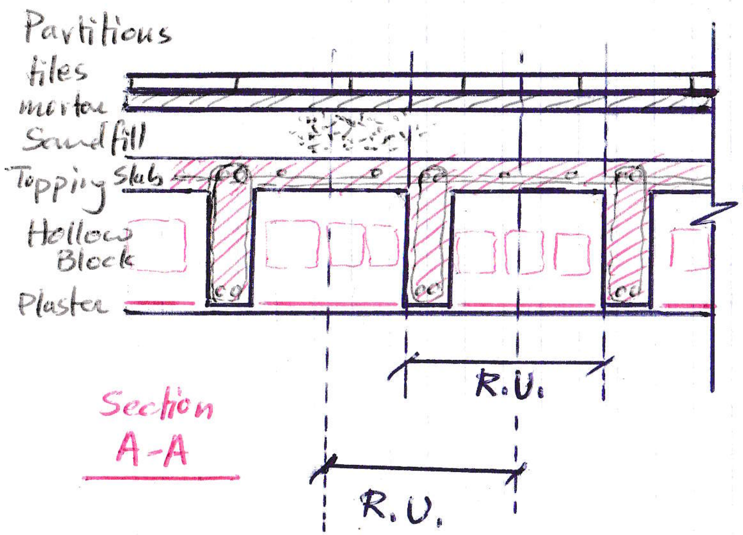
1) For maximum positive moment within a span, load that span and all other alternate spans.
2) For maximum negative moment within a span, load the two spans adjacent to that span and all other alternate spans.
3) For maximum negative moment at a support, load the two spans adjacent to that support and all other alternate spans.
4) For maximum positive moment at a support, load the two spans beyond each of the two spans adjacent to that support and all other alternate spans.

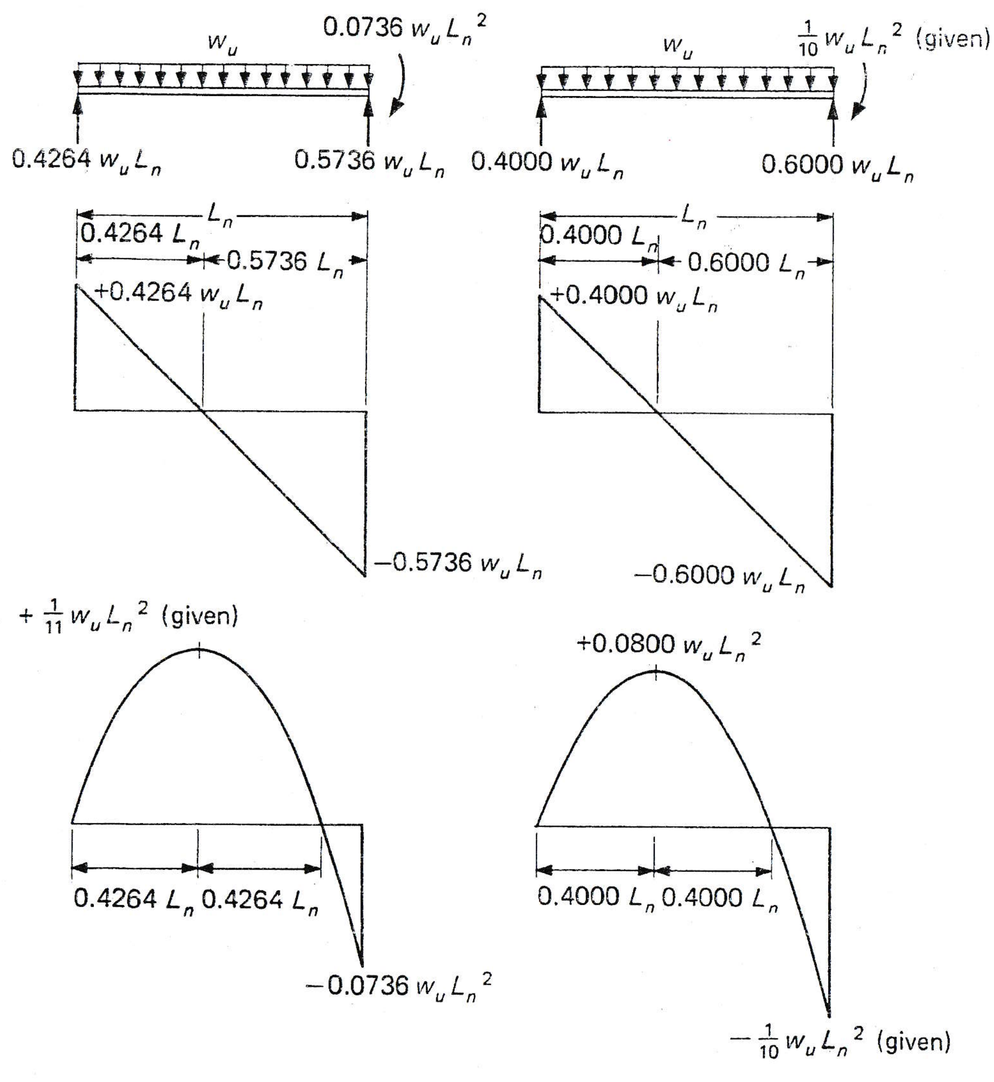
Dr. Ghada تحليل إنشائي II , Dr. Jamal خرسانة مسلحة I

Structural Analysis II
Reinforced Concrete Design I



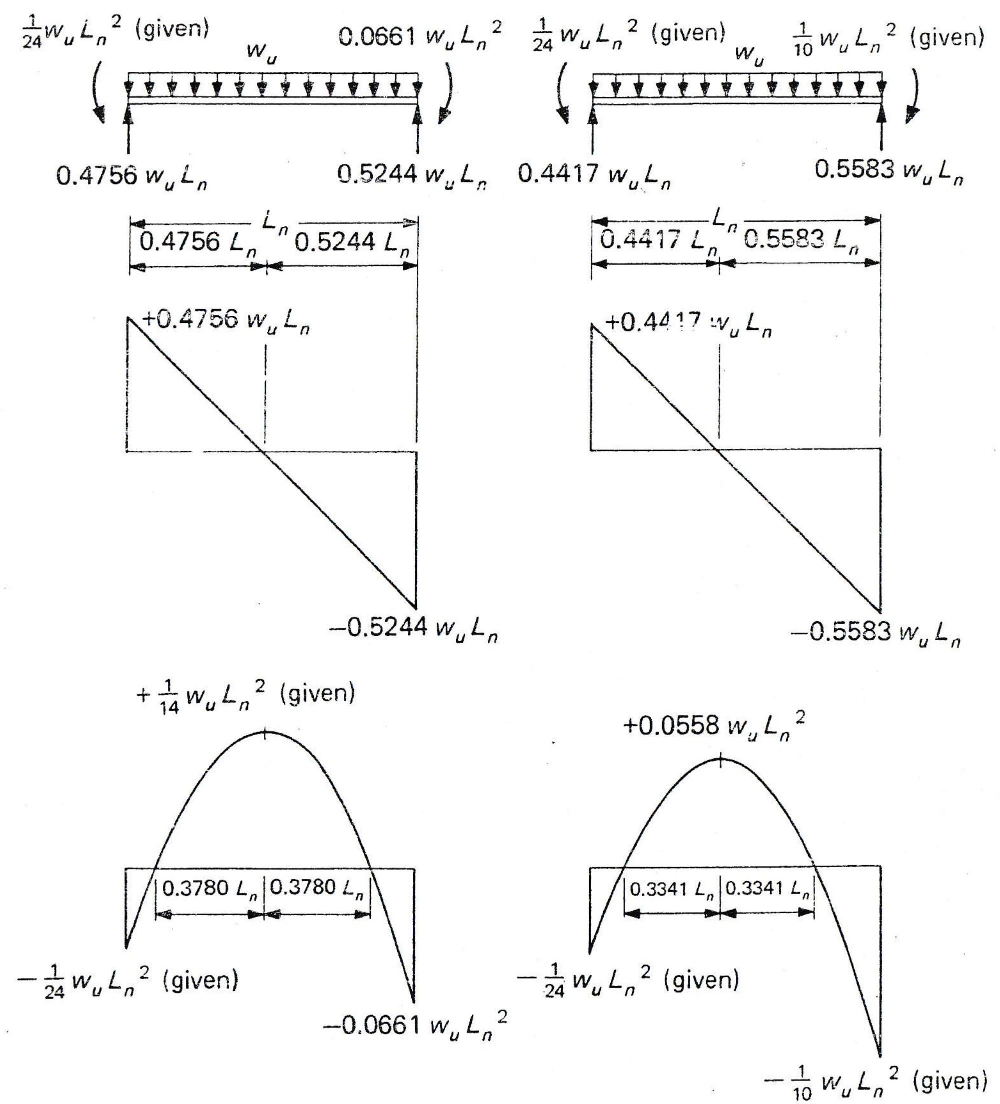






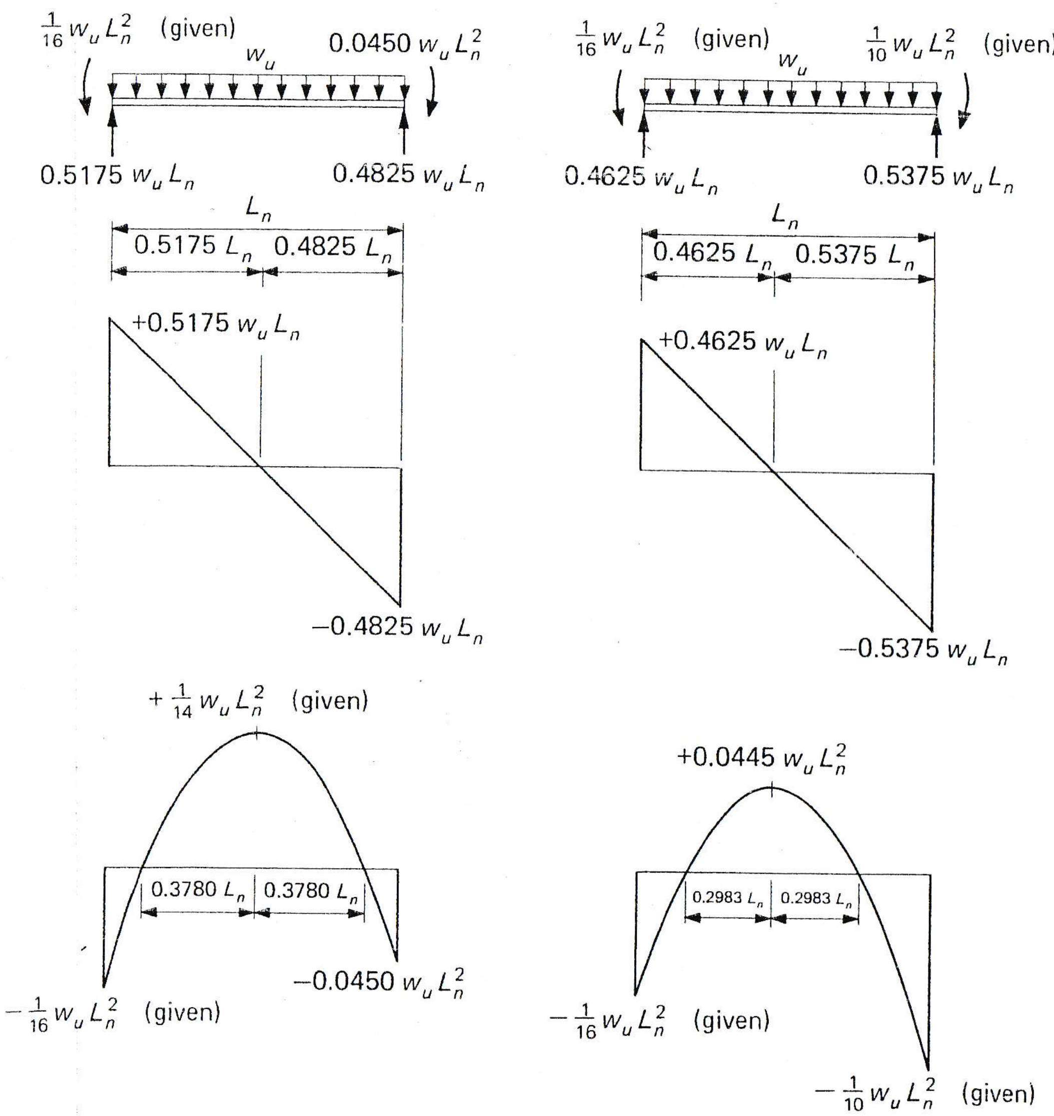
(a) Maximum in the positive zone (b) Maximum in the negative zone

Figure 7.5.1 Exterior span with discontinuous end unrestrained.



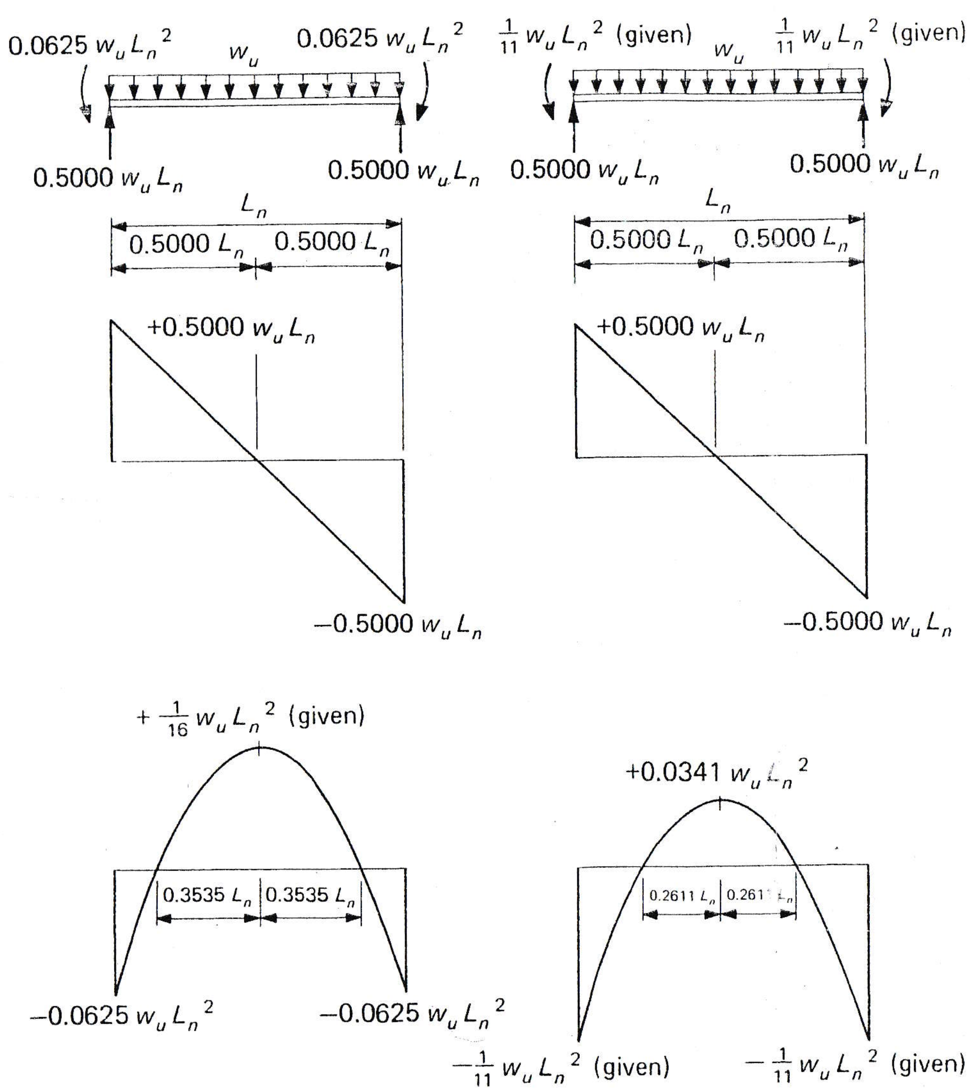
(a) Maximum in the positive zone (b) Maximum in the negative zone

Figure 7.5.2 Exterior span with exterior support built integrally with spandrel beam or girder.



(a) Maximum in the positive zone (b) Maximum in the negative zone

Figure 7.5.3 Exterior span with exterior support built integrally with column.



(a) Maximum in the positive zone (b) Maximum in the negative zone

Figure 7.5.4 Interior span.

Design of One-Way Slabs

Take a typical imaginary strip 1 m wide, the continuous slab may then be designed as a continuous beam having a known width (1 m), the slab thickness is the unknown.

Thickness of slab depends on requirements for:

* deflection
* bending
* shear

ACI Table 9.5 a : One-way slabs must have at least a minimum slab thickness (for Grade 400 steel) of

Beams or ribbed one-way	Solid, one-way	
L/16	L/20	, L = Length of a simply supported span.
L/18.5	L/24	, one end continuous span.
L/21	L/28	, both ends continuous span.
L/8	L/10	, Cantilever span

f_y other than 400 MPa, multiply by $(0.4 + f_y/700)$

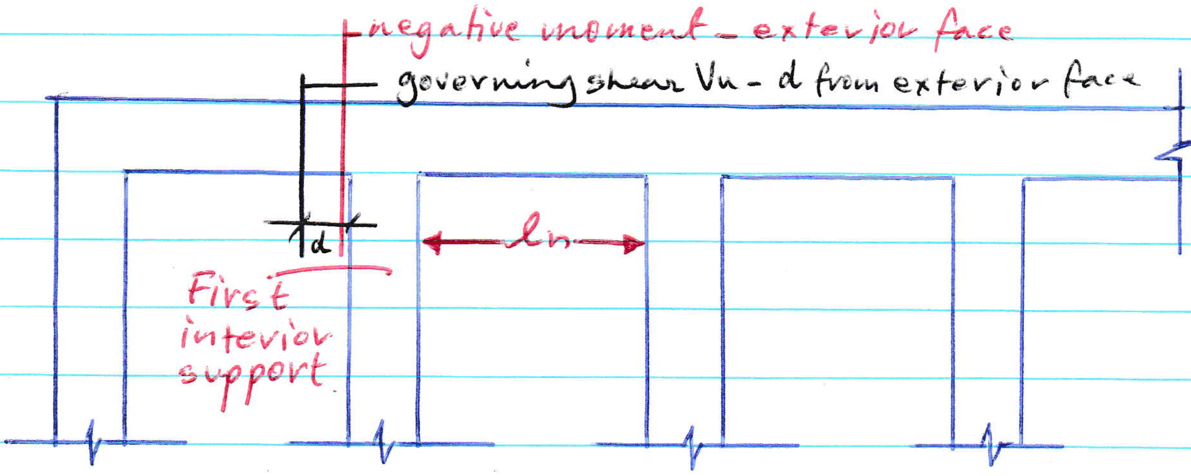
Deflection limits (slab supports construction that may be damaged by large deflections) (ACI Table 9.5 b)

$$\phi M_n \geq M_u$$

R_n can be computed for the desired ρ

$$\text{Required } M_n = \frac{M_u}{\phi} = R_n b d^2$$

Note: for equal continuous spans, the negative moment at the exterior face of the first interior support is the largest ⇒ use to establish the slab thickness.

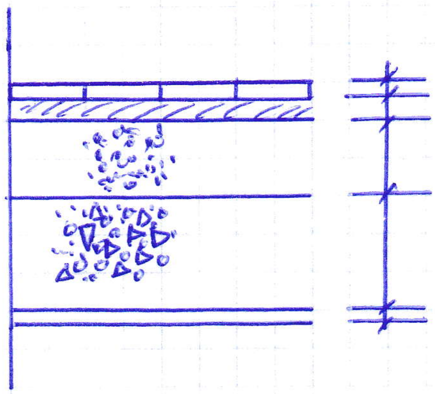


Shear does not usually control – however, it must be checked. Since shear reinforcement is not used in slabs, $\underline{V_u}$ must be $\leq \phi V_c$.

For equal continuous spans, V_u max occurs at the exterior face (a distance d away) of

$$L/24 = \frac{600}{24} = 25\ cm$$

15 cm — 1m x 1m



Tiles $\frac{1}{100} \times 1 \times 1 \times 2.4 = 0.024$

Mortar $\frac{3}{100} \times 1 \times 1 \times 2.2 = 0.066$

Sand Fill $\frac{10}{100} \times 1 \times 1 \times 1.8 = 0.180$

Concrete slab $\frac{15}{100} \times 1 \times 1 \times 2.4 = 0.360$

Plaster $\frac{2}{100} \times 1 \times 1 \times 2.2 = 0.044$

$0.674\ t/m^2$

$LL = 0.35\ t/m^2$

Partitions $= 0.25\ t/m^2$

$$W_u = 1.2(0.674) + 1.6(0.6) = 1.77\ t/m^2$$

$$M_u = -\frac{1}{10} W_u L_n^2 \quad \text{(maximum)}$$

$$V_u = 0.5583\ W_u L_n \quad \text{(maximum)}$$

$l_n = 5.30\ m$

$$M_u = -\frac{1}{10}(1.77)(5.30)^2 = 4.97\ t.m$$

$$M_{n\ req} = \frac{4.97}{0.9} = 5.52\ t.m$$

$$R_{n\ req} = \frac{552}{(100)(12)^2} = 0.03836\ t/cm^2$$

$$\rho_{req} = \frac{1}{17.65}\left(1-\sqrt{1-\frac{2(17.65)(0.03836)}{4.2}}\right)$$

$$= 0.0100$$

$$\rho_{max} = 0.01806$$

$$\frac{0.0100}{0.01806} = 0.5536$$

12 cm , $d = 9$ cm

$DL = 0.602\ t/m^2$

$W_u = 1.68\ t/m^2$

$M_u = 4.73\ t.m$, $M_{n\ req} = 5.25\ t.m$

$R_{n\ req} = 0.06483\ t/cm^2$, $\rho_{req} = 0.01843$

$> \rho_{max}$

$h = 13\ cm, \quad d = 10\ cm$

$DL = 0.626$

$W_u = 1.71\ t/m^2$

$M_u = 4.81\ t.m \quad , \quad M_{n\,req} = 5.34\ t.m$

$R_{n\,req} = 0.05341\ t/cm^2$

$\rho_{req} = 0.01460$

$\frac{\rho_{req}}{\rho_{max}} = 0.81$ OK

Check Shear:

$V_u = 0.5583\,(1.71)(5.3) = 5.06\,t$

$\phi V_c = 0.75\,(0.17)(1.0)\frac{\sqrt{28}}{100}\,(100)(10)$

$= 6.75\ t$

$V_u < \phi V_c = 6.75$ OK

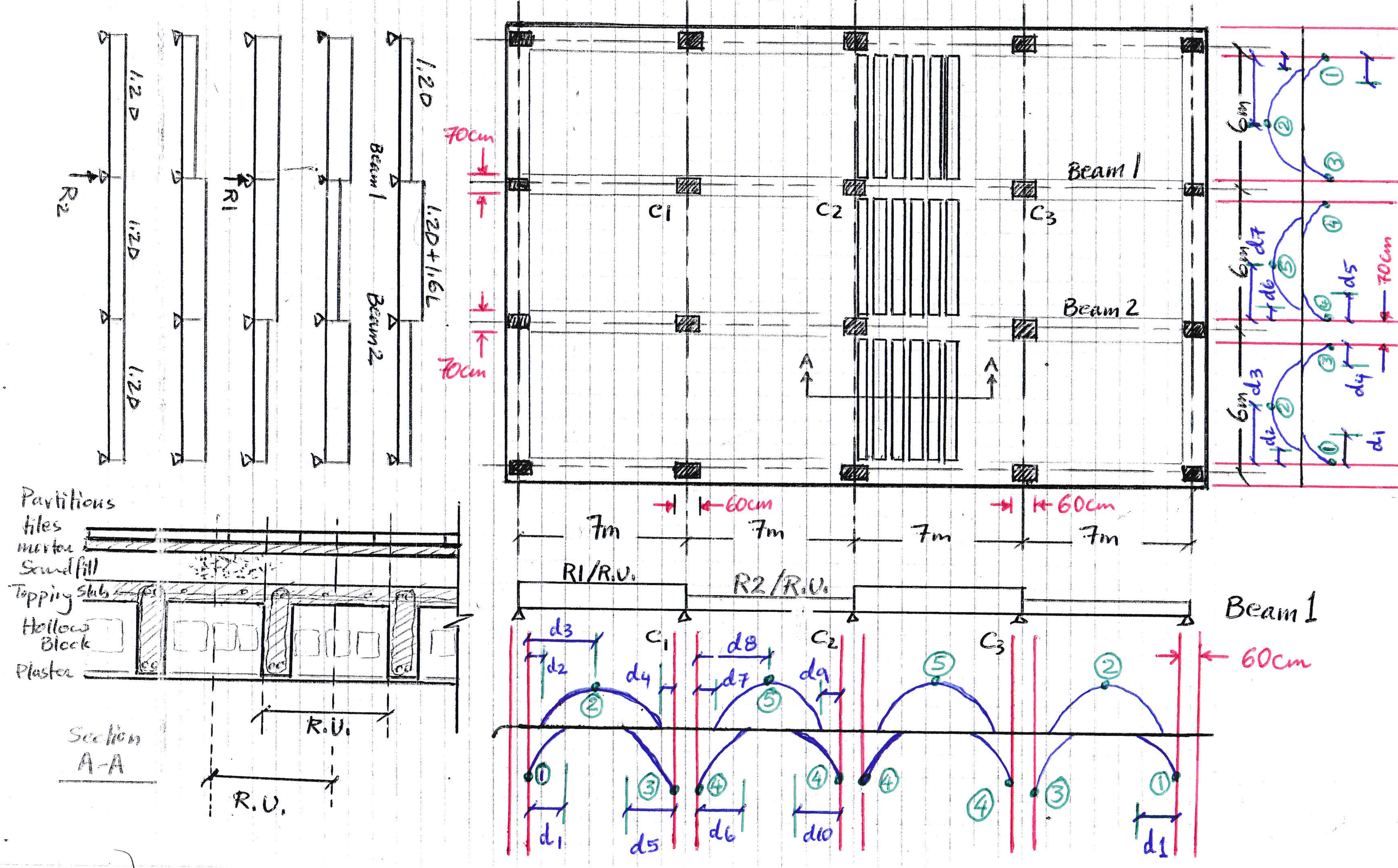
Note that the ACI code permits checking shear at the critical section, d from the face of support.

Dr. Ghada , Dr. Jamal

تحليل إنشائي II — خرسانة I

Structural Analysis II

Reinforced Concrete Design I



Slab $L = 6\,m$, $L_n = 5.3\,m$

① $-\frac{1}{24} w_u L_n^2$

② $+\frac{1}{14} w_u L_n^2$

③ $-\frac{1}{10} w_u L_n^2$

④ $-\frac{1}{11} w_u L_n^2$

⑤ $+\frac{1}{16} w_u L_n^2$

$d_1 = 0.4417 L_n - 0.3341 L_n$

$d_2 = 0.4756 L_n - 0.3780 L_n$

$d_3 = 0.4756 L_n$

$d_4 = 0.5583 L_n - 0.3341 L_n$

$d_5 = 0.5000 L_n - 0.2611 L_n$

$d_6 = 0.5000 L_n - 0.3535 L_n$

$d_7 = 0.5000 L_n$

Beam $L = 7m$, $L_n = 6.4m$

① $-\frac{1}{16} W_u L_n^2$

$W_u = 6 \times 1.71$
+ weight of the drop

② $+\frac{1}{14} W_u L_n^2$

③ $-\frac{1}{10} W_u L_n^2$

④ $-\frac{1}{11} W_u L_n^2$

⑤ $+\frac{1}{16} W_u L_n^2$

$d_1 = 0.4625 L_n - 0.2983 L_n$

$d_2 = 0.5175 L_n - 0.3780 L_n$

$d_3 = 0.5175 L_n$

$d_4 = 0.4825 L_n - 0.3780 L_n$

$d_5 = 0.5375 L_n - 0.2983 L_n$

$d_6 = 0.5000 L_n - 0.2611 L_n$

$d_7 = 0.5000 L_n - 0.3535 L_n$

$d_8 = 0.5000 L_n$

$d_9 = d_7$

$d_{10} = d_6$

$\rho_{req} = 0.01460$

$As_{req} = 0.01460\,(100)(10) = 14.60\ cm^2$

Using $\phi 16$ bars, area = $2.01\ cm^2$

No. of bars = $\frac{14.60}{2.01} = 7.26$ bars

Spacing = $\frac{100}{7.26} = 13.77$ cm

$\therefore$ use $\phi 16$ bars @ 13 cm c/c

spacing = 13 cm $\leq 3h$
≤ 45 cm

$As_{min} = 0.0018\,(100)(13) = 2.34\ cm^2$

$As_{max\ (\epsilon_t = 0.005)} = 0.01806\,(100)(10) = 18.06\ cm^2$

$As\ provided = \frac{100}{13} \times 2.01 = 15.46\ cm^2$

Shrinkage and Temperature Reinforcement

* normal to the principal reinforcement required in structural floor and roof slabs.
ACI

* shall be placed (spaced) not farther apart than (5h) nor (45 cm).
ACI

* Required ρ based on gross concrete area (that is, $h \times$ width), ≥ 0.0014 :

1) Slabs where Grade 350 or less deformed bars are used — 0.0020

2) Slabs where Grade 400 (420) deformed bars or welded wire fabric (plain or deformed) are used — 0.0018

3) Slabs where reinforcement with yield stress >400 MPa measured at a yield strain of 0.35% is used — $\frac{(0.0018)(420)}{fy}$

ACI