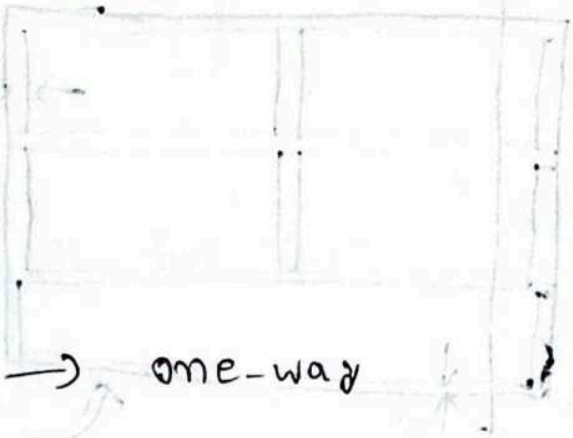
CE 386

1st 7 wk → masonary building

last 7 wk → bridge



Slab

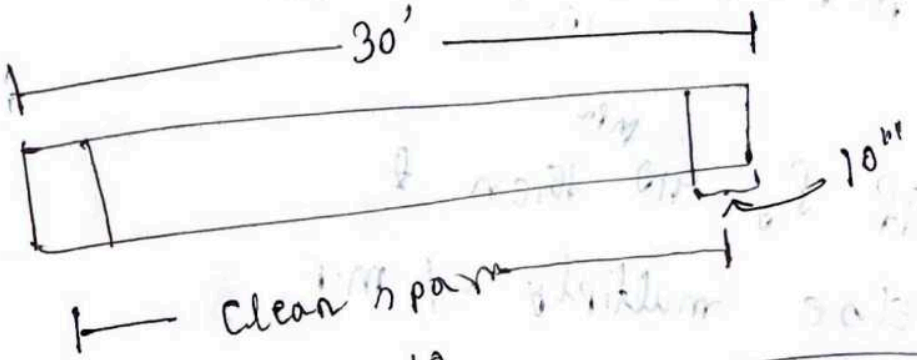
$\frac{L}{B} \geq 2$ → one-way

$\frac{L}{B} < 2$ + beam on 4 sides → two-way

(show calc for all)

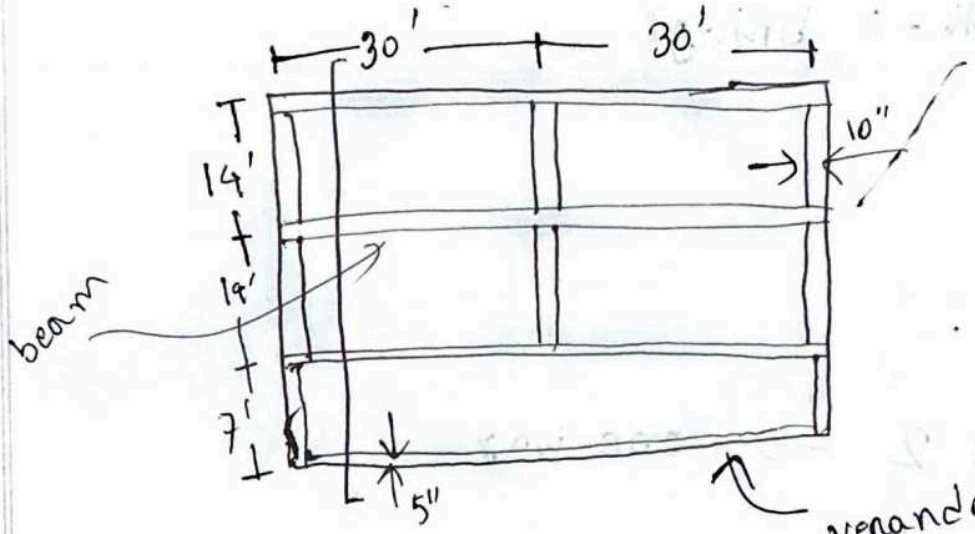
Thickness

t = max of $(l/20, l/24, l/28, l/10)$



$= 30 - \frac{10}{12}$

Use design pad & tracing paper



$f_c' = 4$ ksi

$f_y = 45$ ksi

LL = 40 psf

FF = 30 psf

① L/B check

② thickness, $t = \max(\cdot\ \cdot)$

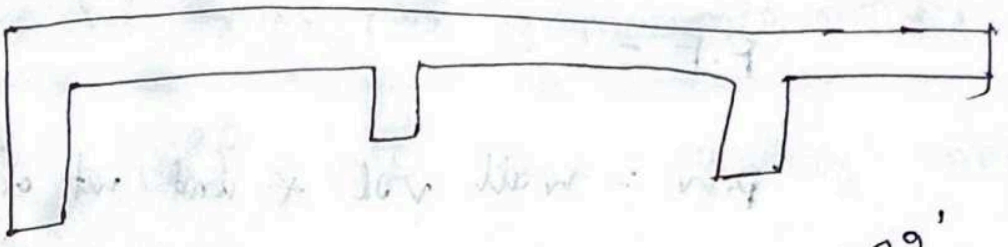
[$t \leq 6" - 0.25"$
$> 6" - 0.5"$

$$M.F = 0.4 + \frac{f_y}{100}, \text{ or } 0.4 + \frac{f_y}{700}$$

(f_y = ksi) (f_y = mpa)

if $f_y = 410$ mpa then 1

else multiply w/ M.F



$l = 14 - \frac{10}{12}$ ~~+0.1~~ $13.17'$ → ← $6.79'$ ~~6.58'~~ →

$= 13.17 ft$

$\frac{l}{24} = \frac{13.17 \times 12}{24} \times mf$ → 0.85 $= 5.6'' \rightarrow 5.75''$

$= 4.8 \rightarrow 5''$

$\frac{l}{28} =$

$= \sim\sim 5.71 \sim\sim \rightarrow 7''$

$\frac{l}{10} =$

$t_{max} = 7''$

side note req:

DL → self wt = $\frac{7}{12} \times 150$ [...]

F.F =

PW = wall vol * unit wt of brick

$\left((30+30') \times 10 \times \frac{10}{12}\right) \times 2 + \ldots$

$\times 0.8$ for window/door gap

verandah + other walls $(14'+14') \times 3$

Exclude 0.8 multiplication for verandah

? on 14" wall as well

Factored $ld = 1.20L + 1.6LL$

work w/ max pos & max neg mmnt

if L is diff, calc max pos/neg mmnt di repeatedly, use max among

---

$d_{req} = \sqrt{\quad\quad}$ | $m = \phi \rho_{0.05} f_y b d^2 (1 - 0.59 \frac{\rho f_y}{f'_c})$

$\rho_{0.05} = 0.85 \beta_1 \frac{f'_c}{f_y} \frac{\varepsilon_u}{\varepsilon_u + 0.005}$

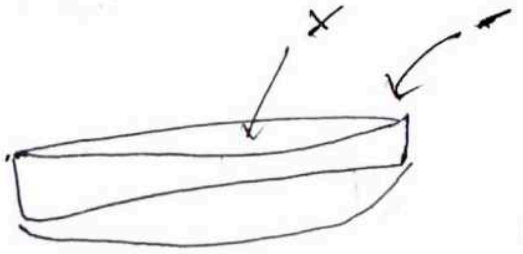
$t_{req} = d_{req} + 1$ ← slab clean-cover

← use Formula

$a = 1'' \quad \cdots \quad a =$

show calc

for lab report start $a = 2''$, 2 trials



check

$A_{s\,min} = 0.002\,bt$ | $= 0.4$

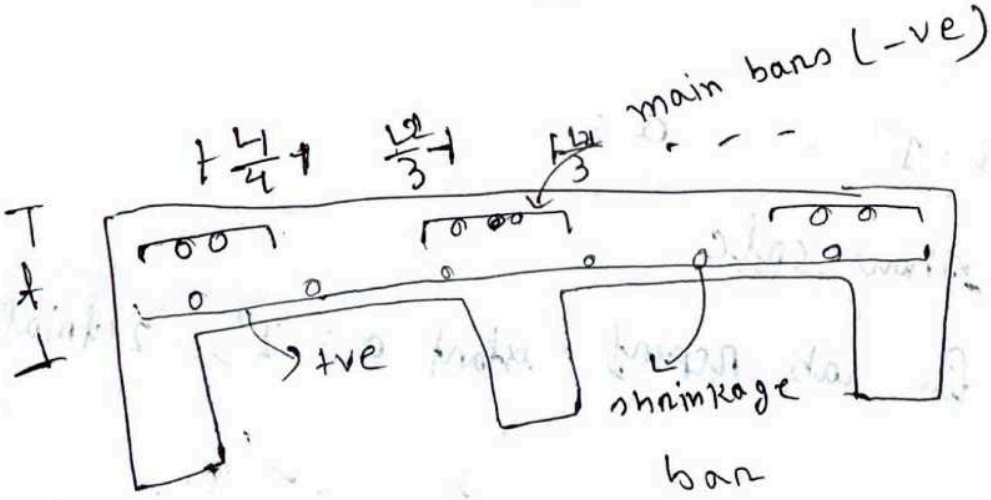
$A_s(+ve) = 0.35\ in^2 \rightarrow 0.4$

$A_s(-ve) = 0.65\ in^2 \rightarrow 0.65$

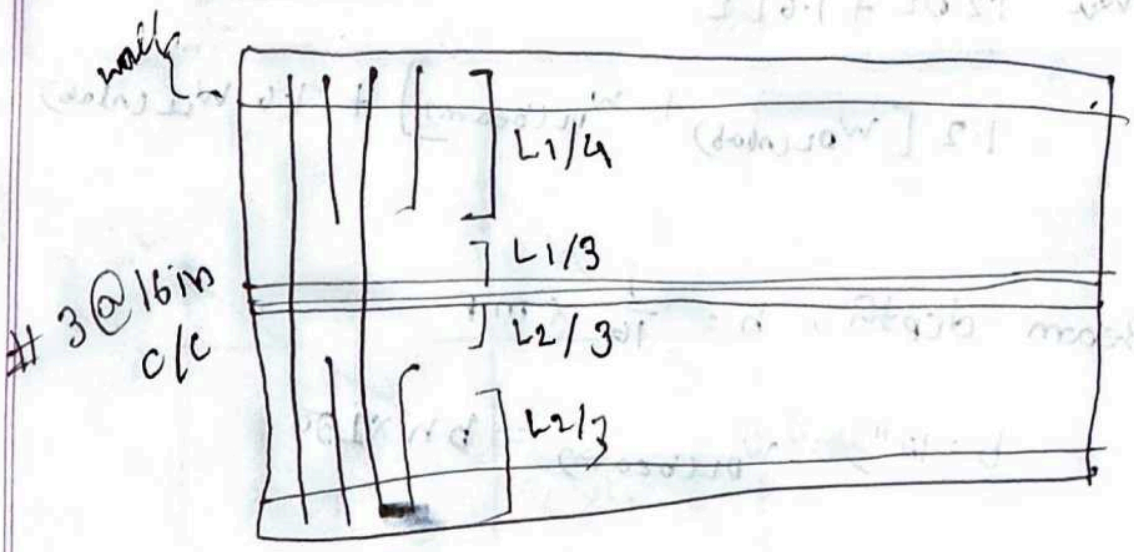
main → cm.

main bars → min (3 t_s, 18")

temp-shn. bars → min(5 t_s, 18")



bars 6" into wall


wall
L1/4
L1/3
#3@16in c/c
L2/3
L2/3

Beam design

① $W_u = 1.2\,DL + 1.6\,LL$

$= 1.2\,[W_{DL(slab)} + W_{DL(beam)}] + 1.6\,W_{LL(slab)}$

Beam depth, $h = \frac{1}{16} \times M.F$

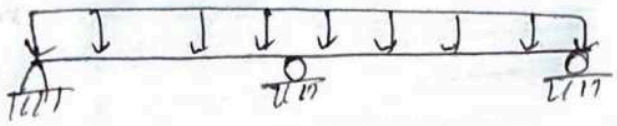
$b = 10''$; $W_{DL(beam)} = bh \times 150$

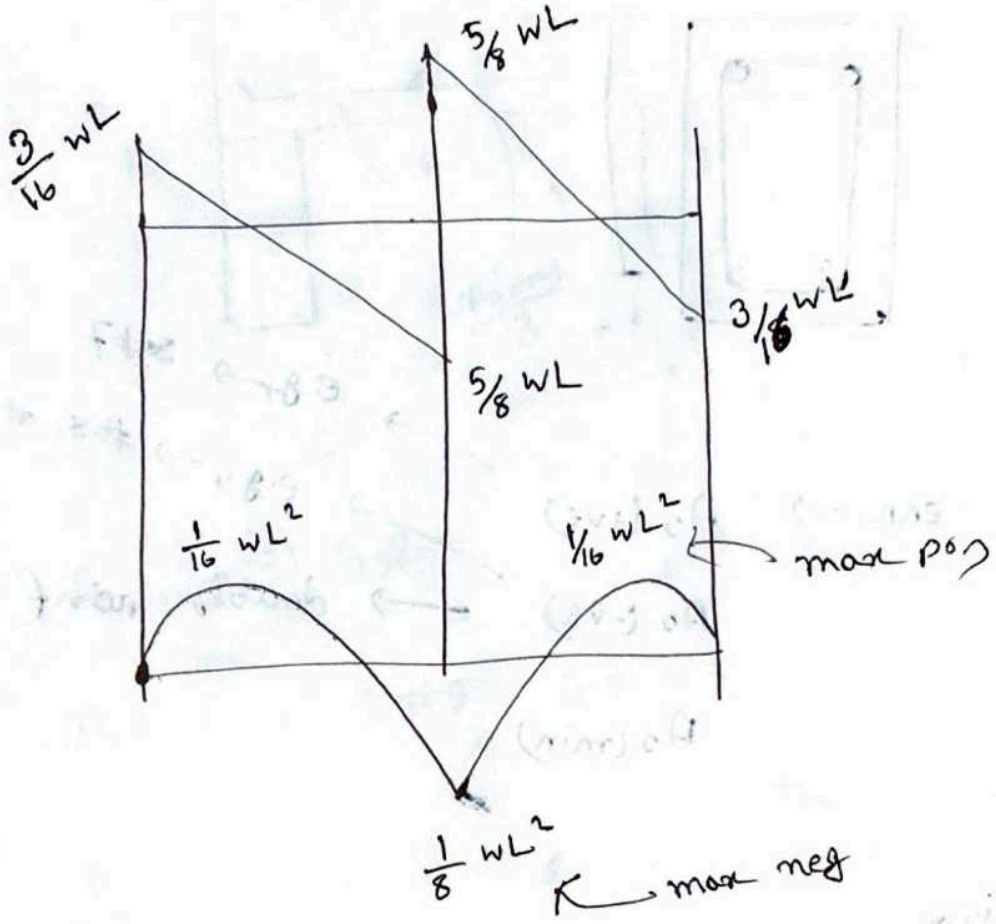
Trapezium area $= \frac{1}{2}(a+b)h$

$W_{LL(slab)} = \frac{\text{Tributary area} \times \text{slab LL from prev}}{\text{Total beam len}}$

$W_{DL(slab)} = \frac{T.A \times \text{slab D.L}}{\text{Total beam len}}$

SFD exact nat^n diagram incorrect





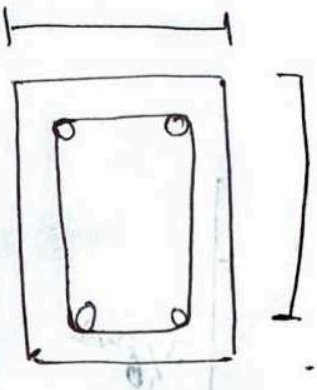
Check thickness

$$d_{req} = \sqrt{\frac{M_u}{\phi \rho b f_y \left(1 - 0.59 \frac{\rho f_y}{f_c'}\right)}}$$

Clear cover 2.5"

$d_{prov.} - 2.5$

Check T beam or rect. beam [rect provided in report]



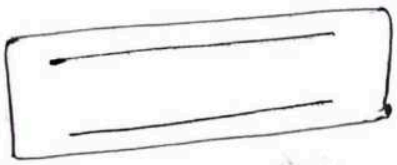
Trial err → A_s (+ve) → e.g. → ~~3#7~~

A_s (-ve) → e.g. → #8, #7 → double reinf

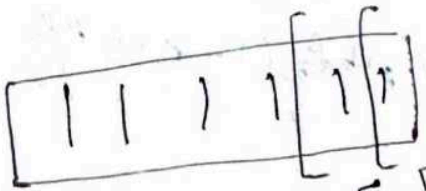
A_s (min)

Detailing

(i)

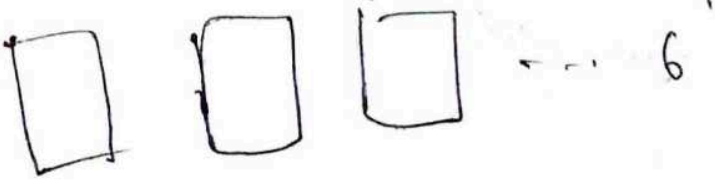


(ii)

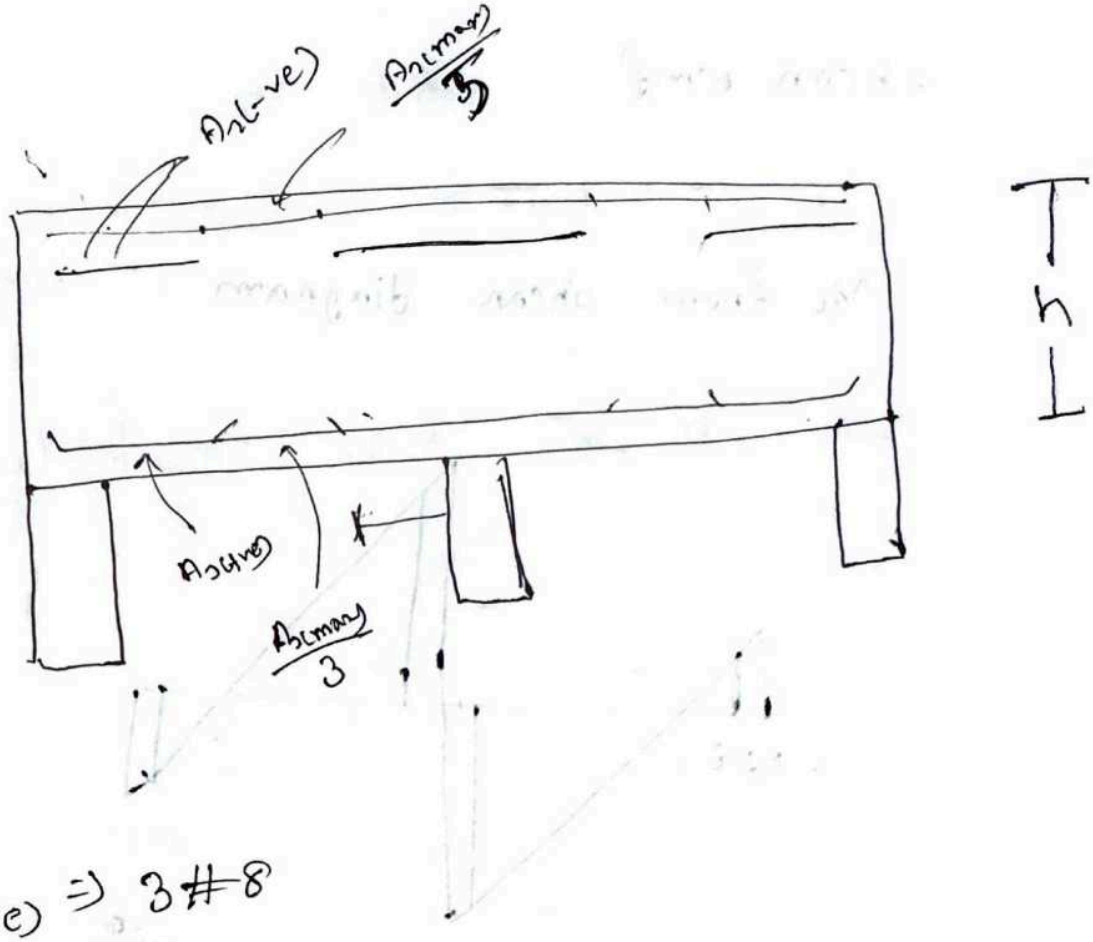


Shear

(iii)



... 6 section

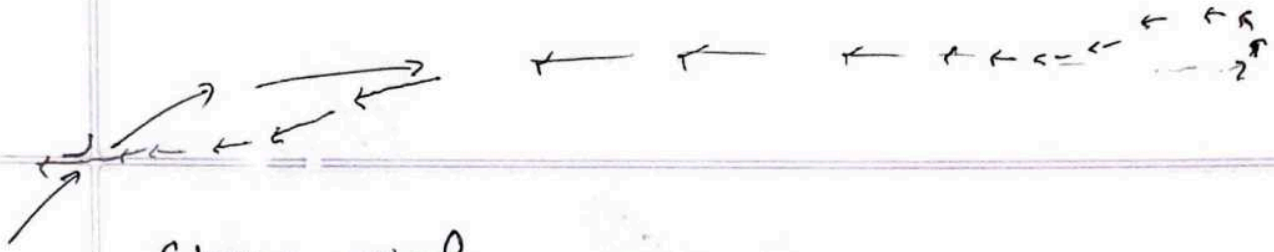


$A_s(+ve) \Rightarrow 3\#8$

$A_s(-ve) \Rightarrow 2\#9 \;,\; 3\#8$

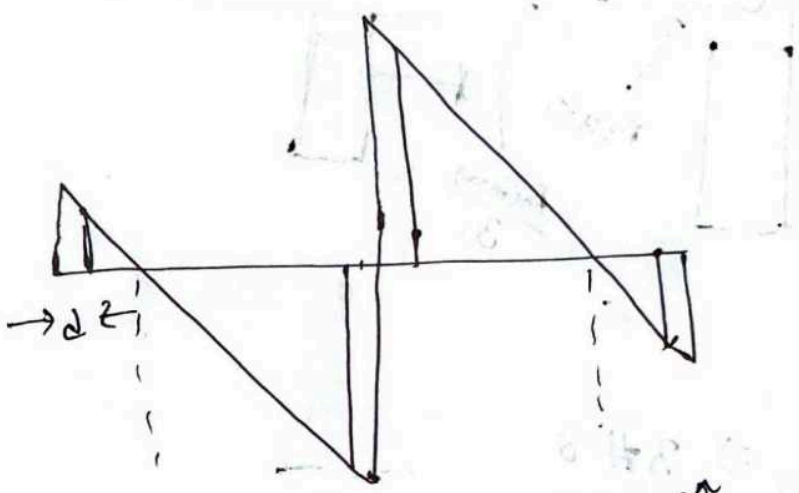
$\frac{A_s(max)}{3} \Rightarrow 3\#8 \longleftarrow$ min reinf

$\frac{A_s(max)}{5} \Rightarrow 2\#8$



Shear reinf

V_u from shear diagram



V_u, ϕV_c, $\frac{\phi V_c}{2}$

$s_1 = \frac{\phi A_v f_y d}{V_u - \phi V_c}$ ← 2 × area → 8"

$s = d/2$ → 11"

$s_2 = \frac{\phi A_v f_y d}{V_u - \phi V_c}$ → 7" ← for middle

$s_{max} = d/4$

8 × smallest main bar dia

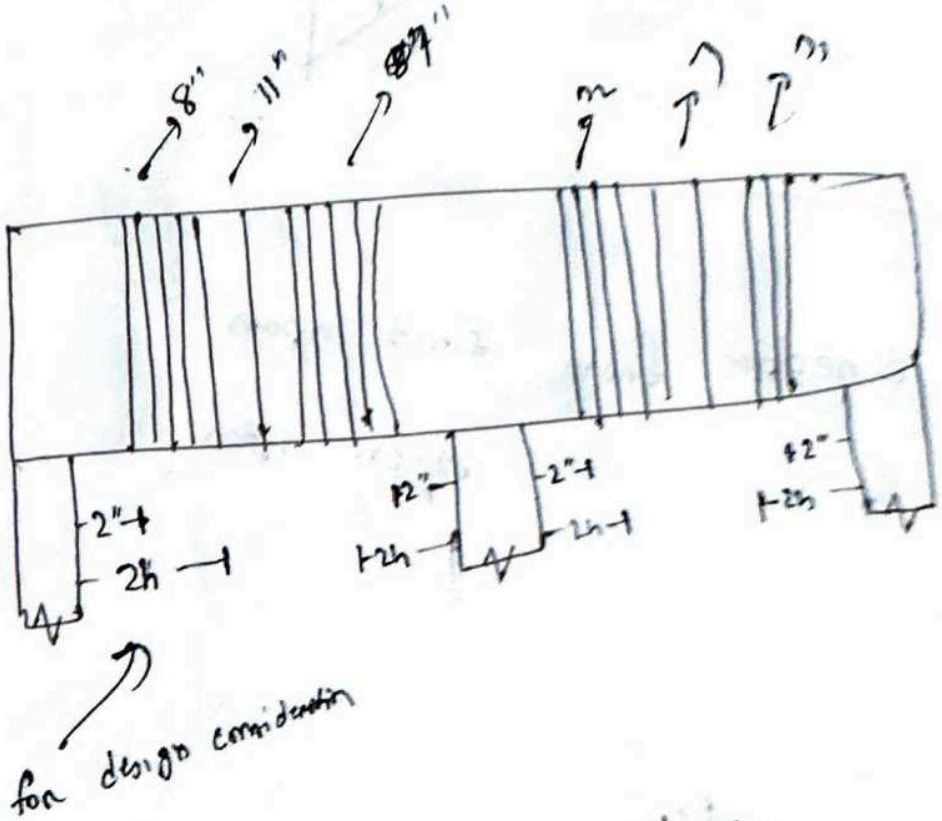
24 × stirrup dia

300 mm = 11.81"

min

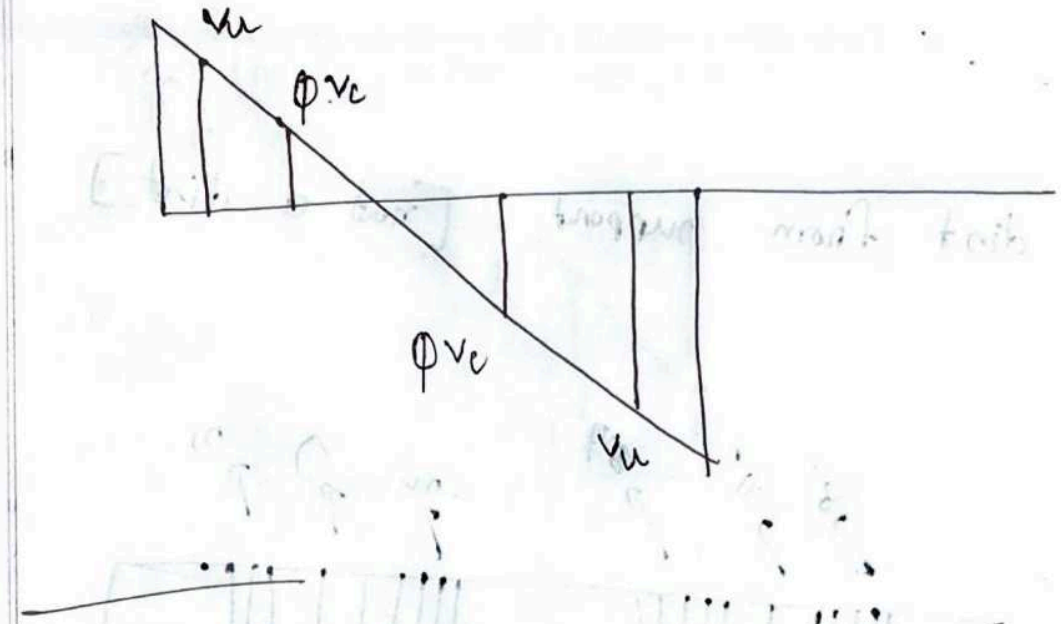
show dist' on diagram [calc not needed]

2" dist from support [not d dist]



for design consideration

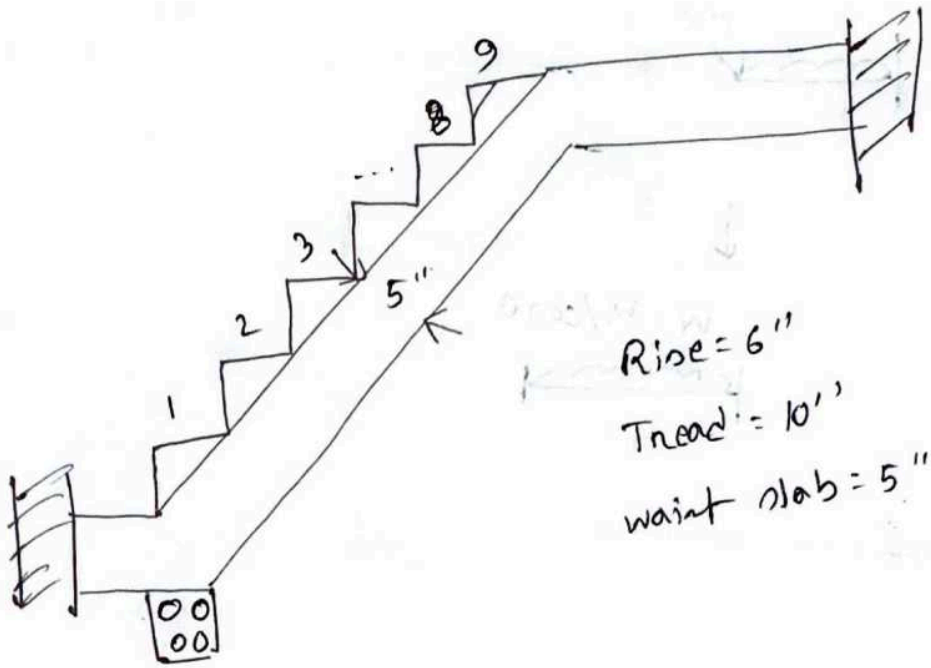
use corresponding V_u values

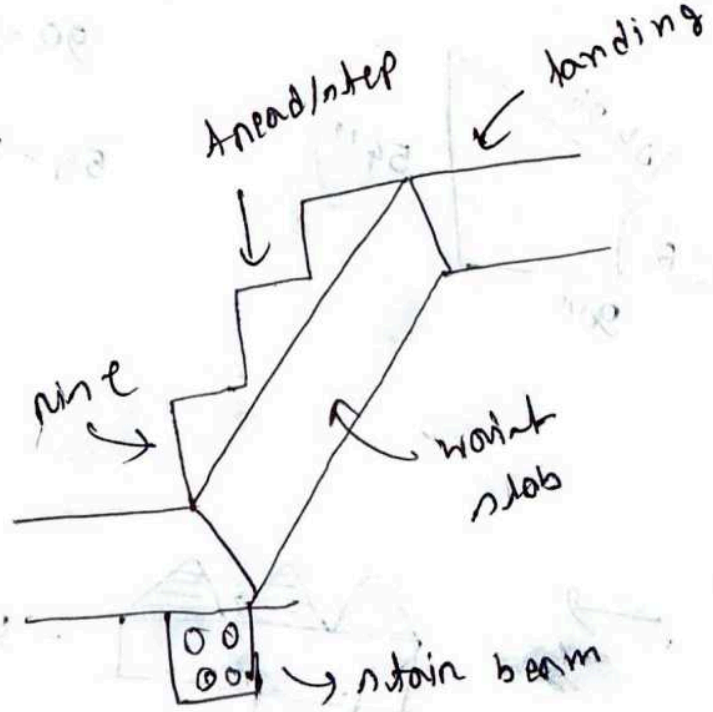


3 section from first span

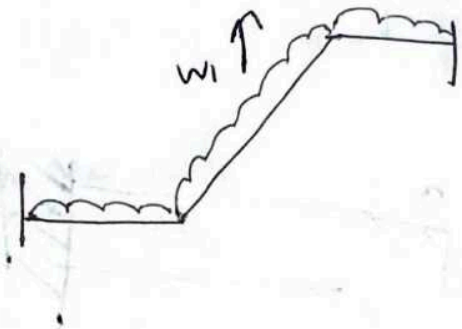
3 " " other span

Staircase



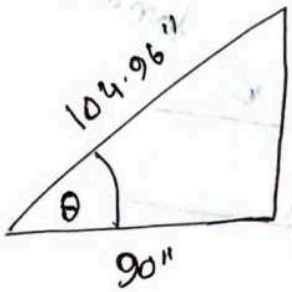


[one for our case]



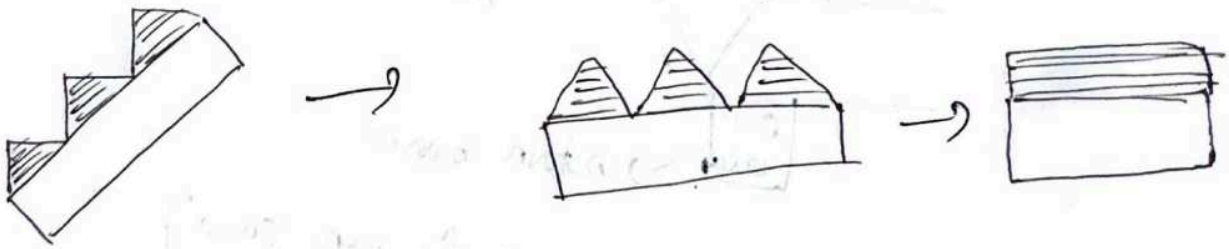
$W_2 = W_1 / \cos\theta$

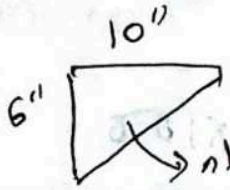




90 → 10×9

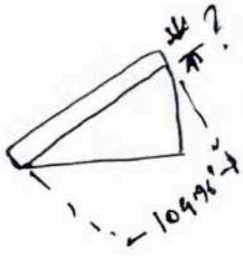
54 → 6×9





Area $= \left(\frac{1}{2} \times 6 \times 10\right) \times 9$

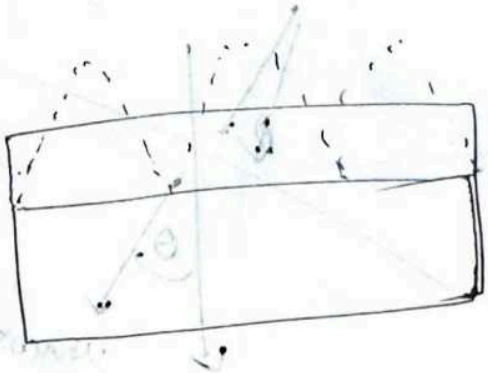
$= 270 \square''$



Thickness $= \frac{\text{Area}}{\text{len}}$

$= 2.57''$

dang $= 5 + 2.57 = 7.57''$



Self wt $= \frac{7.57}{12} \times 150$

$\longrightarrow$ Wu

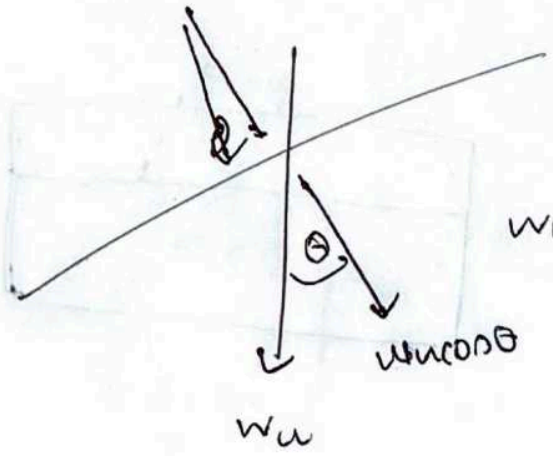
$=$

$W_{inclined} = 1.2DL + 1.6LL$

$= 1.2(94.63 + 25) + 1.6 \times 100$

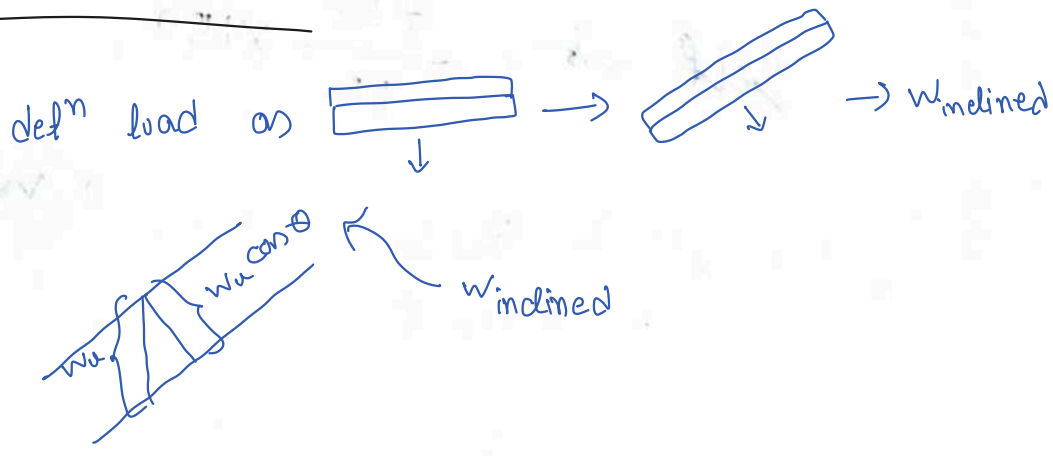
$= 303.56$ psf

F.F. & LL consider same in report



$W_{inc} = W_u \cos\theta$

$W_u = \frac{W_{inc.}}{\cos\theta}$



$$\text{Moment} = \frac{wL^2}{8}$$

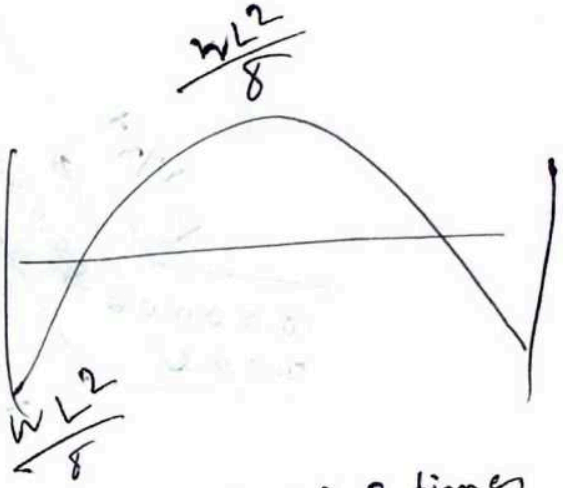
$$= \frac{354.01 \times 7.5^2}{8} \qquad [90''/12 \rightarrow 7.5']$$

$$=$$

$d_{prov.} = t_{avg} - 1 = 7.5 - 1 = 6.5''$

$d_{req} = \ldots$

$prov > req$ ✓



Reinf

$$A_s = \frac{M_u}{\phi f_y (d - a/2)}$$

trial → 2 times

$$a = \frac{A_s f_y}{0.85 f_c' b}$$

$A_{s\,min} = 0.0018\,bt = 0.0018 \times 12 \times 7.5$

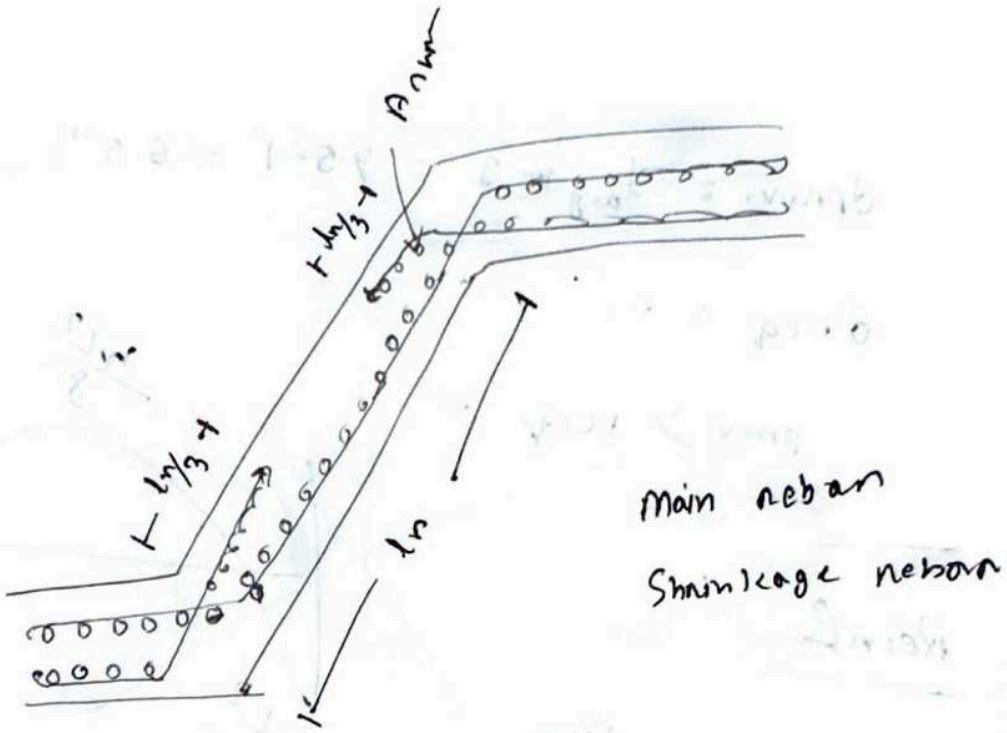
$s_{max} = 1.5t$

$s = \frac{12 \times A_b}{A_s}$ $\quad s_{max} = 3t$ or 18

$5t$ for 18 for shrinkage

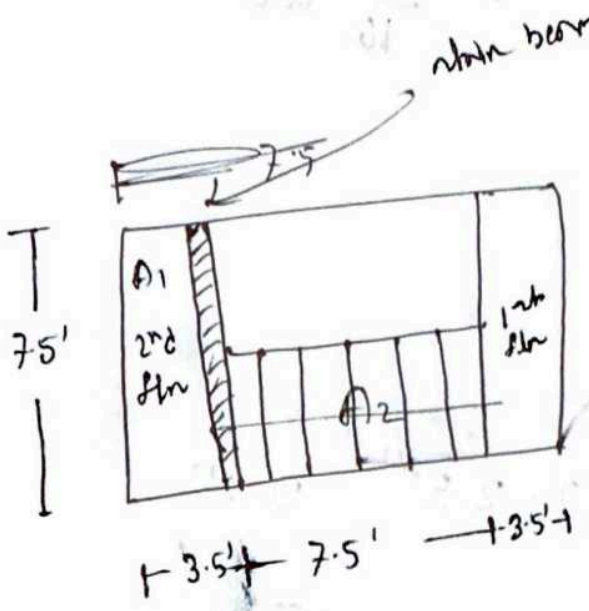
Shrinkage reinf

Reinf



~~Rein~~

Stair beam:



Assumed beam dim → 10" × 12"

def = 12 - 2.5 = 9.5 in

$\gamma_w = \frac{10}{12} \times \frac{12}{12} \times 150 = \cdots$

Load from stair:

$\frac{52.5 \times w_u}{7.5'}$

Total Ld: Load from stair + SW (1-2)

Area = $A_1 + A_2$

$= (3.5 \times 7.5) + (3.5 \times 7.5)$

$= 52.5\ ft^2$

Pos mmnt $= \frac{1}{14} wL^2$

Neg mmnt $= \frac{1}{16} wL^2$

M_{max} —

dreq

dprov → 12" − 2.5" = 9.5"

—

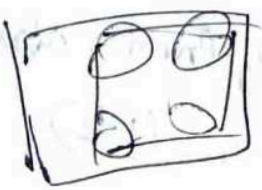
$A_{s\,min} = \max \begin{cases} \frac{3\sqrt{f_{ck}(psi)}}{f_y(psi)} bd \\ \frac{200}{f_y(psi)} bd \end{cases}$

M (+ve) → As (+ve) } = —

M (−ve) → As (−ve)

usually single bar can cover both

... Stirrups not needed



$d_{req} > d_{prov}$

$t_z \rightarrow$

self wt $\rightarrow$

$m \rightarrow$

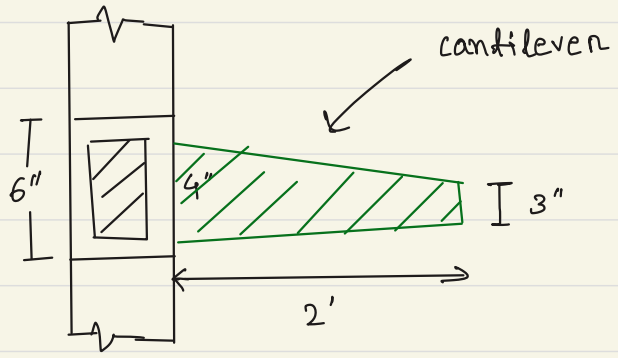
In a nutshell,

1. Transform stair into a horizontal rect. member
2. Def^n factored load ($w_{inc} \rightarrow w_u$)
3. Check d_{prov} w/ d_{req} (d_{prov} from t_{avg})
4. Compute reinf. (main & shrinkage reinf)
5. Design stair beam

S04 18/12

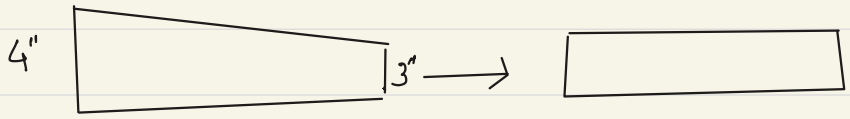
Sunshade & Lintel

Combined lab reps



→ sunshade

$w_{LL} = 10$ psf [L.L due to rain retention snow]



$t_{avg} = \frac{4+3}{2} = 3.5"$

$w_{DL} = \frac{3.5}{12} \times 150$

$w_{LL} = 10$ psf

$w = 1.2\,DL + 1.6\,LL$

$\rightarrow 43.75$

$M_u = \frac{wL^2}{2} = \frac{w \times 2^2}{2}$

d-check → $d_{req} = \cdots$;

$d_{prov} = 3.5 - 1 = 2.5"$

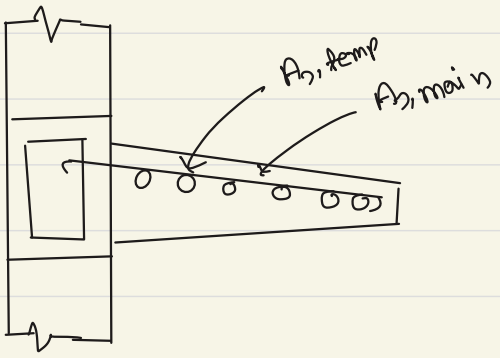
$b = 12"$

$A_b = \cdots$
$a = \cdots$
} $A_s = \cdots \rightarrow$ #4 bar

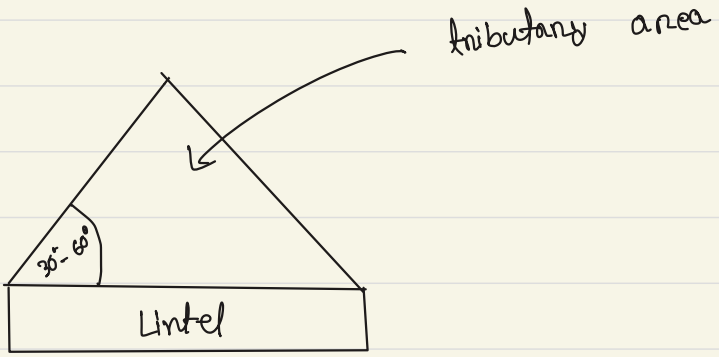
$A_{s,min} = 0.0018\, bt$ ↗ check

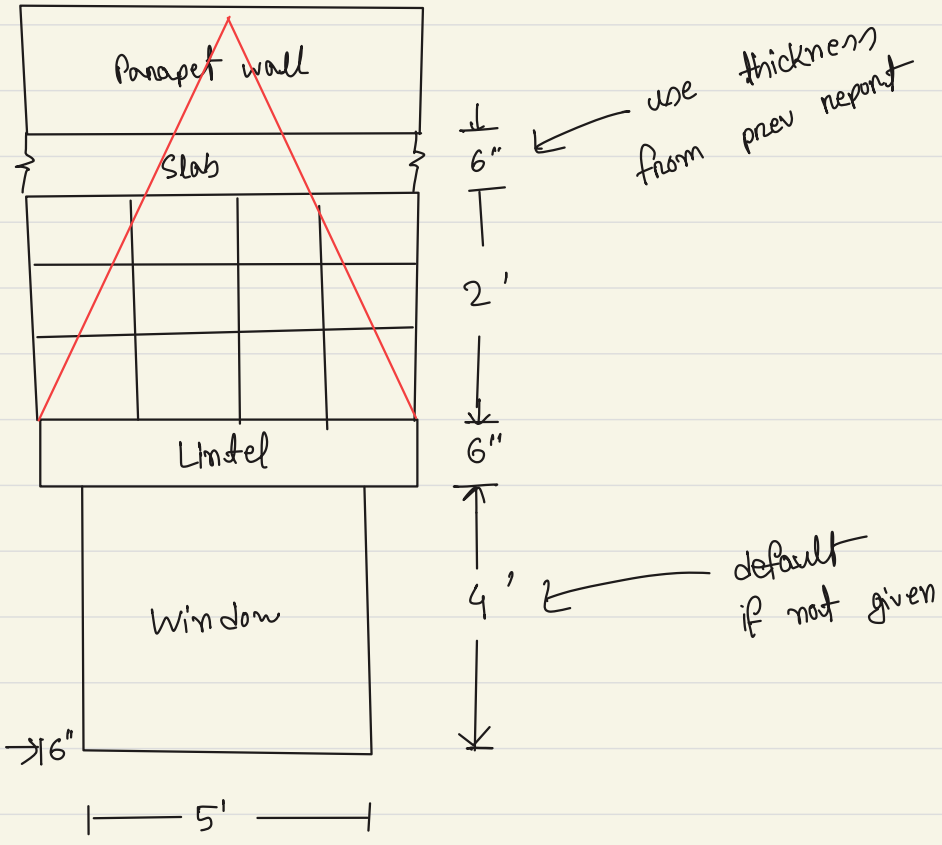
$S = 12 \times \frac{A_b}{A_s}$, $S_{max} = 3t$ or $18''$

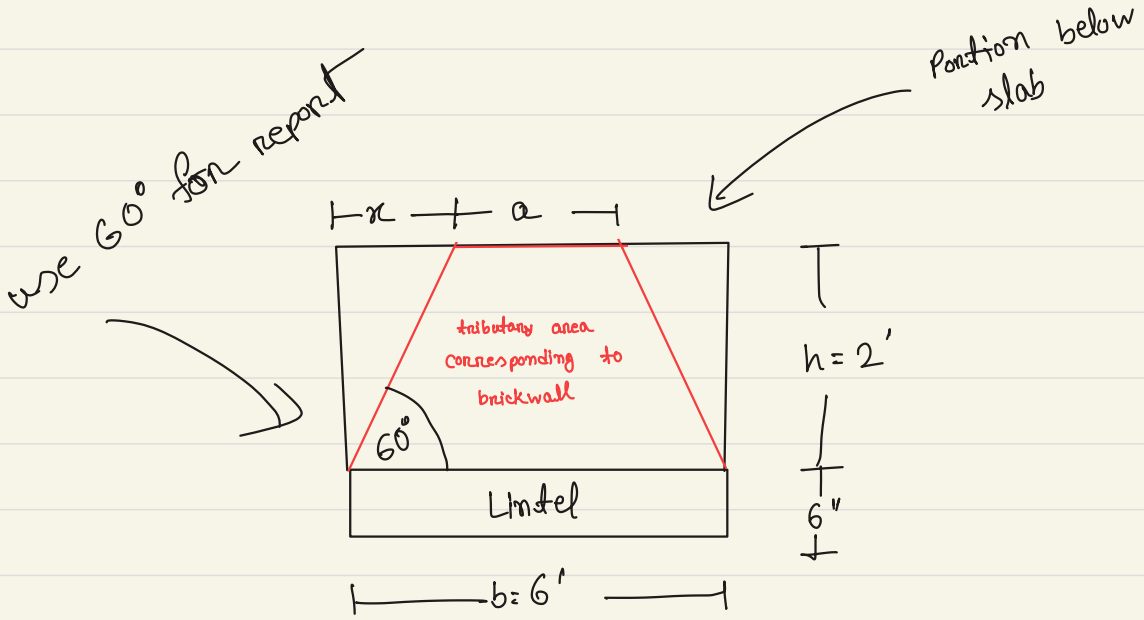
$S_{min} = \cdots$



Lintel


tributary area
25°-60°
Lintel


Parapet wall
Slab
6"
use thickness from prev report
2'
Lintel
6"
Window
4'
default if not given
6"
5'



$$\tan 60 = \frac{h}{x}$$

$$\Rightarrow x = 1.15'$$

$$a = 6' - (2 \times 1.15)' = 3.7'$$

Load from brickwall:

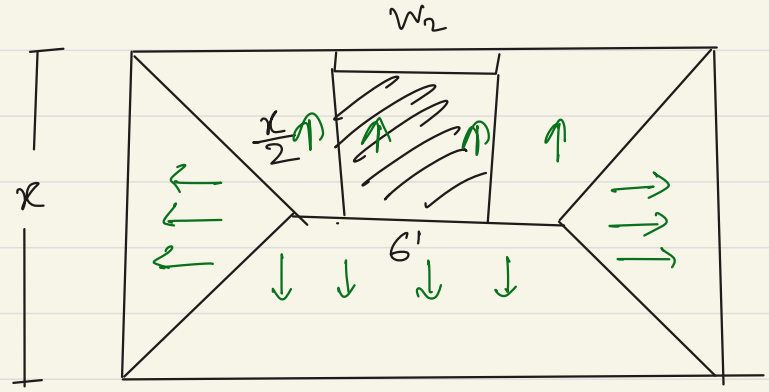
unfactored

$$Ld = \underbrace{\frac{1}{2}(6 + 3.7) \times 2}_{\text{area}} \times \underbrace{\frac{10}{12} \times 120}_{\text{vol}}$$

Load from slab:

factored

w = from report

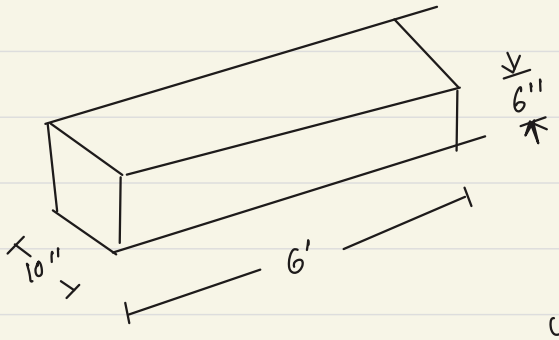


Area $b \times h$

$= \frac{6x}{2}$

$= 3x$

Load from Lintel:



$\frac{10}{12} \times \frac{6}{12} \times 150$

unfactored

Load from sunshade

unfactored

$\frac{3.5}{12} \times 2 \times 150$

use this on report

L.L = 20 psi

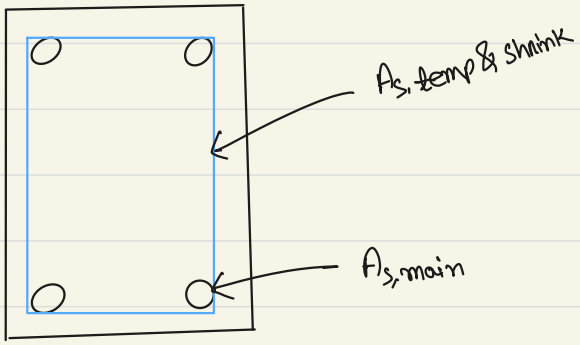
Total load = $1.2[w_1 + w_3 + w_4] + w_2 + 1.6\, w_L$ = ---

Moment calculation :

$$M_u = \frac{wL^2}{8}$$

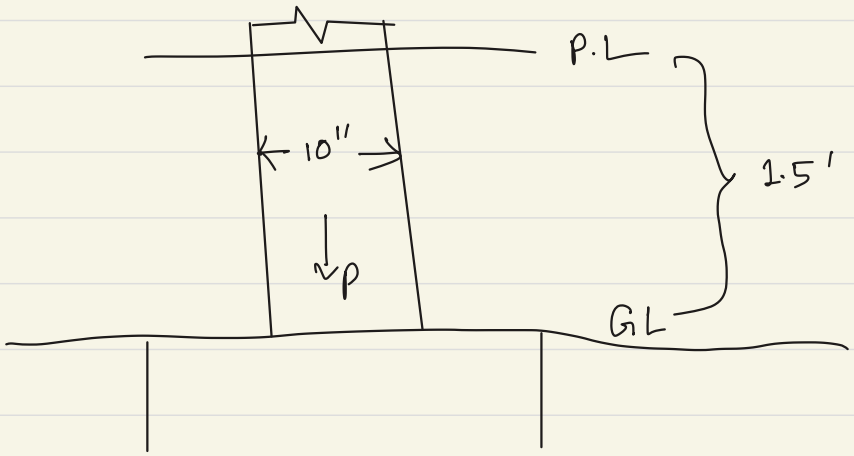
d-check : $d_{prov} = 6" - 1.5"$ $L = 6'$

Reinf:, spacing :



do combined diagram

Wall Foundation Design :



Show two foundation on report ; assume two stoney

1. Load from slab :

- P.W = ☐
- D.L = ☐
- L.L = ☐
- F.F = ☐

→ Slab wt = $\frac{7"}{2} \times 150$

No. of stoney = 2

Roof : L.L = 50% of L.L

D.L = Slab wt + F.F.

Typical floor DL = 2 (Slab wt + F.F. + P.W)

LL = 2 × L.L

Total ld, LL = Floor + Roof

DL = Roof DL + Floor DL

2. From sunshade : - - -

3. From Lintel : - - -

4. From wall : $= 10' \times \frac{10''}{12} \times 1' \times 120$

5. PL to G.L wt : $= 1.5' \times \frac{10''}{12} \times 1' \times 120$

$\therefore P = 1 + 2 + 3 + 4 + 5 \longrightarrow$ lb/ft

$TL = DL + L.L \longrightarrow$ lb/ft^2

$\square$ lb $\rightarrow$ lb/ft

$A = \frac{1}{2} \times [27' + \square] \times \frac{12'}{2}$

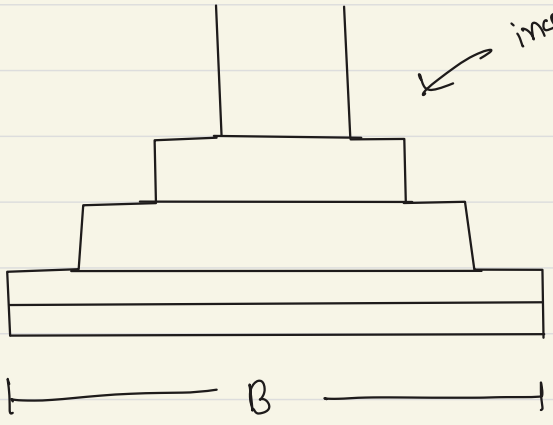
$= \ldots$

$\times$

Foundation wt : 10% P

$q_{allowable} = \frac{P + W}{B \times 1'}$ → upper rounding

→ Let 2300 psf



Check:

Fdn self wt = ...

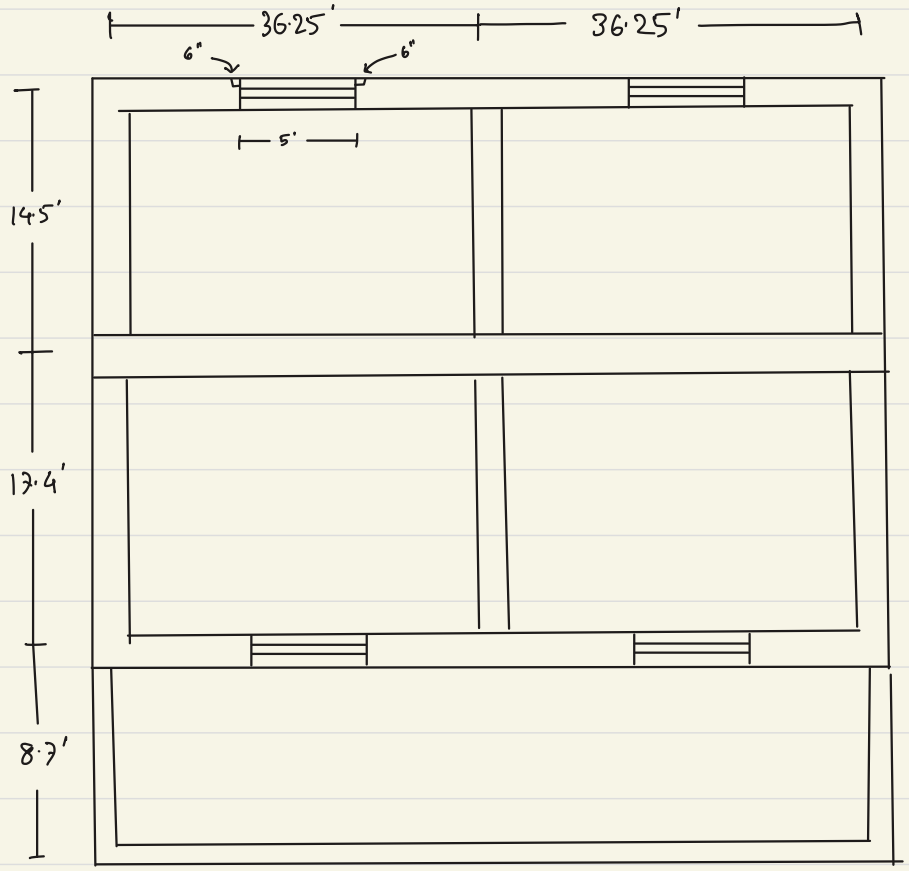
From row, find B and check
if check failed, redo with bigger value

For exam

Last portion; P may be given
including check

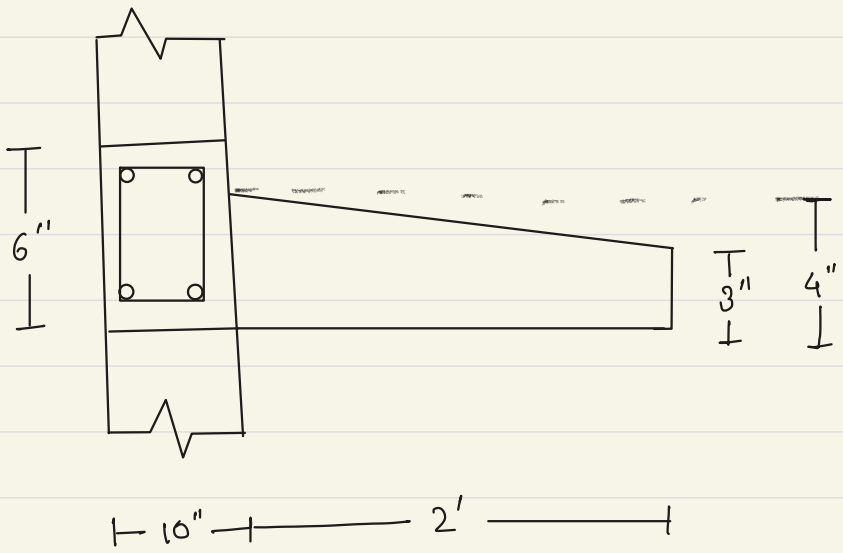
Next monday → assessment
Syllabus → only foundation

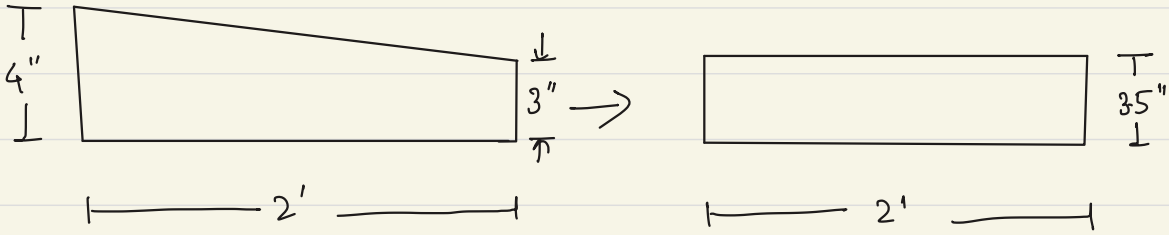
Rough / Sunshade & Lintel Design 21/12



Plan view

Sunshade:





$t_{avg} = 3.5"$

$\therefore$ Self wt $= \frac{3.5}{12} \times 150$ psf $= 43.75$ psf

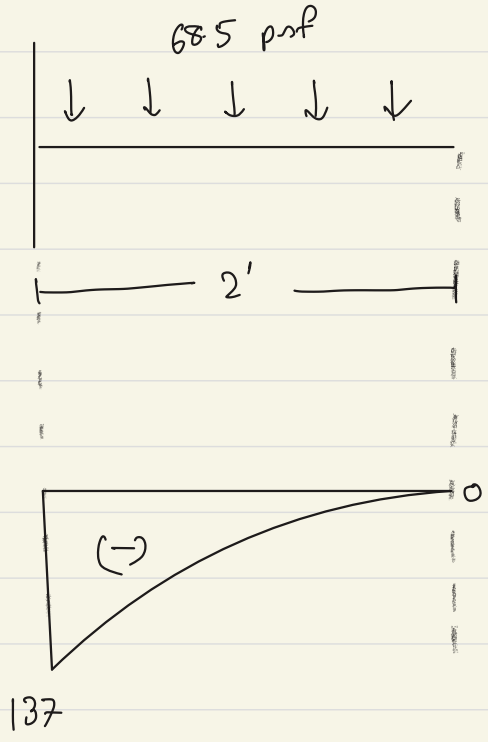
Live load $= 10$ psf

$\therefore$ Factored load $= 1.2\,DL + 1.6\,LL$

$= 1.2 \times 43.75 + 1.6 \times 10$ psf

$= 68.5$ psf

Hence, $M_{max} = \frac{wL^2}{2} = \frac{68.5 \times 2^2}{2} = 137$ lb-ft



d - check

$$\rho_{0.005} = 0.0255$$

$$M_u = \phi \rho b d^2 f_y \left(1 - 0.59 \frac{\rho f_y}{f_c'}\right)$$

$$\Rightarrow 0.132 \times 12 = 0.9 \times 0.0255 \times 12 \times d^2 \times 50 \left(1 - 0.59 \frac{0.0255 \times 50}{5}\right)$$

$$\Rightarrow d = 0.375'' \quad < \quad (d_{prov} = 3.5'' - 1'' = 2.5'') \qquad [ok]$$

Reinforcement :

$$A_{s,min} = 0.0018 bt = 0.0018 \times 12 \times 3.5 = 0.076 \text{ in}^2$$

$$A_s = \frac{M_u}{\phi f_y (d - a/2)} \; ; \qquad a = \frac{A_s f_y}{0.85 f_c' b}$$

(M_u: 0.132×12; f_y: 50; d: 2.5"; f_c': 5; b: 12")

$$A_s = 0.015 \text{ in}^2 \; ; \quad a = 0.014 \text{ in}$$

$$\rightarrow 0.076 \text{ in}^2$$

Spacing

$$S_{min} = 1.5t = 1.5 \times 3.5 = 6.5''$$

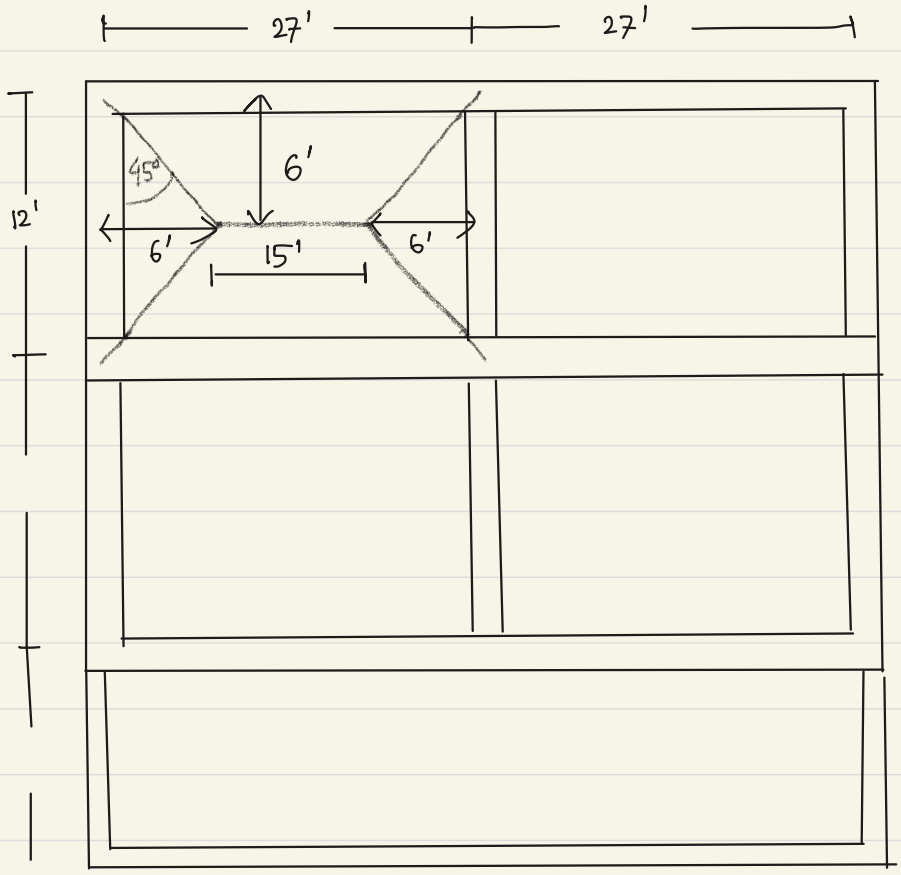
$$S_{max} = \min(3t, 18'') = 10.5''$$

$$S = \frac{0.11}{0.076} \times 12 = 17''$$

$$\rightarrow 10.5'' \qquad (\#3 \; @ \; 10.5'' \; c/c)$$

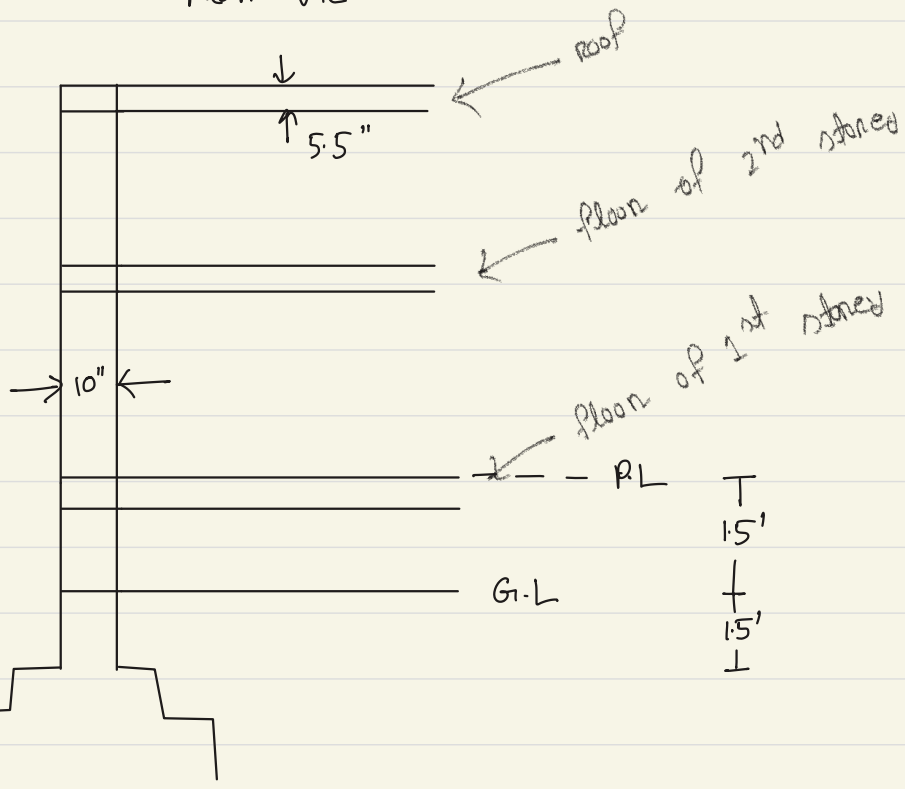
Rough / Foundation Design 21/12

Using manual data:



Plan view

No. of stones → 2



Section view

Total unfactored load:

1) From slab:

Floor: DL + LL = (Self wt + F.F.) + L.L
(per)

$= \left(\frac{5.5}{12} \times 150 + 25\right) + 40$ psf

$= 93.75 + 40$ psf

$= 133.75$ psf

Roof: DL + LL = DL + 50% of LL on floor

$= 93.75 + 40 \times 0.5$ psf

$= 113.75$ psf

Load $= 133.75 \times 2 + 113.75 = 381.25$ psf

Total ld $= 381.25 \times 126 = 48038$ lb

UDL $= \frac{48038}{27} = 1780$ lb/ft

Tributary area

$= \frac{27+15}{2} \times 6 = 126$ ft^2

2) From sunshade:

D.L $= 150 \times \left(8 \times 2 \times \frac{3.5}{12}\right) = 700$ lb

L.L $= 10 \times (8 \times 2) = 160$ lb

$\therefore$ Total $= 860$ lb

$\therefore$ UDL $= \frac{860}{27} = 32$ lb/ft

3) From lintel:

Total ld = self wt = $150 \times \left(\frac{6}{12} \times \frac{10}{12} \times 8\right) = 500$ lb

UDL = $\frac{500}{27} = 18.5$ lb/ft

4) From wall:

Total ld = Self wt = $120 \times \left(\frac{10}{12} \times 10 \times 1\right) = 1000$ lb/ft

5) From P.L to G.L:

Total ld = $120 \times \left(1.5 \times \frac{10}{12} \times 1\right) = 150$ lb/ft

∴ Total ld on foundation, P = 1780 + 2[32 + 185 + 1000) + 150 lb/ft

= 4032 lb/ft

For foundation, let self wt, w = 10% of P

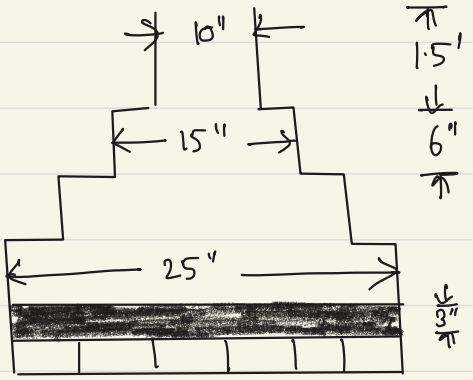
= 403 lb/ft

For q_{all}: 2300 lb/ft^2, $B = \frac{w+P}{q_{all}} = 1.93' = 23'' \sim 25''$

Check:

Wact = $120 \times \left(10 \times 1.5 \times 12 + 15 \times 6 + 20 \times 6 + 25 \times 6 + 25 \times 3\right) \times \frac{1}{144} + \frac{25 \times 3}{144} \times 150$

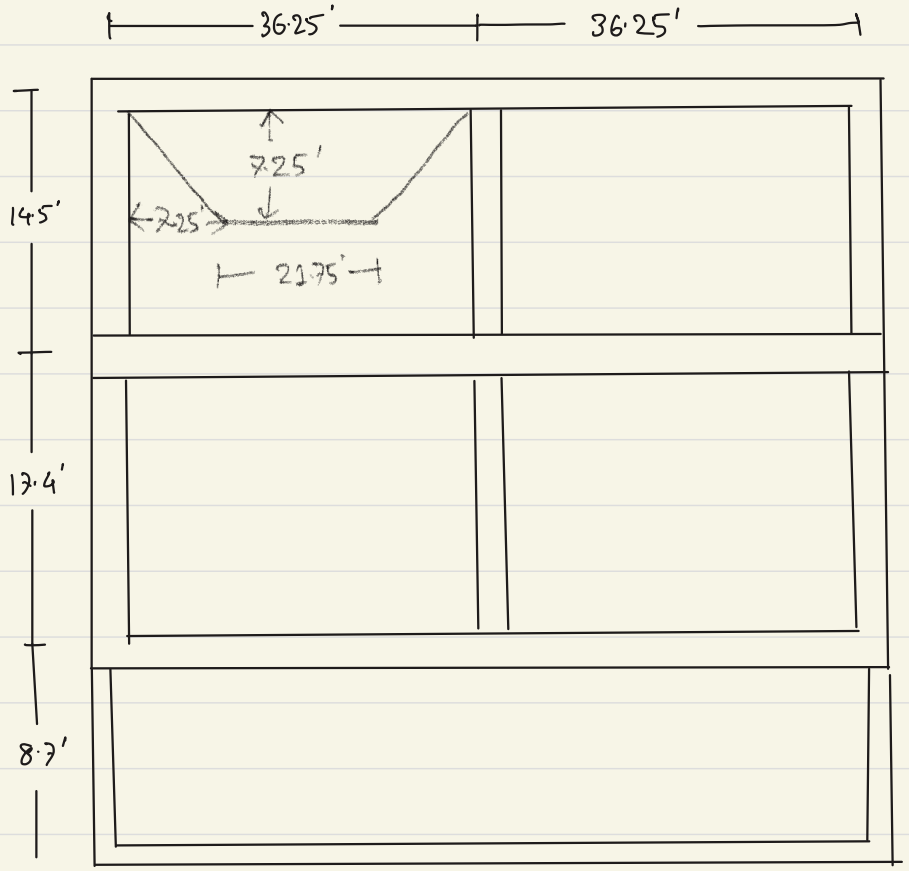
= 591 lb/ft



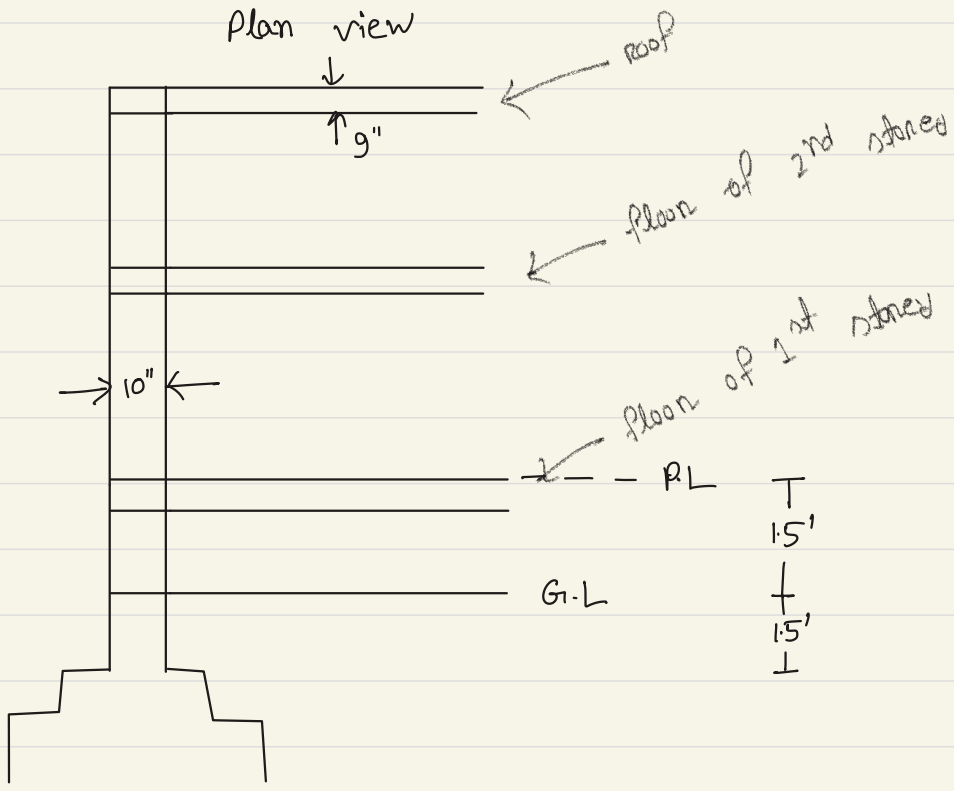
$$B = \frac{W_{tot} + P}{q_{all}} = \frac{5924 + 4031}{2300} = 2' = 24'' \simeq 25'' \quad [OK]$$

21/12

Using own data:



No. of stoned
→ 2



Section view

WSD method

Total unfactored load,

1) From slab:

Floor, DL = Self wt + F.F

$= 150 \times \frac{9}{12} + 25 = 137.5$ psf

LL = 40 psf

∴ Load = 177.5 psf

Roof, DL = 137.5 psf

LL = 50% of 40 = 20 psf

∴ Load = 157.5 psf

$$\text{Area} = \frac{36.25 + 21.75}{2} \times 7.25 = 210.25 \text{ ft}^2$$

∴ Total ld = $[(177.5 \times 2) + 157.5] \times 210.25$ lb

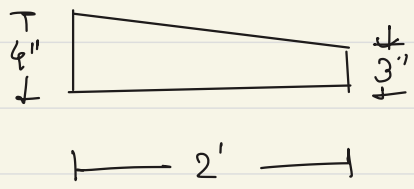
$= 107753.1$ lb

$$\therefore \text{UDL} = \frac{107753.1}{36.25} = 2973 \text{ lb/ft}$$

2) From sunshade:

$DL = 150 \times \left(\frac{3.5}{12} \times 2 \times 6\right)$ lb

$= 525$ lb



LL = 10 psf → $10 \times (2 \times 5) = 100$ lb

∴ Total = 625 lb

$$\therefore \text{UDL} = \frac{625}{36.25} = 17.24 \text{ lb/ft}$$

3) From lintel:

$$\text{Total lb} = \text{self wt} : 150 \times \frac{6}{12} \times \frac{10}{12} \times 6 = 375 \text{ lb}$$

$$\therefore \text{UDL} = \frac{375}{36.25} = 10.34 \text{ lb/ft}$$

4) From wall:

$$\text{UDL} : 120 \times \left(\frac{10}{12} \times 10 \times 2\right) = 1000 \text{ lb/ft}$$

5) From P.L to G.L:

$$\text{UDL} = 120 \times \left(\frac{10}{12} \times 1.5 \times 1\right) = 150 \text{ lb/ft}$$

$\therefore$ Total ld from above, $P = 2973 + 2[17.24 + 10.34 + 1000] + 150$ lb/ft

$= 5178$ lb/ft

Assume, wt of foundation $= 0.1 \times 5178 = 517.8$ lb/ft

$\therefore$ Total ld on foundation $= 5178 + 517.8 = 5699$ lb/ft

$q_{all} = 2300$ lb/ft^2

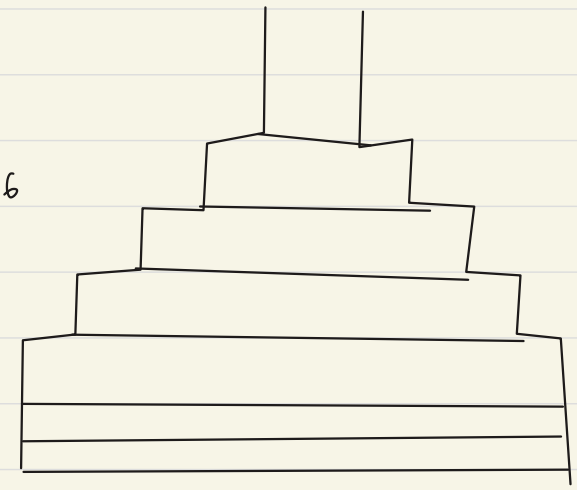
Required $B = \frac{5699}{2300} = 2.48' = 29.76'' \sim 30''$

Check:

$$W_{act} = 120 \times (10 \times 1.5 \times 12 + 15 \times 6 + 20 \times 6 + 25 \times 6 + 30 \times 6 + 30 \times 3) \times \frac{1}{144} + 150 \times \frac{30 \times 3}{144} \text{ lb/ft}$$

$= 768.8$ lb/ft

$$B_{act} = \frac{5699 + 769}{2300} = 2.81' = 33.7'' \sim 35''$$

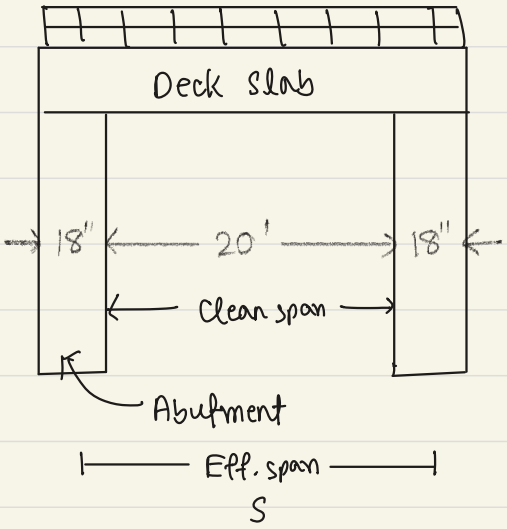


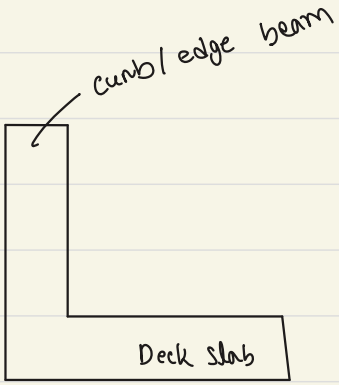
$$w_{revised} = 120\left(10\times1.5\times12 + 15\times6 + 20\times6 + 25\times6 + 30\times6 + 35\times6 + 35\times3\right)\frac{1}{144} + 150\times\frac{35\times3}{144} \quad lb/ft$$

$$= 972 \; lb/ft$$

$$B_{revised} = \frac{5699+972}{2300} = 2.9' = 34.8'' < 35'' \quad (OK)$$

Slab bridge





Live load

i) Truck ld

ii) Lane ld

Dead ld

i) Self wt of slab

ii) From wearing course

Truck ld

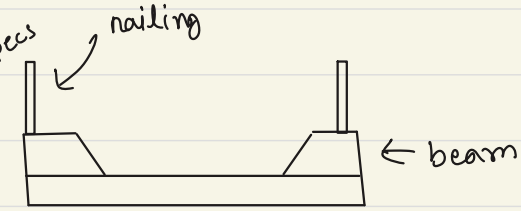
1 ton = 2000 lb

i) H15-44 & H20-44 → Standardized in 1944 AASHTO specs

(Truck → 15 ton; 20 ton)

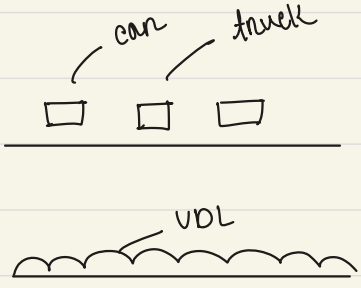
ii) HS15-44 & HS20-44

↘ Semitrailer Truck



Truck load distribution figure

Lane ld



Two lds to be summed

concentrated ld, UDL

WSD method

Effective span:

S = c/c btwn supports
= clean span + $\left(\frac{18}{2} + \frac{18}{12}\right)''$
= $20' + \left(\frac{18}{2} + \frac{18}{2}\right)''$

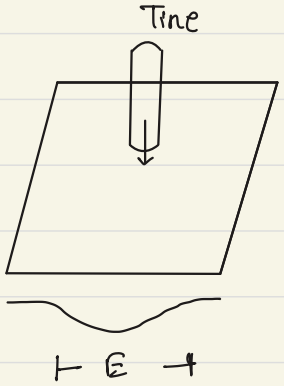
S_1 = C/C dist btwn support ← S_1 ← in ft
slab thickness, $t_{min} = 1.2 \times \left(\frac{S+10}{30}\right)$ ft → in
S_2 = clear span + slab thickness
} whichever is smaller

Determine moment individually for each type ld

Dead ld:

w_{DL} = SW + wearing course

$M_{DL} = \frac{w_{DL} \times S^2}{8}$



Live ld:

$E = (4 + 0.6S) \leq 7'$

if not, use std
w = 480 lb/ft → H15, HS15
w = 640 lb/ft → H20, HS20

conc. ld

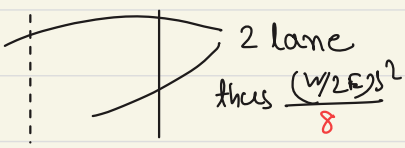
$M_{LL(truck)} = \frac{P/E}{4} S$ — begin

$M_{LL(lane)} = \frac{(P/2E)S}{4} + \frac{(w/2E)S^2}{8}$ lb-ft/ft

wheel load distribution width

P based on req → e.g., for HS15

$P_{(truck)} = 12000$ lb; $P_{(lane)} = 13,500$ lb



Impact ld: → sudden break vibrate, ...

Factor, $IF = \frac{50}{S+125} \leq 0.3$

$M_I = IF \times M_{LL}$

$M_{Design} = M_{DL} + M_{LL} + M_I$

Main Reinforcement:

$f_c = 0.45 f_c'$ $\qquad E_s = 29000$ ksi

$f_s = 0.40 f_y$ $\qquad E_c = 57000\sqrt{f_c'}$ psi

6 or more

$n = \frac{E_s}{E_c}$; $r = \frac{f_s}{f_c}$

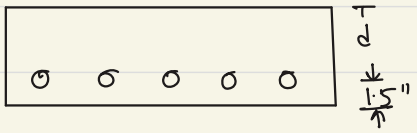
$k = \frac{n}{n+r}$; $j = 1 - k/3$

12"

$M_d = \frac{1}{2} f_c k j b d^2$

$\Rightarrow d = \cdots$

$t_{req} = d + 1.5 < t_{prov}$ (earlier)



if doesn't satisfy, redo w/ $t = t_{req}$

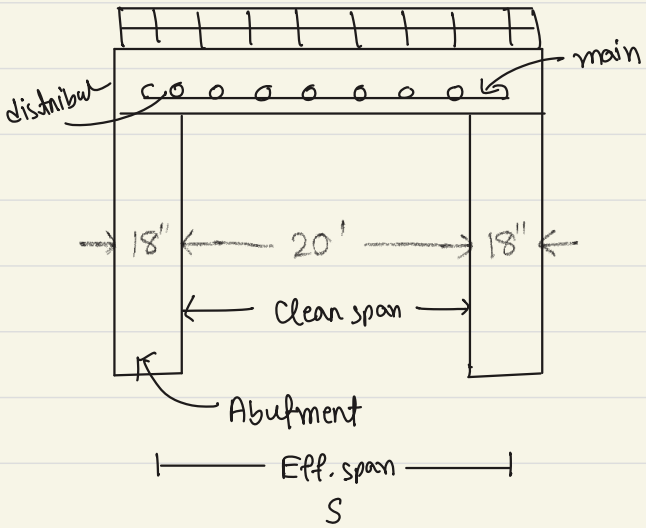
$A_s = \frac{M}{f_s \times j \times d}$

$0.4 f_y$

eff. span

$\left(\frac{100}{\sqrt{S}} \leq 50\right)\%$ $A_{s,main}$

distribution bar



Temp & Shrinkage: $\frac{1}{8}$ in²/ft

Check for min reinf.

$f_r = 7.5\sqrt{f_c'}$

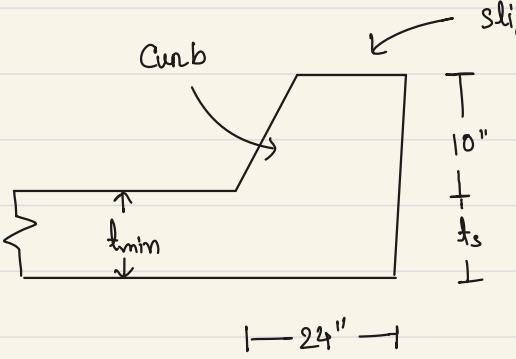
$I_{cr} = \frac{bh^3}{12}$ ← 12"

$M_{cr} = \frac{f_r I_{cr}}{h/2}$

$1.2\, M_{cr} < M_{Design} \rightarrow$ ok

if not ok increase slab thickness [use own discretion for how much to increase]

Edge beam



customary to use 24" for design

$$S.W = \frac{10+t_s}{12} \times \frac{24}{12} \times 150 \quad lb/ft$$

Railing = 15 lb/ft ← use in report

$W_D = \cdots$

$$M_{DL} = \frac{W_D \times S^2}{8}$$

$M_{LL} = 0.1 \times P \times S$ [P = 12K, 15K for ... ; memo, not be given]

$M_{Design} = M_{DL} + M_{LL}$

d-check,

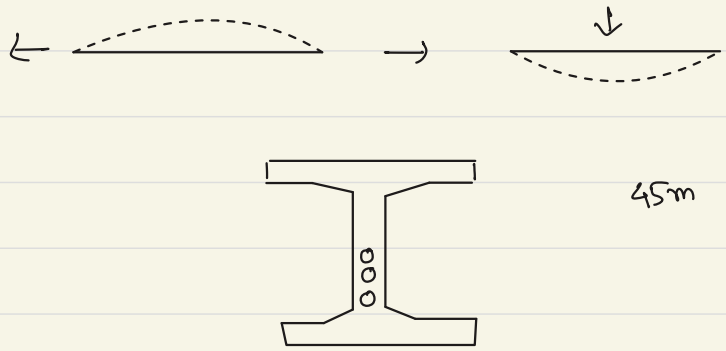
$A_{s,main} = \cdots$

$A_{s,min} = \frac{200}{f_y} \times b \overset{24"}{d}$

Detailing [Stirrup optional]

Bridge

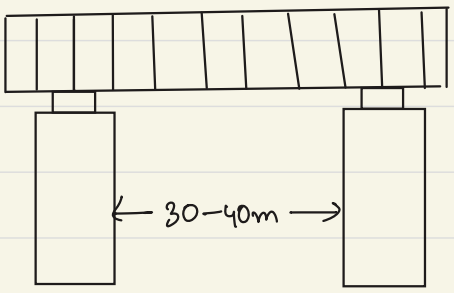
1. Slab bridge
2. Steel bridge
3. Prestressed I-ginder



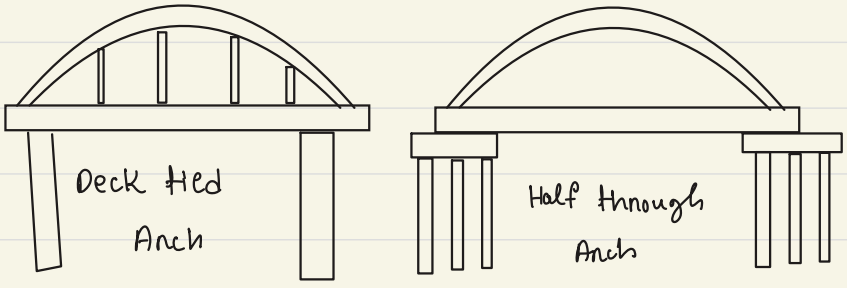
4. T-ginder
5. Boxex

   Span: 30-40m

   Metro → pre-cast



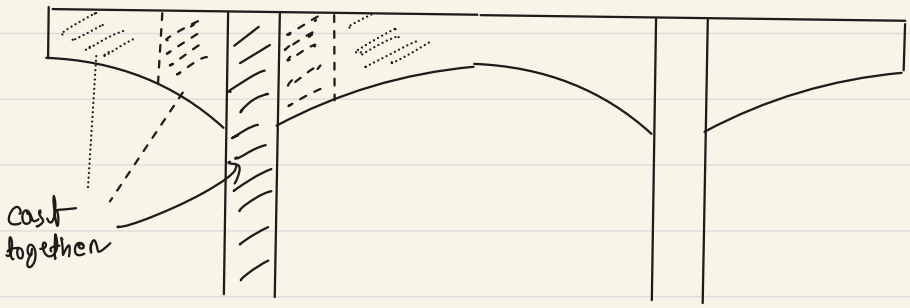
for aesthetic



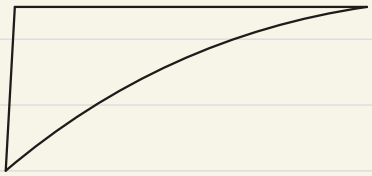
6. Balanced cantilever

for large span

balanced — constructed



Parabolic → cantilever BMD



On river bcz → more pillar

means more river obstruction

unexpected effect on bank

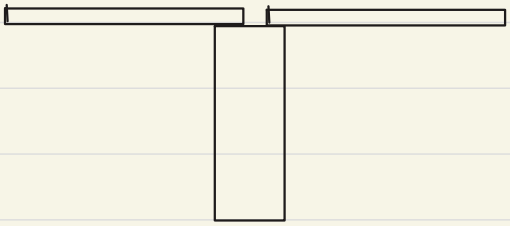
Bridge height → optimum

more for ship

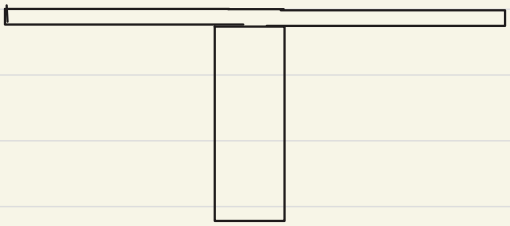
less to maintain grade

Simply supported spans (not casted together)

mmnt at support zero
determinant struct
supports differential settlement
large mmnt at middle → disadv.



Continuous span



Balanced cantilever form (adv of above both)

Internal hinge placed → bearing pad [see example images on slide]

↓

whenever moment is zero

✱✱✱ what is diaphragms? why used

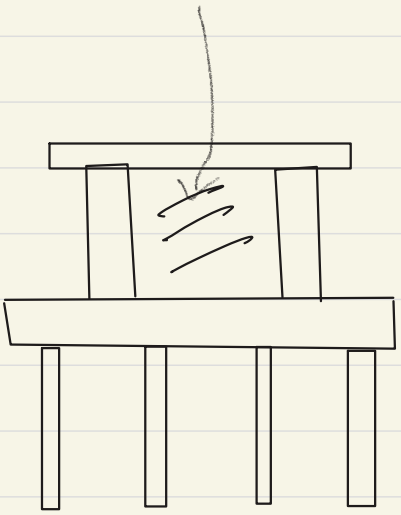
wind → differential ⋯ → torsion

diaphragms provide lateral mov., torsion resistance

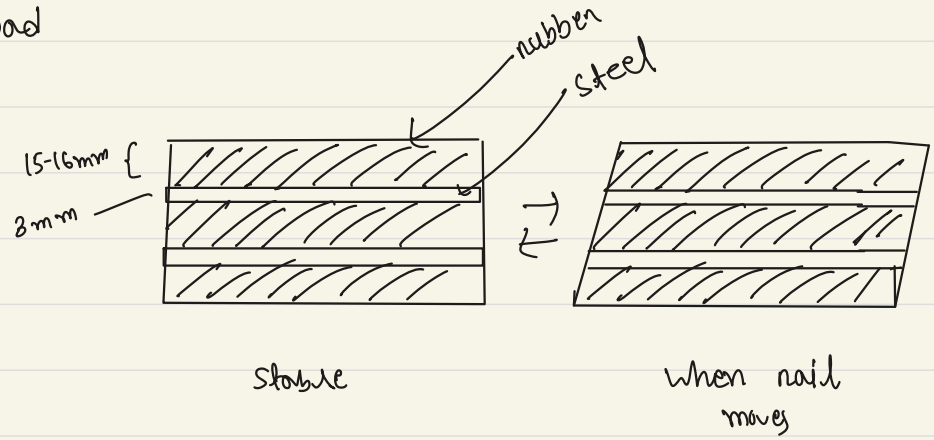
Abutment → acts like retaining struct

Wing wall → extended portion of abutment (may not always be necessary)

why not pier → soil pass, road gets down



Bearing pad



Permanent ld

creep → perma ld

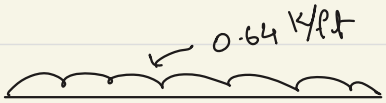
downgrade → during piling ↑soil create neg friction

Vehicular live ld

HL-93
- Truck
- Tandem
- Lane

memo truck config
HS 20

Consider point ld for truck & stuffs
UDL for private cars

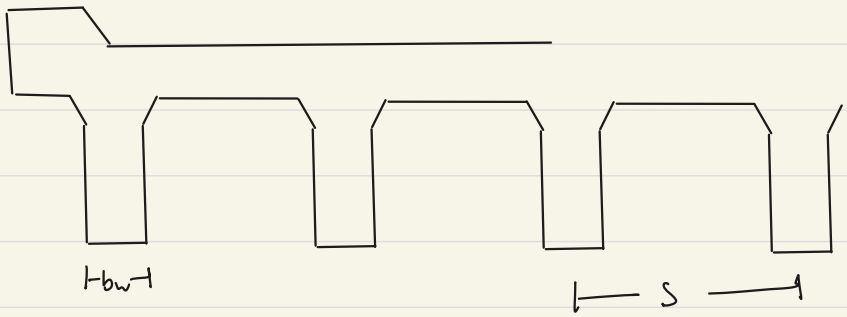


P = 1.2DL + 1.6LL → strength
P = DL + LD → service ld
} building

Strength → 1.25DL + 1.5WC + 1.75LL
Impact ld for truck & ...

mmnt from chart
impact ld included

$L_m = 1.4 L_E$
$L_c = 0.3 L_s$
$H \geq 0.07 L_s$
$L_m = L_s + 2L_c$
$L = 2L_E + L_m$



width = 2x lane + 2x side
S: ...

① Thickness ($\geq 7''$) ; t_s =

② Load

③ moment

④ Reinf. → +

→ −

→ $A_{s,min}$

→ Distribution reinf

Len

$L = L_m + 2L_E$

$\Rightarrow L_E = \cdots$ (round to nearest int; not just even)

$H_p = \cdots$

Load calc

Self wt → UDL

m_{DL} →

m_{WC} →

LL → from chart

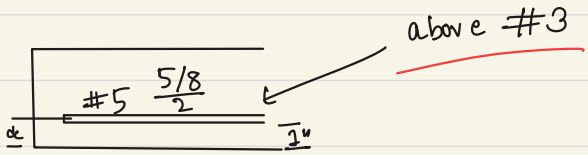
$M_{u,strength} = 1.25\,DC + 1.5\,WC + 1.75\,LL$

$\ominus = \cdots$

Crack check:

$\gamma_e =$ [class 1)

$d_c =$



$1 + 5/8/2$

$f_{ss} = \cdots$

$\cdots$

$B_s \rightarrow s$

Reinf. calc

$d \rightarrow$ substract 1.5

$b = 12"$

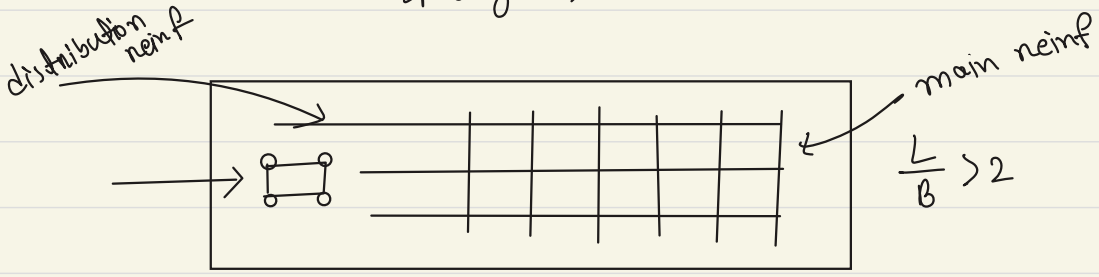
$s \rightarrow 6" \simeq 8"$

check w/ above s as well

Temp & shrinkage $A_s \geq \dfrac{1.30\,bh}{2(b+h)\,f_y}$ ← bridge width

$0.11 \leq A_s \leq 0.60$

Spacing $\rightarrow \cdots \rightarrow 6" \simeq 8"$



temp, shrinkage reinf not provided

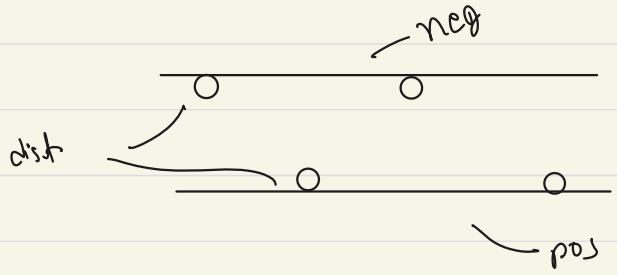
distribution reinf.

$\leq 220/\sqrt{s_c} \leq 67\%$ → of pos reinf

→ clear dist. btwn ginders s-bw

Detailing

[get printed dia then copy]



Use tracing paper

Exam ques → check crack
draw dia
etc

Rough / Midquiz 18/01

Slab

Procedure!

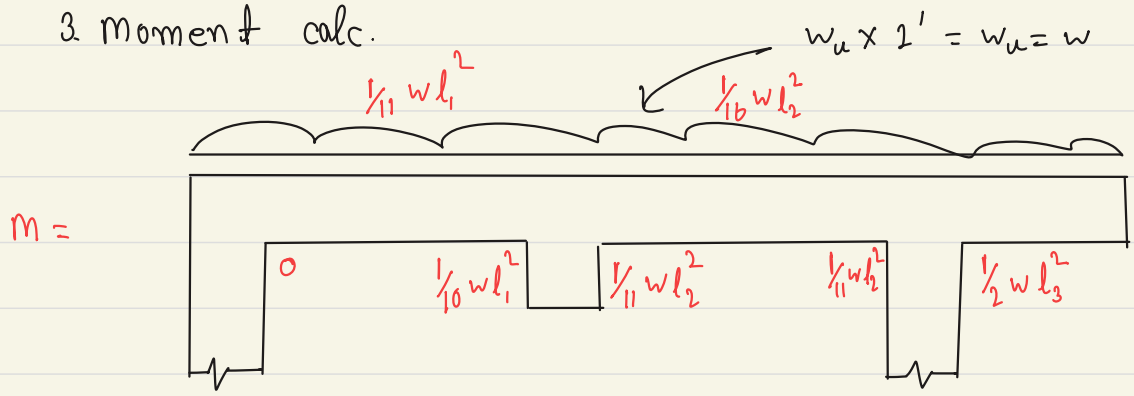
1. Check one-way → $\frac{L}{B} \geq 2$
2. Thickness determination
   → upper rounding; 0.25" for $t < 6"$, 0.5" else
   → min thickness = Clear span $\ell/20$ simply supported, $\ell/24$ one end cont, $\ell/28$ both end cont, $\ell/10$ cantilever } × M.F

$$M.F = 0.4 + \frac{f_y}{100}; \quad f_y \text{ in ksi}$$
$$0.4 + \frac{f_y}{700}; \quad f_y \text{ in mpa}$$

   → Preliminary thickness : max(d_{min})
3. Factored ld
   → DL : self wt + partition wall wt (psf) + Floor finish
   P.W wt : wall vol × unit wt of brick ← 120 lb/ft³
   ↙ consider for windows by multiplying 0.8.
   $\frac{\text{P.W wt}}{\text{Slab area}}$ → psf

   → L.L
   → $w_u = 1.2\,DL + 1.6\,LL$

3. Moment calc.



Def^n max pos & neg moments

Use l_x as l_n (clear span)

4. Thickness check

→ $\rho_{0.005} = 0.85 \beta_1 \frac{f_c'}{f_y} \frac{\varepsilon_u}{\varepsilon_u + \varepsilon_t}$ ← 0.003, ← 0.005

→ find d_{req} from $\phi M_{u,max} = \phi \rho b d^2 f_y (1 - 0.59 \frac{\rho f_y}{f_c'})$

5. Reinf. area calc

→ temperature & shrinkage reinf. (min reinf) : $0.0018 bt$ → $f_y = 60$ ksi

: $0.0020 bt$ → $f_y = 40, 50$ ksi

: $\frac{0.0018 \times 60}{f_y}$ → $f_y > 60$ ksi

longer dir ←

→ main reinf. by trial & error

shorter dir ←

$A_s = \frac{M_u}{\phi f_y (d - a/2)}$; $a = \frac{A_s f_y}{0.85 f_c' b}$

Find A_s for max pos & max neg moments

($b = 12''$ or $1'$ → in^2/ft)

6. Reinf spacing

bars 6" into wall ←

→ main bars $s_{max} = \min(18'', 3t)$

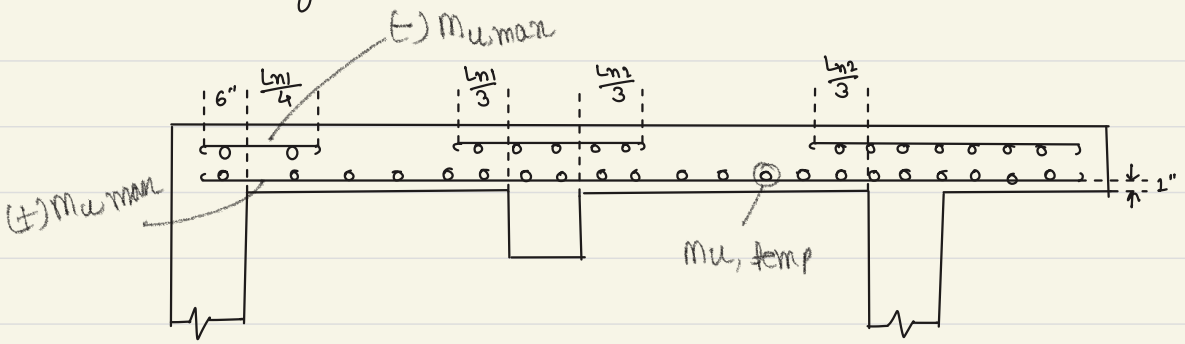
→ temp, shr bars, $s_{max} = \min(18'', 5t)$ | $s_{min} = 1.5t$

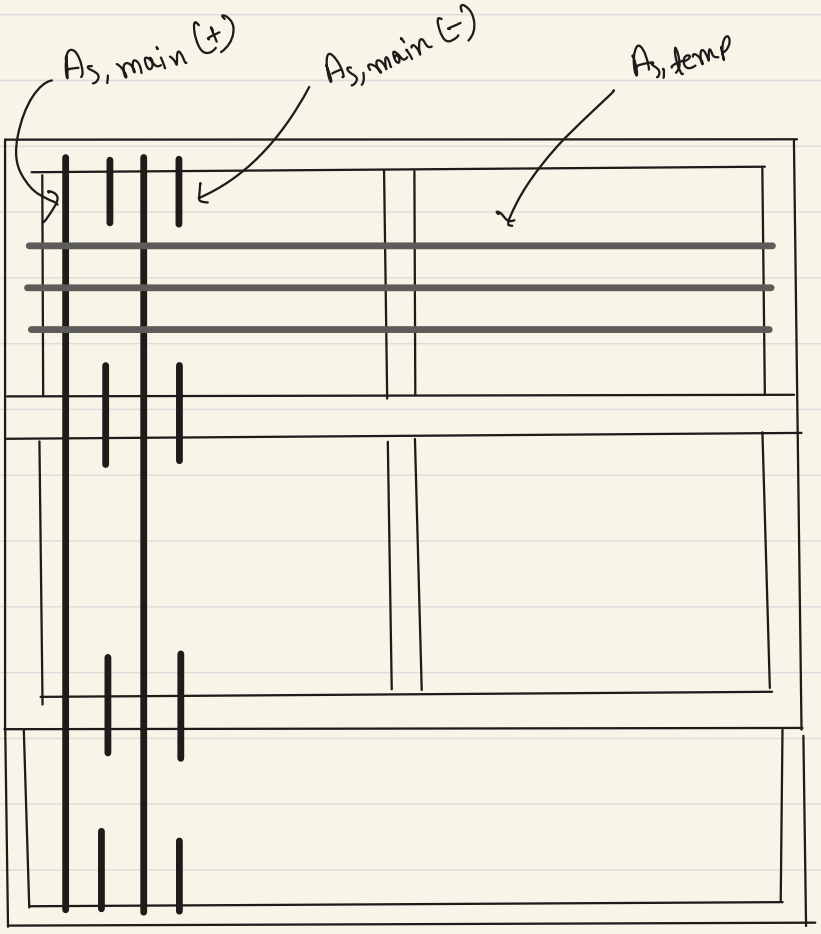
→ shorter dir, find s individually for max pos, neg moments

longer dir, find s for temp shrnk reinf

s = x req in 12"; 1" req in $\frac{12}{1}$"; (bar area) req in $\frac{12 \times \text{bar area}}{x}$

2. Detailing

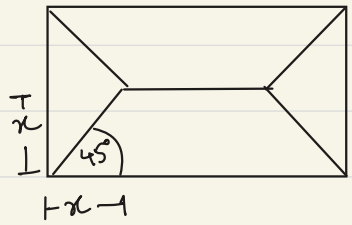

(-) Mu,max
6"
Ln1/4
Ln1/3
Ln1/3
Ln2/3
(+) Mu,max
Mu, temp
h - 1"


As, main (+)
As, main (-)
As, temp

Beam

Procedure:

1. Tributary area (TA)
   → 45°



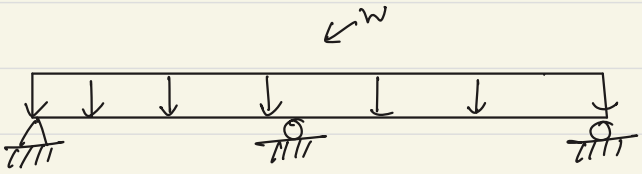
2. Factored ld
   → $1.2[DL_{slab} + DL_{beam}] + 1.6\,LL_{slab}$
   → $DL_{slab} = \frac{DL \text{ on slab (psf)} \times TA}{\text{len of beam}}$ (lb/ft)
   → $LL_{slab} = \frac{LL \text{ on slab (psf)} \times TA}{\text{len of beam}}$ (lb/ft)

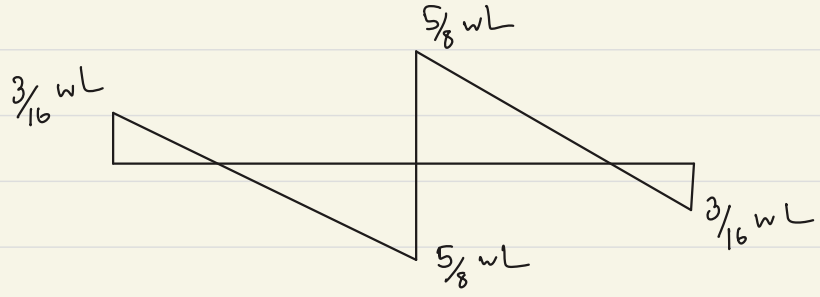
   → Thickness = $\frac{l_n}{16} \times m.f = h$

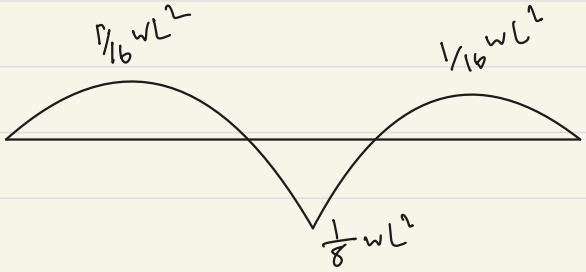
   width = 10" = b

   → $DL_{beam} = 150\,bh$

3. Shear and moment calculation







4. Thickness check

→ $m_{u,max}$ → d ?? d_{prov} (= h - 2.5")

5. Rect or T-beam

→ $b_{eff} = b_w + 2\min(8h, \frac{l_n}{8}, \frac{s_w}{2})$

→ rect beam if $a \leq t$; then $b = b_{eff}$

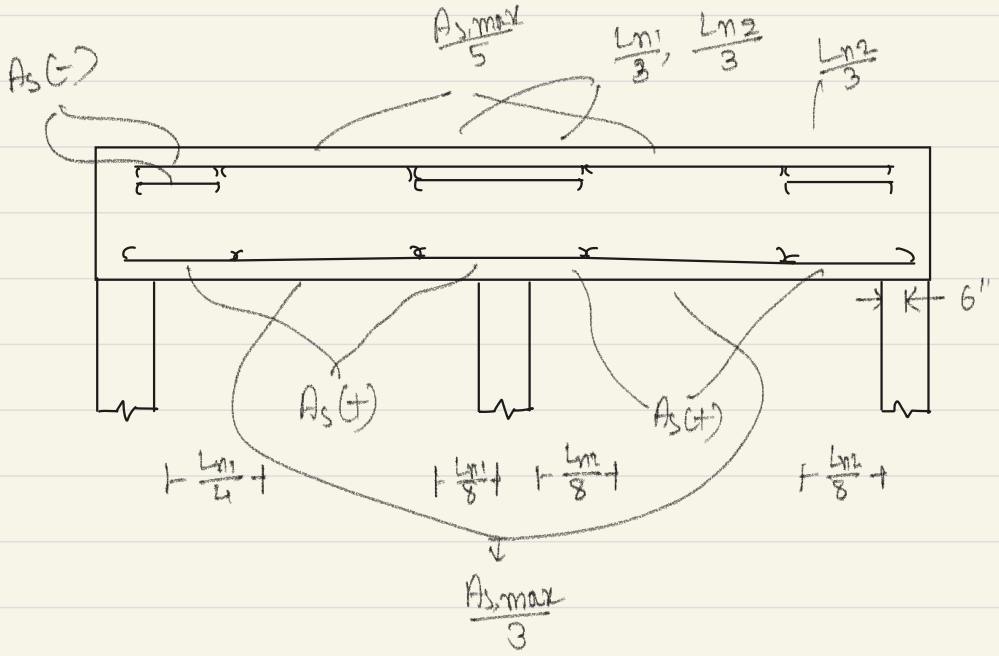
find a by trial & err ; let $a = t$ initially

6. Reinf calculation

→ $A_{s,min} = \frac{3\sqrt{f_c'}}{f_y} b_w d \geq \frac{200}{f_y}$

→ for pos moment $(\frac{1}{16} wL^2)$

→ for neg moment $(\frac{1}{8} wL^2)$



7. Shear reinf. calc

→ $V_c = 2\lambda\sqrt{f'_c}\, bd$; ϕV_c ; $\frac{1}{2}\phi V_c$

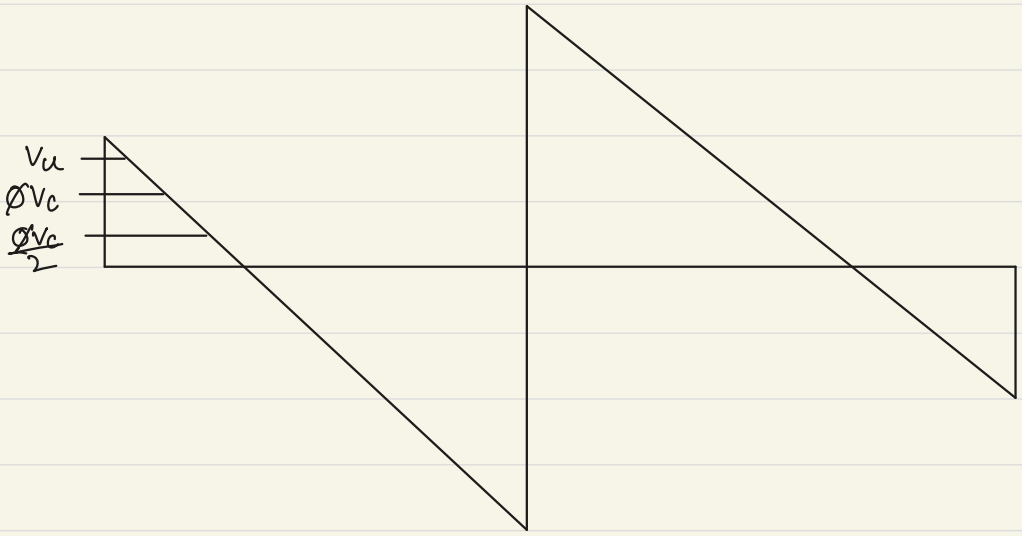
V_u → $V_u = \phi V_c + \frac{A_v f_{yt} d}{s}$ → s

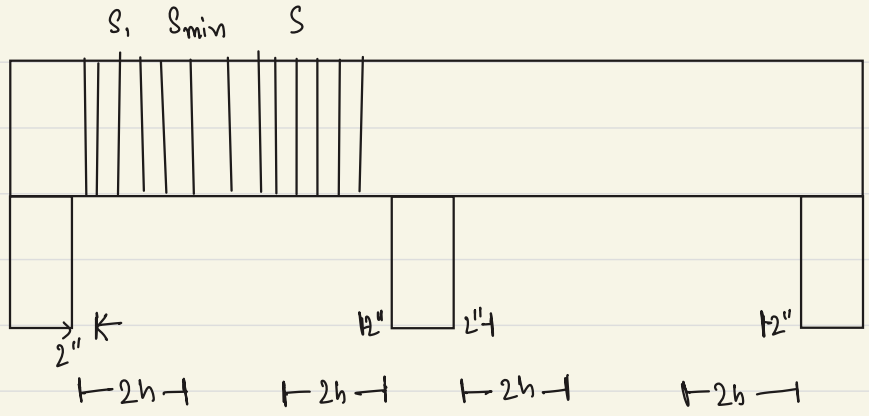
ϕV_c → $s = \frac{d}{2} = s_1$

$\frac{1}{2}\phi V_c$ → $s = s_{min} = \min$ of:

- $\frac{d}{4}$
- 8 × smallest main bar dia
- 24 × stirrup dia
- 300 mm

0

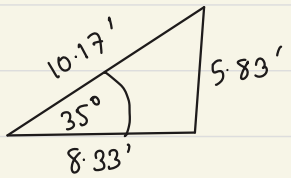




6 sections . . .

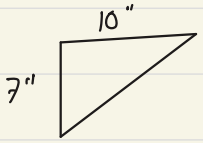
Stair Design — Practice

Triangle area $= \frac{1}{2}\frac{7 \times 10}{144} \times 10 = 2.43\ ft^2$



$\therefore$ thickness $= \frac{2.43}{10.17} = 2.87"$

$\therefore$ $t_{avg} = 6 + 2.87 = 8.87"$



$\therefore$ self wt $= 150 \times \frac{8.87}{12} = 111$ psf

LL $= 100$ psf

$\therefore w_{inc} = 1.2D + 1.6LL = 1.2(111+25) + 1.6 \times 100 = 323$ ksf

$\therefore w = w/\cos\theta = 394$ psf $= 0.394$ ksf

Moment $= \frac{wL^2}{8} = \frac{0.394 \times 8.33^2}{8} = 3.42$ K-ft

d-check: $3.42 \times 12 = 0.9 \times \rho \times b d^2 f_y \left(1 - 0.59\frac{\rho f_y}{f_c'}\right)$ (b = 12")

$\Rightarrow d = 1.88" < (d_{prov} = 8.87 - 1)$

$\rho = 0.0255$

Reinf calc: $A_{s,min} = 0.0018bt = 0.19\ in^2/ft$

$A_s = 0.12 \not\geq 0.19 = 0.19\ in^2/ft$ [#4]

$A_{s,temp} = 0.19\ in^2/ft$ [#4]

Spacing: main bar $\rightarrow$ max $= \min(3t, 18")$; min $= 1.5t$

temp bar $\rightarrow$ max $= \min(5t, 18")$; "

$s = \frac{bar \times 12}{actual}$

Stain beam:

Preli size = 10" x 12"

self wt → lb/ft

Ld from stain = $\frac{W_u \times A}{L}$ ← Stain + landing area

Total factored ld = 1.2 self wt + from stain

M_u = (+) → $\frac{1}{14} wL^2$

(−) → $\frac{1}{16} wL^2$

d-check

Reinf

Sunshade:

→ self wt

→ Factored ld [LL = 10 psf]

→ $m = \frac{wL^2}{2}$

→ d-check

→ Reinf.

→ Spacing

Lintel:

→ ld from brickwall → 60° TA per ft of lintel

→ ld from slab → $(w_u \times TA)/L$

→ ld from lintel → self wt

→ ld from sunshade → LL, DL

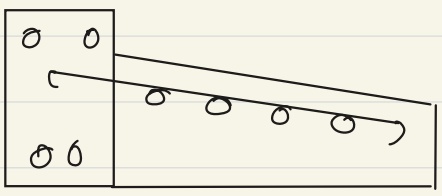
→ w_u = sum (unfactored) X2 + factored

→ $m_{max} = \frac{wL^2}{8}$

→ d-check

→ Reinf. $A_{s,min}$ $\left(\frac{3\sqrt{f_c'}}{f_y} bd, \frac{200}{f_y} bd\right)$

A_s →

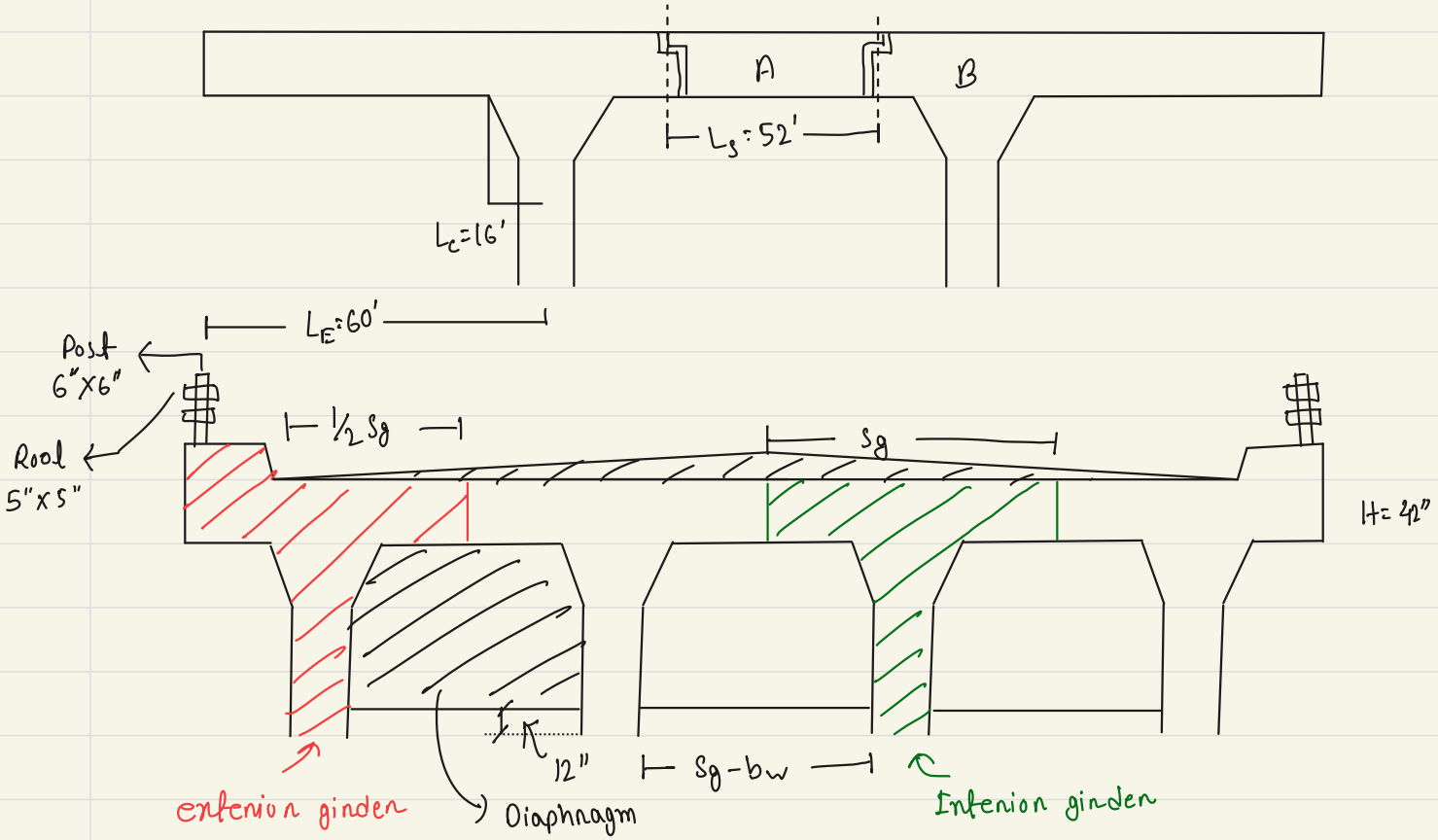


Dead load analysis

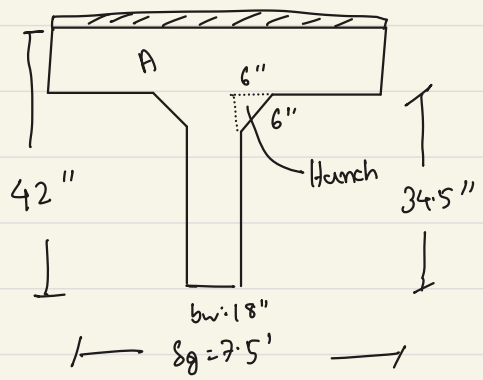
① Load — Dead load

⑪ Moment, shear

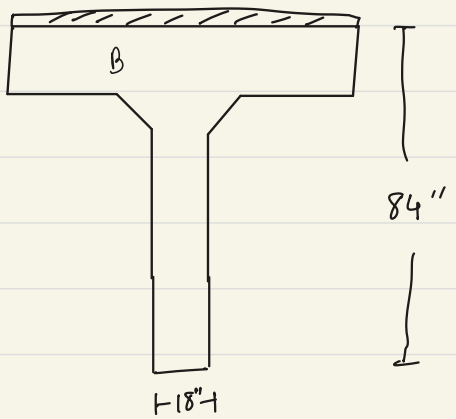
Long section



Interior girder at interior section



Int girder at ext. section



Diaphrams: ← support ← intermediate

Width = 18"; 10"

Depth = 12" →

Spacing = 14'–30'

w_{wc}, w_{sf} calc differently bcz factor diff

Dead ld analysis

→ UDL from wearing course = 30 psf × 7.5 ← Sg

= 0.225 K/ft

→ UDL from deck = $0.150 \times \frac{7.5"}{12} \times 7.5'$ ← ts

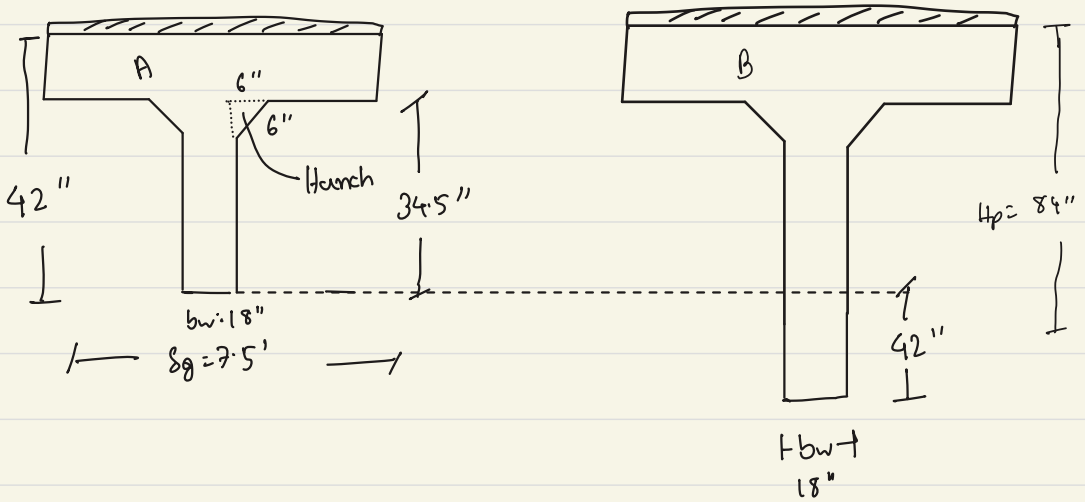
= 0.7 K/ft

→ UDL from const ginden depth = $0.150 \frac{34.5"}{12} \times \frac{18"}{12}$

= 0.64 K/ft

→ UDL from hunch = $\left(0.150 \times \frac{1}{2} \times \frac{6 \times 6}{144} \times\right) 2$

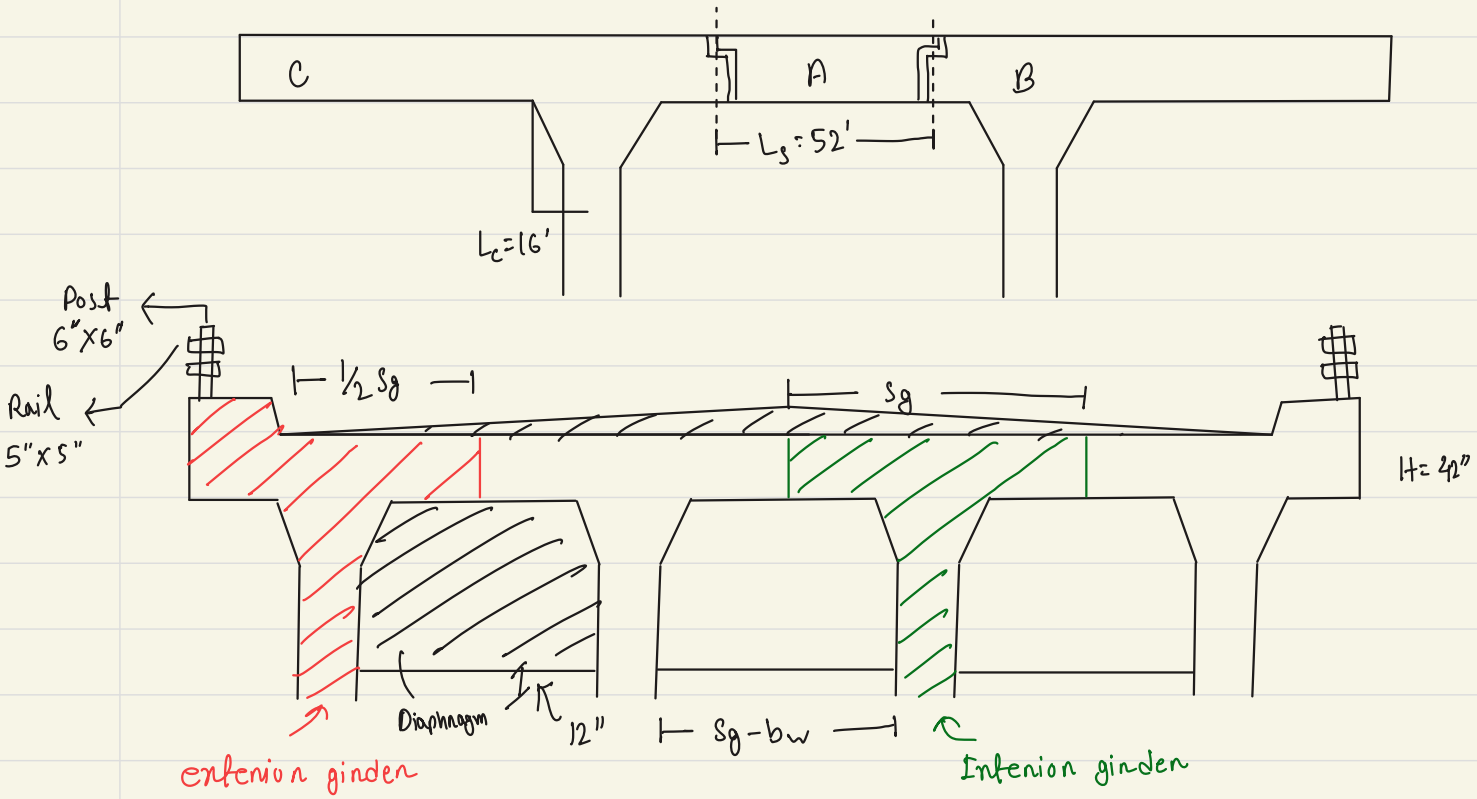
= 0.037 K/ft



→ UDL from extra ginden = $0.150 \times \frac{42"}{12} \times \frac{18"}{12}$

depth at pier location = 0.7 K/ft

Concentrated ld from Diaphragms:

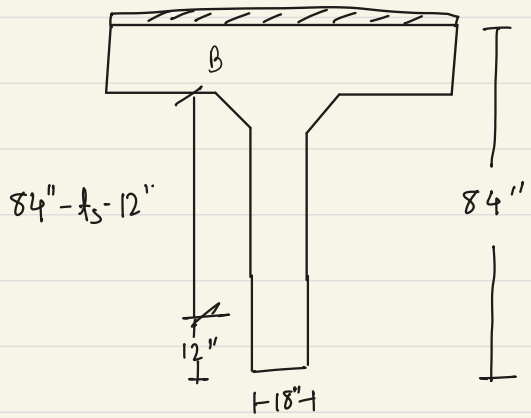


→ At pier location

L x W x Depth x 150

$= (7.5 - \frac{18}{12}) \times \frac{18}{12} \times \frac{64.5}{12} \times 0.150$

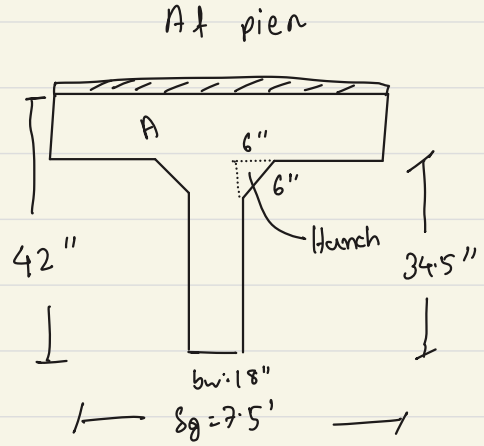
$= 7.3$ k



→ At intermediate

$(7.5 - \frac{18}{12}) \frac{10"}{12} \times \frac{34.5 - 12}{12} \times 0.150$

$= 2.2$ k



→ At abutment location $\left(7.5-\frac{18}{12}\right)\frac{18}{12}\times\left(\frac{42-12-7.5}{12}\right)\times 0.0150$

$= 2.5\ K$

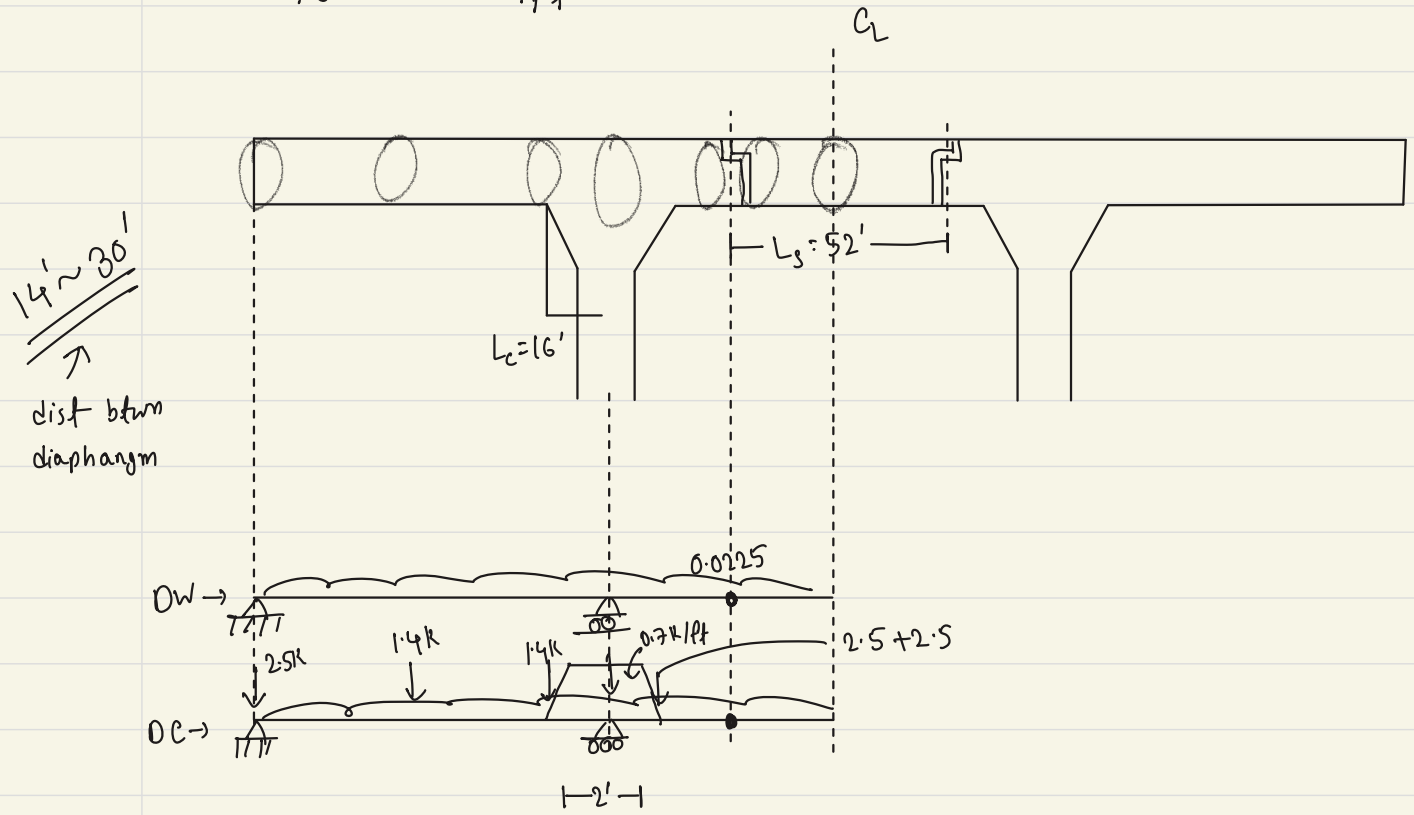
concrete → weaning

DW = 0.225

DC = Deck + Haunch + constant

$= 0.7 + 0.04 + 0.64$

$= 1.38 \simeq 1.4\ K/ft$



Design 4 ginder fiwm A, B, C, D section [see slide #18]

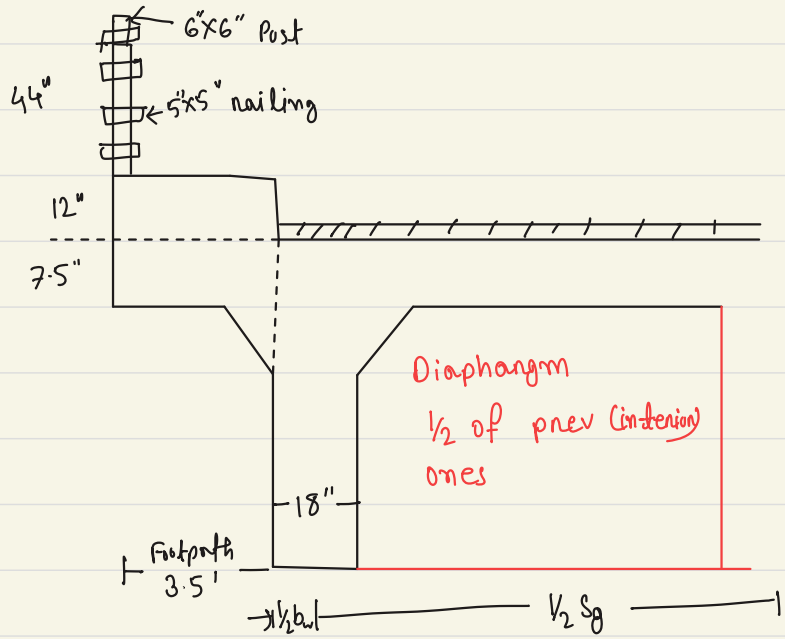
Ⓐ → $\frac{\frac{L_s=52'}{2}}{3} = 8.67'$

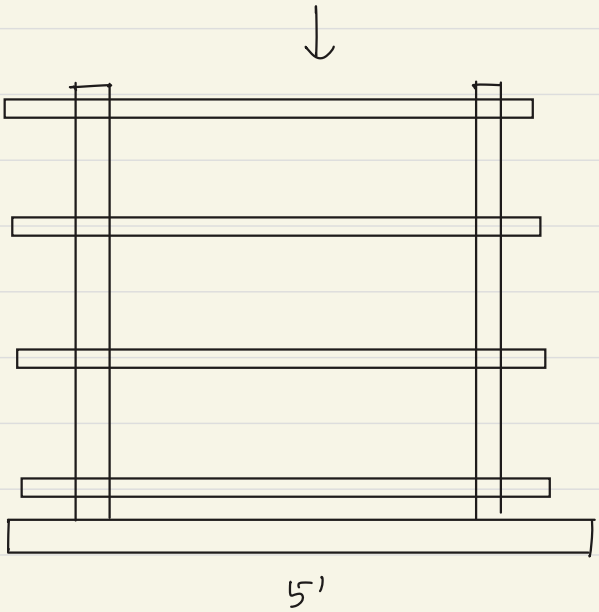
Ⓑ → $\frac{L_c=16'}{3} = 5.33'$

Ⓒ → $5.33'$

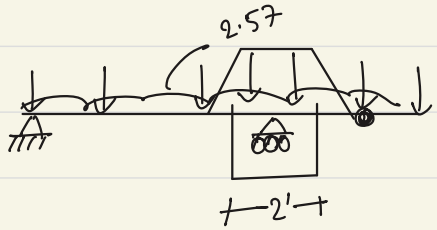
Ⓓ → $\frac{60-16}{4} = 11'$

Dead ld analysis for exterion ginder

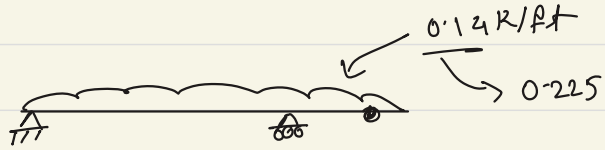




DC

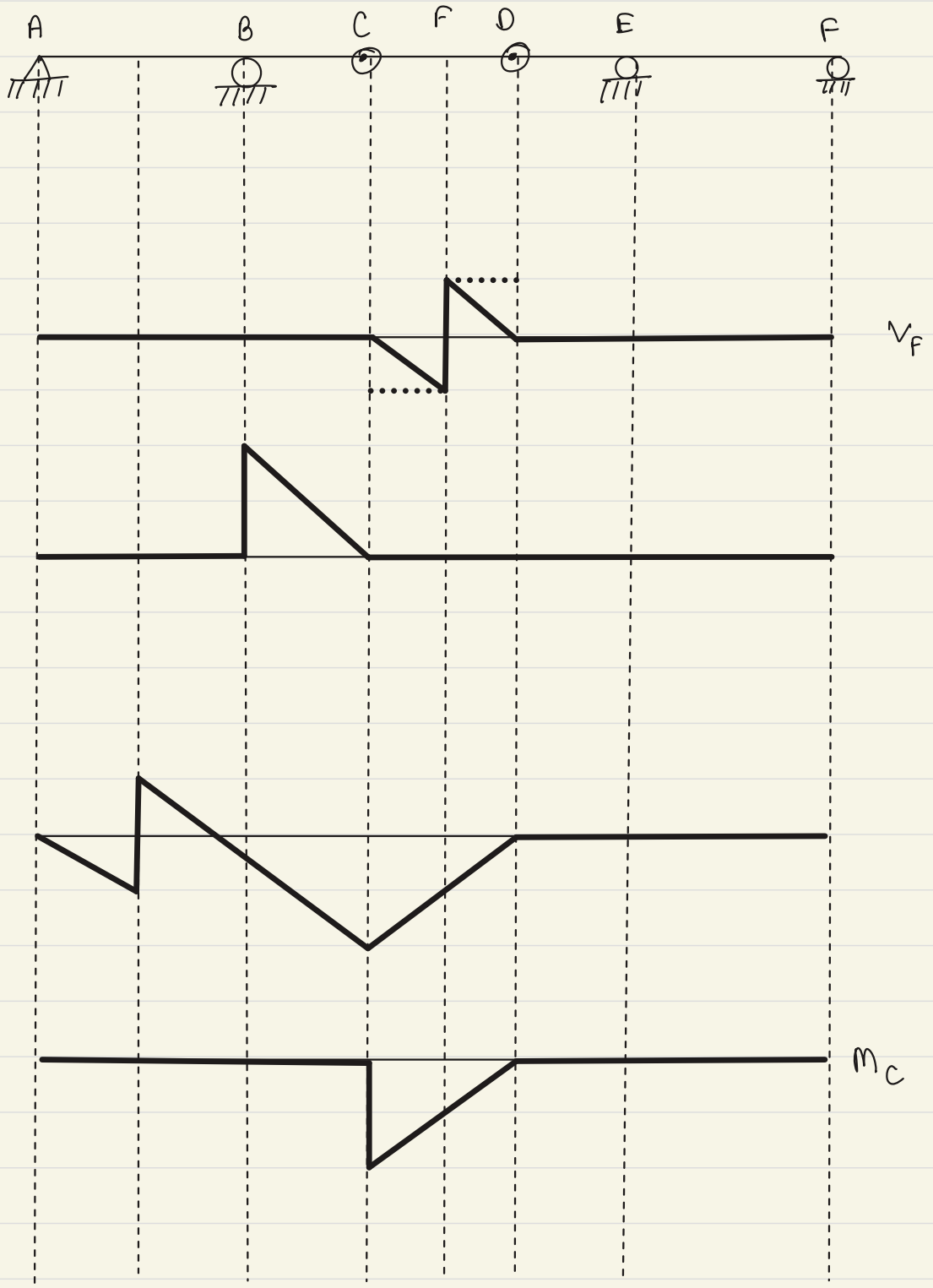


DW



Live Load Analysis:

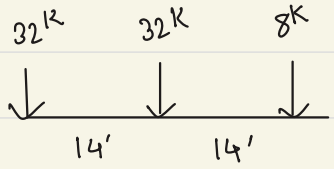
ILD: Draw for the 4 section chose on earlier report

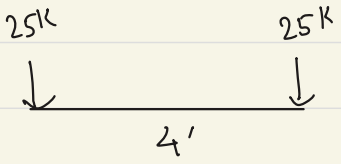


HL 93 → Truck

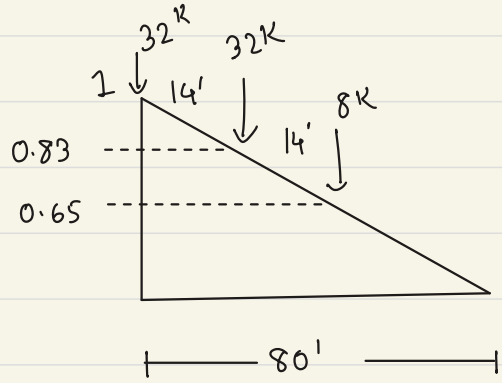
Tandem

Lane



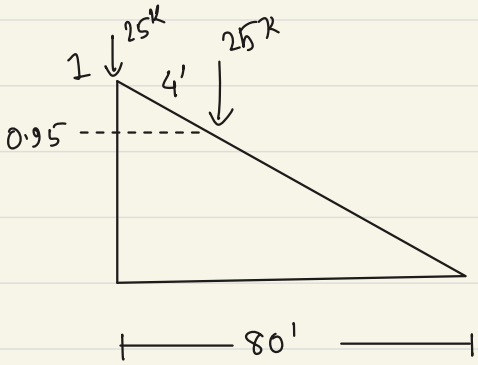


4-4 section



$M_{max\ shear} = 32 \times 1 + 0.83 \times 32 + 0.65 \times 8$

$= 63.76^{K}$

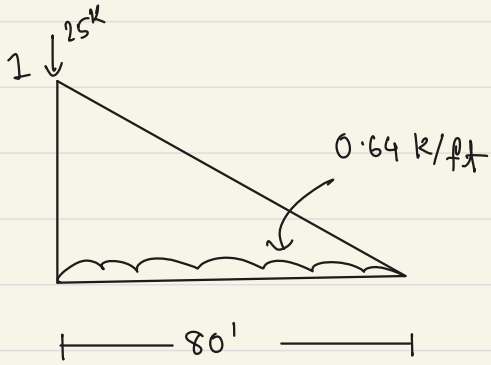


$M_{max\ +ve} = 25 \times 1 + 25 \times 0.95$

Shear for tandem $= 48^{K}$

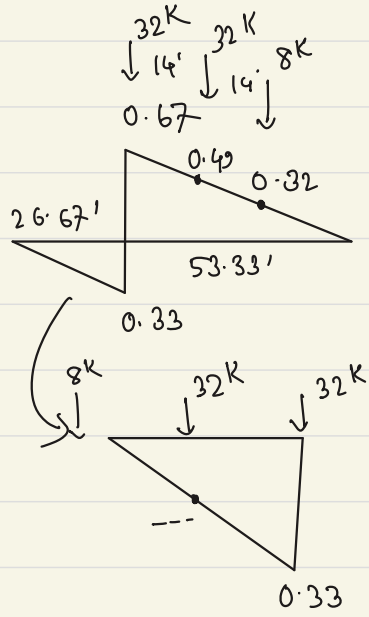
$M_{max\ +ve}$ for lane load $= \frac{1}{2}(80 \times 1) \times 0.64$

$= 25.6^{K}$

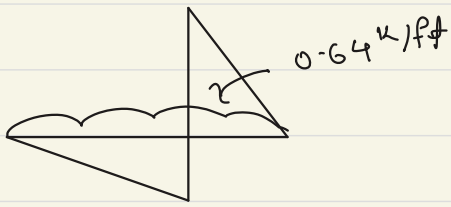


Section 2-2:

Tandem ld:



Lane ld:

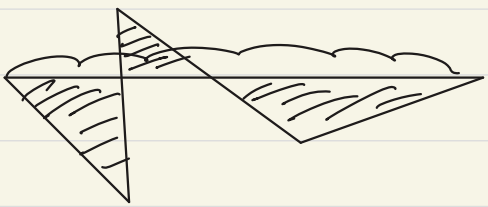


— — —

Place ld in config that would produce most shear

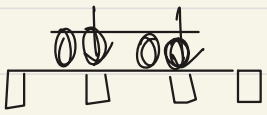
Section 10:10:

Lane ld



Calc 3 triangles

Distribution factor



for shear

$$V_{design} = 1.25\,DC + 1.50\,DW + 1.75\,V_{LL}$$

$$V_{LL} = \max(V_{truck}, V_{tandem}) \times IM \times DF + V_{lane}$$

$IM \rightarrow$ all others ... $\rightarrow 0.33 \rightarrow (1 + 0.33)$

for moment

$\frac{F_{S(0)}}{F_{S(S)}}$

$K_g \rightarrow$ Stiffness factor

$$= n[I_g + A_g e_g]$$

For specified criteria $\left(\frac{K_g}{12.0\,L\,t_s^3}\right)^{0.1} = 1.05$

when any matches

would match; on exam as well

$L \rightarrow$ for pos moment $\rightarrow$ length of area where (+)

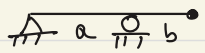
for neg moment $\rightarrow$ point of contraflexure to

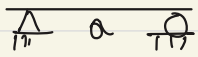
" of " $\rightarrow$

adjacent span's avg

- - -

Section	Span (L) in x_m
1, 2, 3	L_s
4	0
5, 6	$\frac{a+b}{2}$
7	0
8, 9, 10	$\frac{a+b}{2}$
11, 12, 13	a
14	0





$$m_{LL} = \max(m_{truck}, m_{tandum}) \times IM \times x_m + m_{Lane}$$

$$m_{Design} = 1.25\, m_{DC} + 1.5\, m_{wc} + 1.75\, m_{LL}$$

Load combination table (do on Excel)

Shear & moment

Exterion ginder $\propto$ diff

$\propto$ for interion

$$x_{e,m} = e\, x_{i,m}$$

$$e = 0.77 + \frac{de}{9.1}$$

← footpath corner to exterion ginders center $bw/2$ in ft

$$x_{e,v} = e\, x_{i,v}$$

$$e = 0.6 + \frac{de}{10}$$

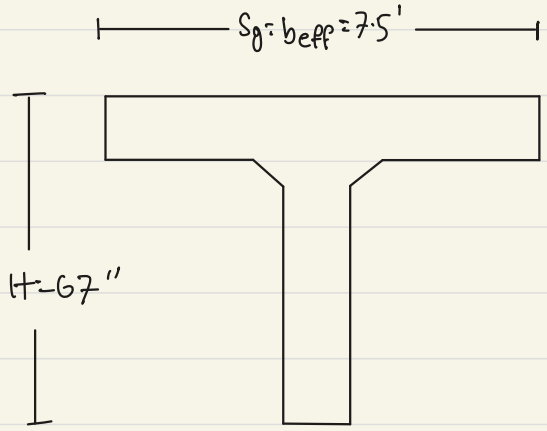
For final → cantilever – check – deck

nailing ld

diaphn. - -

~54:00

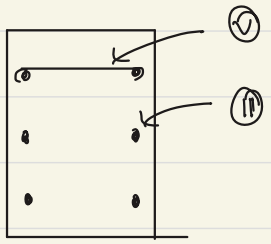
Design of Interior Girder

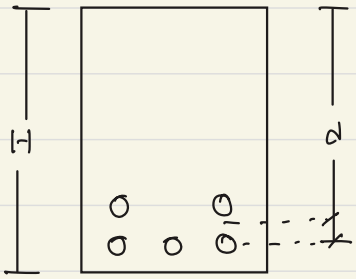


when beam depth ≥ 3'

if used above #10
shear → #4

① Main reinf. (#9 & above)
② Shear reinf. (#3 or #4)
③ Skin reinf. (#6 & above)
④ Haunch reinf. (#3 / #4)
⑤ Link reinf. (#3 / #4)





1 layer → d = H - 2.5"
2 " → d = H - 4"
3 " → d = H - 5"

For bridge → Moment $\phi = 0.90$
Shear $\phi = 0.90$

Main reinf: T-beam

M_u (+ve):

$H = 67''$ $\quad A_s = \dfrac{M_u}{\phi f_y (d - a/2)}$

Initially assume 3 layer → $d = H - 5'' \rightarrow 62''$

$a = t_s = 7.5''$

$a_{trial} = \dfrac{A_s f_y}{0.85 f_c' b}$ ← b_{eff}

$a_{trial} < t_s \rightarrow$ rectangular [our example contains rect.]

$A_{s,init} \rightarrow$

$a_{revised} \rightarrow$ [check $a < t_s \rightarrow$ rect]

Trial & error to figure out A_s

$A_{s,min} = \dfrac{200}{f_y} b_w d$

Check tension controlled

$c = \dfrac{a}{\beta_1} < \dfrac{3}{8} d \rightarrow$ tension-controlled

if not tension controlled → inc. d [will be tension controlled]

Even if three layers not req, may continue with providing three layers.

$M_u(-ve) = -3388.6$ k-ft

$d = H - 4" = 63"$

- - -

$$a_{trial} = \frac{A_s f_y}{0.85 f_c' b}$$ ← b_w

Shear reinf.

$V_u > \frac{1}{2}\phi V_c \longrightarrow$ stirrup

If $V_u > 0.25 \phi f_c' b_w d \longrightarrow$ dim revise [would be OK] ← least

$\phi V_c = 0.0316 \beta \sqrt{f_c'}\, b_w d$ [memo]

↖ least 'd' (62")

if $V < \frac{1}{2}\phi V_c \longrightarrow$ $s = s_{max}$ (file 3, P. #19)

0.8d	0.4d
24"	12"

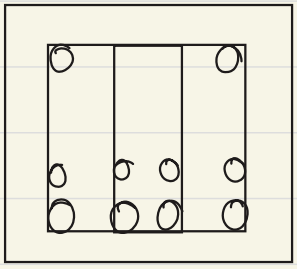
Minimum transverse reinf.

$$A_v \geq 0.0316 \sqrt{f_c'}\, \frac{b_w s}{f_y} \longrightarrow \boxed{s_{max} = \frac{A_v f_y}{0.0316 \sqrt{f_c'}\, b_w}}$$

$$s_{req} = \frac{\phi A_v f_y d}{V_u - \phi V_c}$$

↓

if pos, then check w/ s_{max}



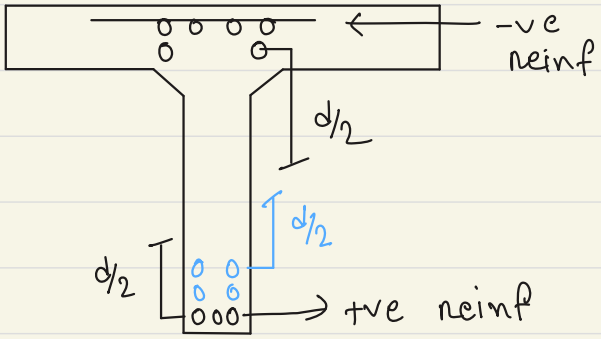
$A_v = 4 \times 0.22$ considering

Haunch reinf.

#3 @ 6" c/c or,
#4 @ 9" c/c } either works

Skin reinf.

if no pos/neg moment
then no corresponding skin.



$$A_{sk} \geq 0.012(d_t - 30) \leq \frac{A_s}{4}$$

$$\Rightarrow A_{sk} \geq 0.384 \leq 2.5$$

$$\Rightarrow 0.384 \leq A_{sk} \leq 2.5$$

pos As for pos reinf
Skin reinf

$$s_{max} = \begin{cases} d_t/6 \\ 12" \end{cases} \longrightarrow \text{consider a 's'}$$

$$A_{s,prov} = \frac{12\,A_b}{s_{prov}}$$

For exam
simple
pos may be given
find neg

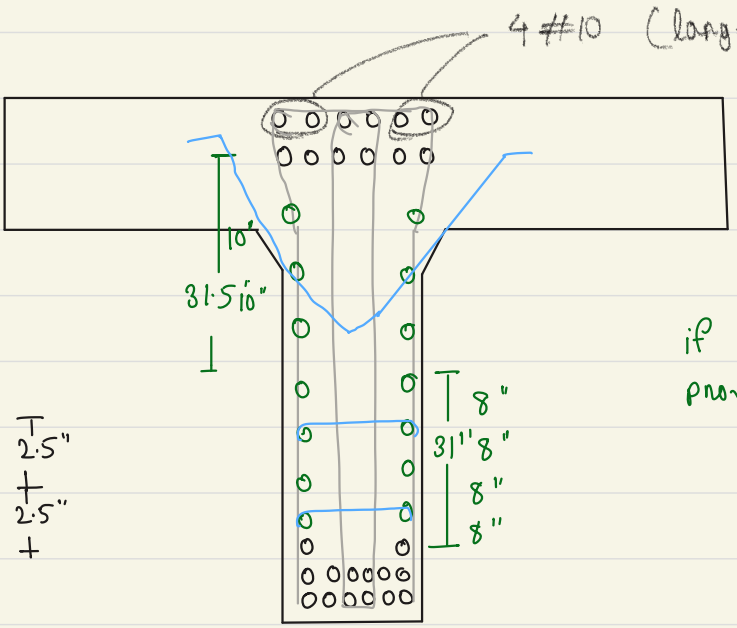
① Main reinf. → +ve 14 #8
→ -ve 8 #9 & 4 #10

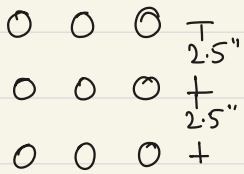
② Shear reinf. → #3 — 4 legged stirrup @ 20.5" c/c

③ Skin reinf. → +ve #7 @ 8" c/c (31")
→ -ve #7 @ 10" c/c (31.5")

④ Haunch reinf. → #3 @ 6" c/c

⑤ Link reinf.





if overlaps provide only the higher spacing config for the part
[fillup edge bars first]

Link reinf.
Skin reinf can't exceed 24" gap

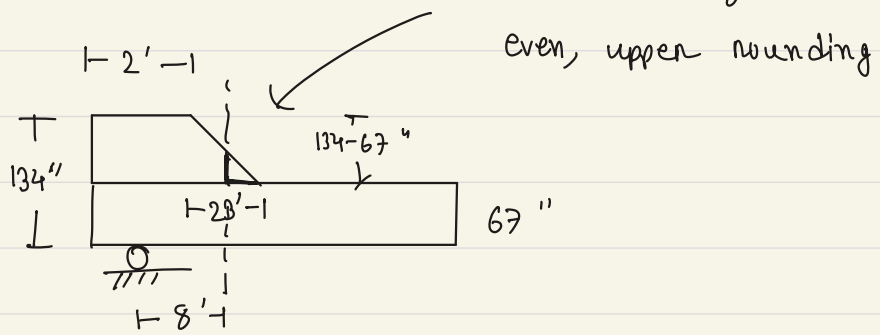
Sections 3

config. $M_{u+} = 0$, $M_{u-} = \square$ → min reinf

$M_{u+} = \square$, $M_{u-} = 0$ → prov

$M_{u+} = \square$, $M_{u-} = \square$

Variable len section



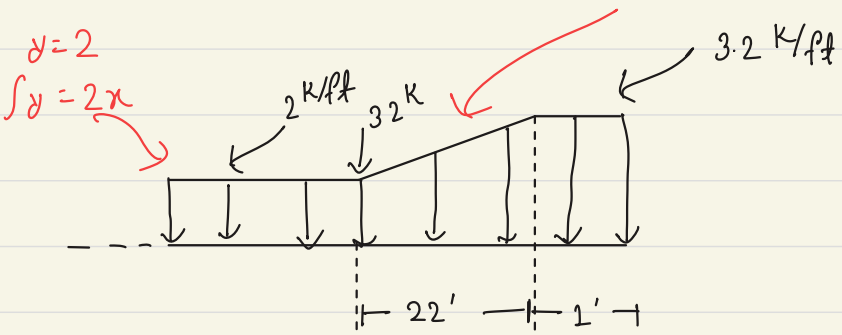
Rough / Dead Ld Analysis – BCB

21/02

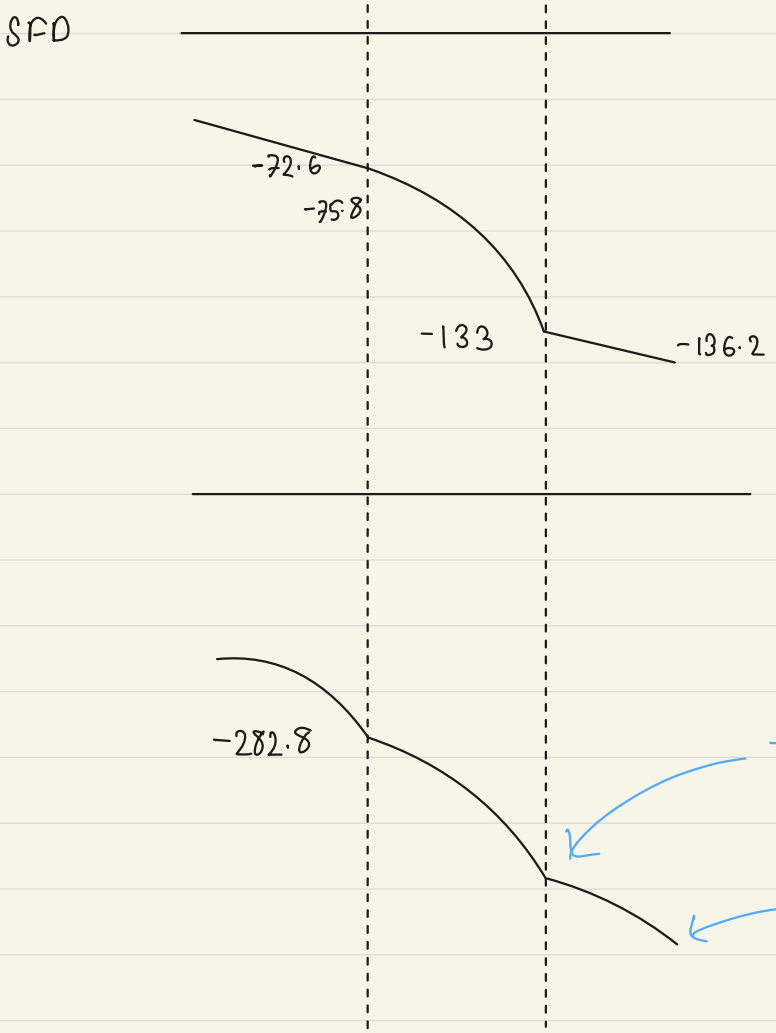
$y = (2 + \frac{1.2}{22}x) \Rightarrow \int y = (2x + \frac{1.2x^2}{22 \times 2})$

$y = 2$

$\int y = 2x$



SFD



$-282.8 - 75.8 \times 22 - \int_0^{22} (2x + \frac{1.2}{22 \times 2}x^2)\,dx$

$= -2531.2$ K-ft

$-2531.2 - 133 \times 1 - \int_0^{1} 3.2x\,dx$

$= 2665.8$ K-ft

Rough / Dead Ld Analysis – BCB

23/02

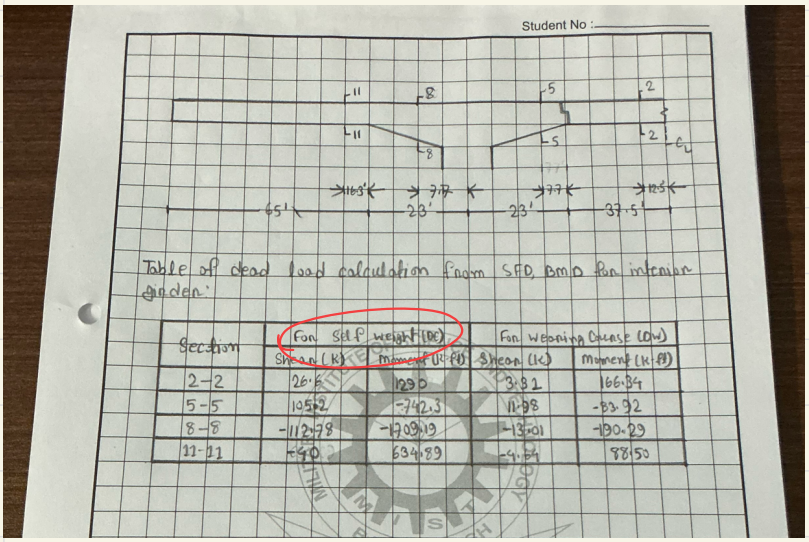
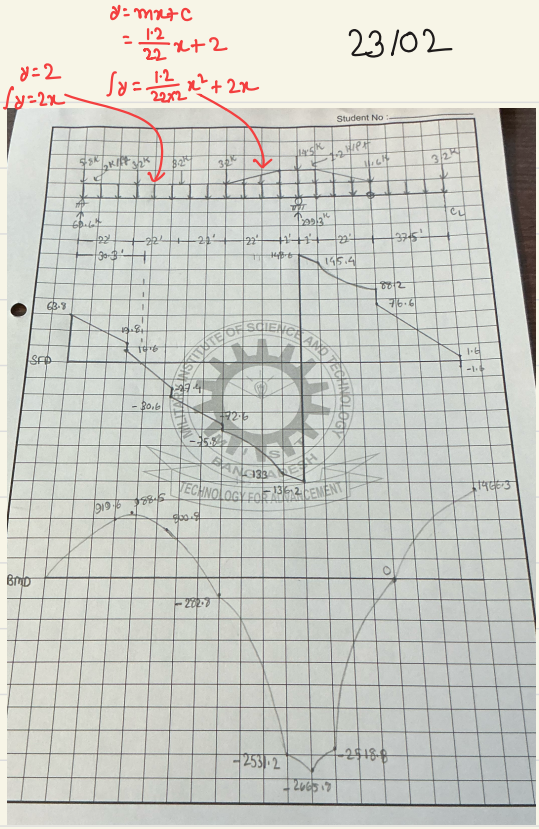


Table of dead load calculation from SFD, BMD for interior garden.

Section	For Self weight (DL)		For Wearing Course (DW)	
	Shear (K)	Moment (K-ft)	Shear (K)	Moment (K-ft)
2–2	26.6	1290	3.82	166.34
5–5	105.2	-742.3	11.38	-83.32
8–8	-112.78	-1709.19	-13.01	-130.29
11–11	-40	634.89	-4.64	88.50



2–2: 37.5 – 12.5 = 25

Shear: $76.6 - 2 \times 25 = 26.6^{K}$

Moment: $0 + 76.6 \times 25 - \int_0^{25} 2x\,dx = 1290$ K-ft

5–5: 23 – 7.7 = 15.3 or 22 – 7.7 = 14.3

Shear: $145.4 - \frac{1}{2}\left(3.2 + \left(2 + \frac{1.2}{22} \times 7.7\right)\right) \times 14.3 = 105.2^{K}$

or, $145.4 - \int_0^{14.3} 3.2 - \frac{1.2}{22} x\,dx = 105.2^{K}$

Moment: $-2518.8 + 145.4 \times 14.3 - \int_0^{14.3} 3.2x - \frac{1.2}{22x2} x^2\,dx = -740.18$ K-ft

8–8: 22 – (7.7 – 1) = 15.3

Shear: $-75.8 - \int_0^{15.3} 2 + \frac{1.2}{22} x\,dx = -112.78^{K}$

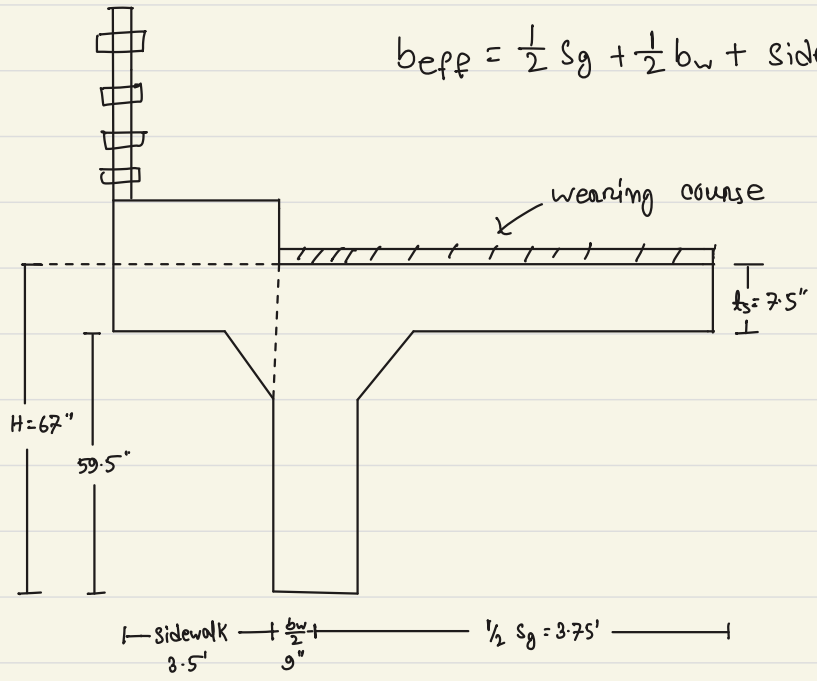
Moment: $-282.8 - 75.8 \times 15.3 - \int_0^{15.3} 2x + \frac{1.2}{22x2} x^2\,dx = -1709.19$ K-ft

11–11: 21 – 16.3 = 4.7

Shear: $-30.6 - 2 \times 4.7 = -40^{K}$

Moment: $800.8 - 30.6 \times 4.7 - \int_0^{4.7} 2x\,dx = 634.89$ K-ft

Design of Exterion Girder



if used above #10

Shear → #4

① Main reinf. (#9 & above)

② Shear reinf. (#3 or #4)

③ Skin reinf. (#6 & above)

④ Haunch reinf. (#3 / #4)

⑤ Link reinf. (#3 / #4)

Effective depth, d

$d = H - 2.5"$ [1 layer]

$d = H - 4"$ [2 layers]

$d = H - 5"$ [3 layers]

Resistance factor, ϕ

$\phi = 0.9$ [moment]

$= 0.9$ [shear]

$\begin{cases} M_{u(+ve)} = 2000 \\ M_{u(-ve)} = 0 \end{cases}$

$\begin{cases} M_{u(+ve)} = 0 \\ M_{u(-ve)} = 2000 \end{cases}$

$\begin{cases} M_{u(+ve)} = 2000 \\ M_{u(-ve)} = 2000 \end{cases}$

Show 3 type configs for interion

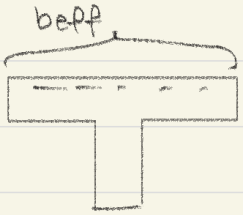
Show only this config for exterion

$M_{u(+ve)} = 2092.2$ k-ft

$M_{u(-ve)} = -3344.2$ k-ft

Check T-beam or rect $\quad a < t_s \longrightarrow$ rect

Positive moment



$d = H - 5'' = 62''$ [3 layers]

$a_{init} = t_s = 7.5'' \longrightarrow A_s = \dfrac{M_u}{\phi f_y (d - a/2)}$

$a_{rev} = \dfrac{A_s f_y}{0.85 f_c' b_{eff}} = \square < t_s \longrightarrow$ rect (would be on report)

$A_{s,min} = \dfrac{200}{f_y} b_w d$

$c = \dfrac{a}{\beta_1} < \dfrac{3}{8} d \longrightarrow$ tension controlled

For negative moment

$d = H - 4'' = 63''$

$a = \dfrac{A_s f_y}{0.85 f_c' b_w} \qquad A_s = \ldots$

$A_s = \ldots$

$A_{s,min} = \ldots$

Check tension controlled

Haunch reinf

#3 @ 6" c/c on #4 @ 9" c/c

Shear reinf.

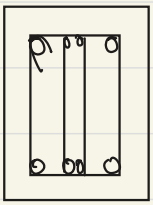
$V_u = 248.9^k$

d = smaller one [min (63", 62") → 62"]

Check concrete dim $V_u < 0.25 \phi f_c' b_w d$

$V_u > \frac{1}{2} \phi V_c$

$$S_{req} = \frac{\phi A_v f_y d}{V_u - \phi V_c}$$



4 legged stirrup

$A_v = 4x(\quad)$

Check S_{max}

$V_u < 0.125 \phi f_c' b_w d,$

$$S_{max} = \begin{cases} \dfrac{A_v f_y}{0.0316 \sqrt{f_c'} b_w} \\ 0.8d \\ 24" \end{cases}$$

$V_u > 0.125 \phi f_c' b_w d,$

$$S_{max} = \begin{cases} \dfrac{A_v f_y}{0.0316 \sqrt{f_c'} b_w} \\ 0.4d \\ 12" \end{cases}$$

Skin reinf.

+ve skin reinf

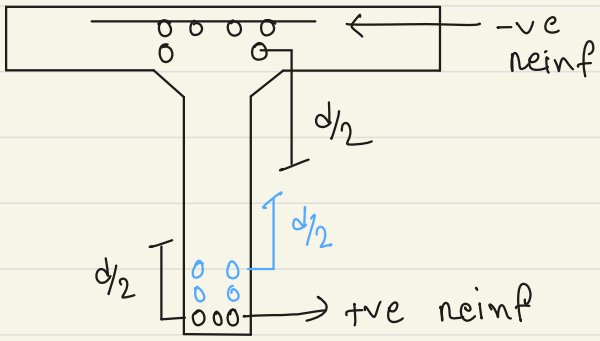
↳ d = 62" = dl

$$0.012(dl - 30) \leq A_{sk} \leq \frac{A_s}{4}$$

$$\Rightarrow 0.384 \leq A_{sk} \leq 2.5$$

$$S_{max} = \begin{cases} \frac{dl}{6} \\ 12" \end{cases}$$

$$A_{sk} = \frac{0.6 \times 12"}{8"} = \square$$



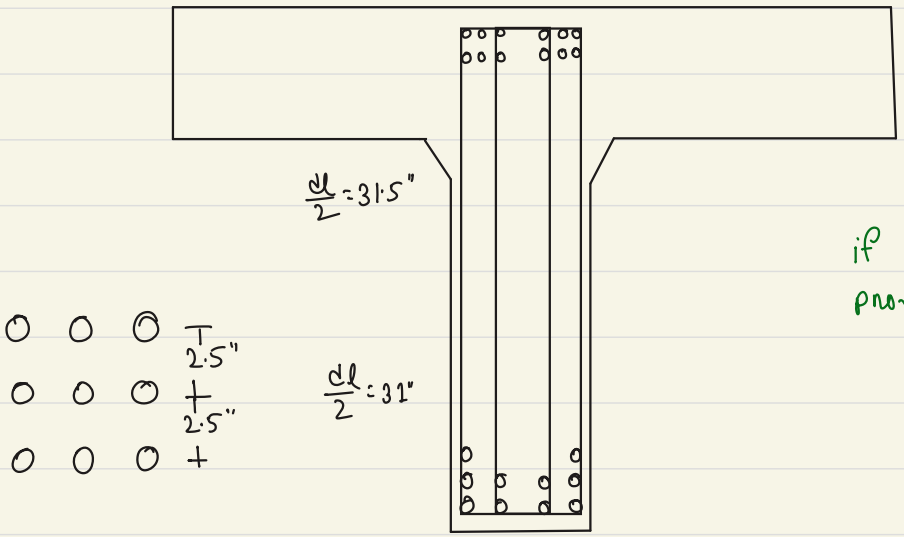
① Main reinf. → +ve 10 #9
→ -ve 8 #9 & 4 #10

② Shear reinf. → #3 — 4 legged stirrup @ 13.5" c/c

③ Skin reinf. → +ve #7 @ 8" c/c (31")
→ -ve #7 @ 10" c/c (31.5")

④ Haunch reinf. → #3 @ 6" c/c

⑤ Link reinf.

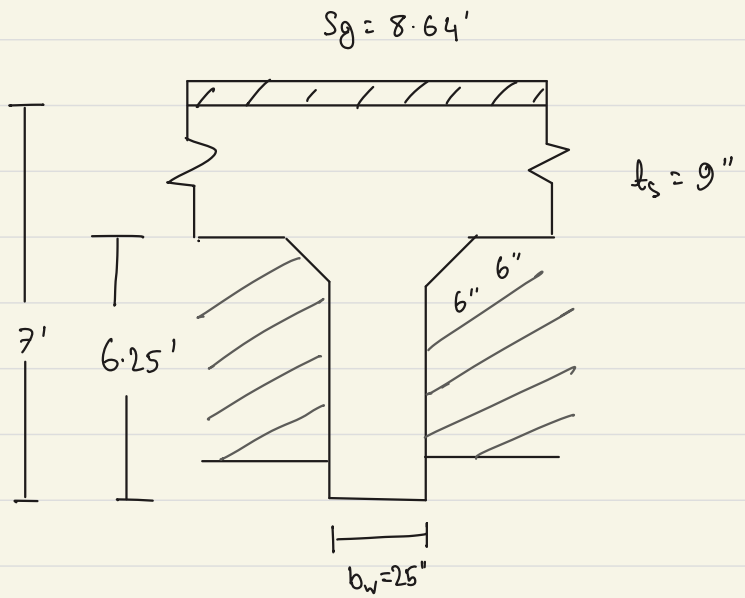


if overlaps provide only the higher spacing config for the part
[fillup edge bars first]

Link reinf.

Skin reinf can't exceed 24" gap

Design of Diaphragms do for any one location



depth = H - 12" - ts

$A_{SL} = \frac{200}{f_y} bd$

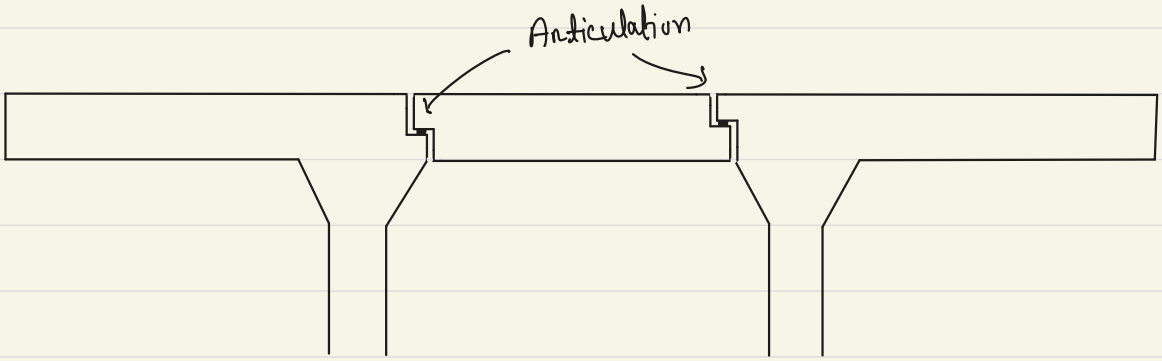
18", 10"

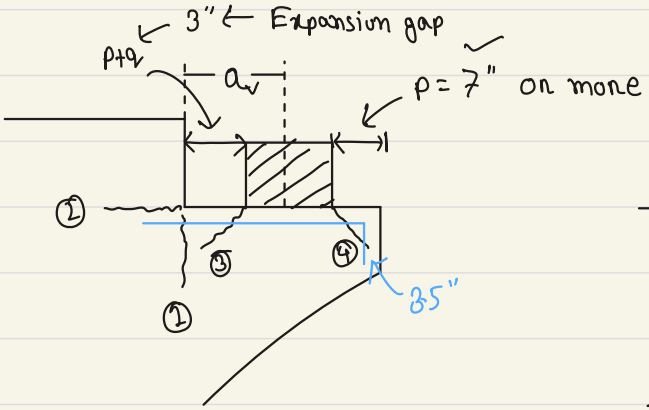
$A_{SH} = 0.002 b t$

$\frac{63" - 5"}{4} = 14.5$

Say 14.2" then 14"

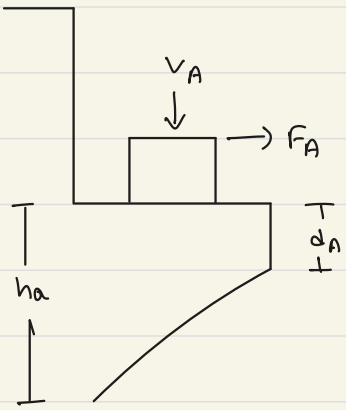
Articulation

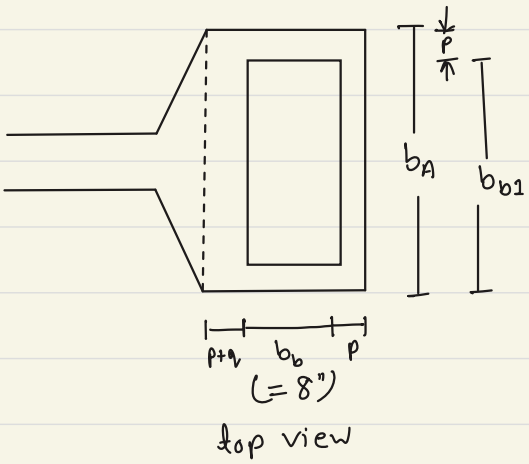




$a_v = p + q + \frac{1}{2}$ (bearing pad width)

generates moment at this distance





top view

$b_A = 2p + b_{b1}$

Formula:

$V_A = (1 + 0.02) \times V_4$

$F_A = 0.5 V_{4,LL} \geq 0.2 V_A \longrightarrow F_{bearing}$

V_4:

(Truck) $V_{LL} = 0.78 [1.33 \times$ Truck load shear + Lane load shear$]$

Combined (+ve) shear = 1.25 x self wt. shear + 1.5 wearing course shear + 1.75 $V_{LL(truck)}$

(Tandem) $V_{LL} = \ldots$

Combined (+ve) shear $= \ldots$

$V_{LL} = \max(\uparrow)$

Design:

Bearing criterion,

$F_{bearing} = A_{bearing} \times \sigma_{bearing}$ -> find b_A

$\Rightarrow 8"(b_A - 2\rho) = \dfrac{F_{bearing}}{\sigma_{bearing}}$

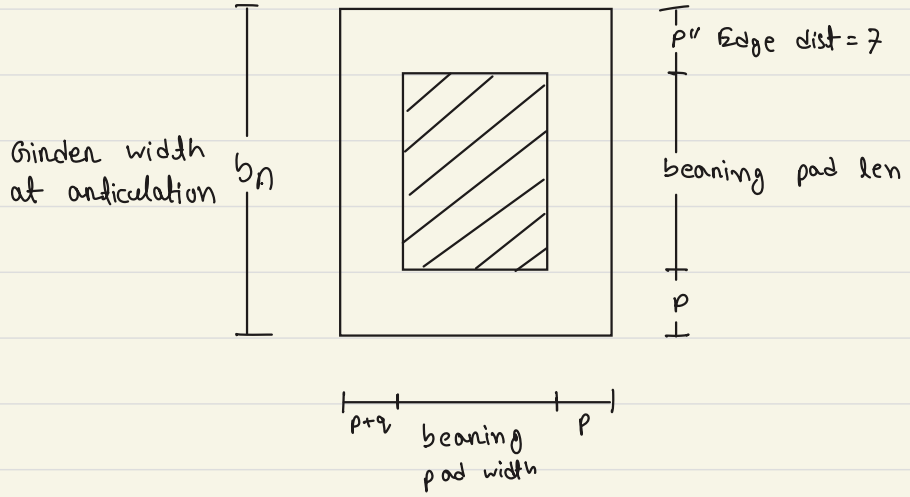
$\Rightarrow b_A = ?$

$\sigma = \phi 0.85 f_c'$

$= 0.9 \times 0.85 \times 4$

$b_A = bb_1 + 2\rho$

$A_{bearing} = 8" \times (b_A - 2\rho)$



Shear friction criterion,

Length of articulation = $2p + q + b_b$

$= 2 \times 7'' + 3'' + 8''$

bearing pad depth

Total depth at articulation = $\frac{H+4}{2} + \left(\text{Length of articulation} \times \frac{2H-H}{L_c}\right)$

$h_a = \square$

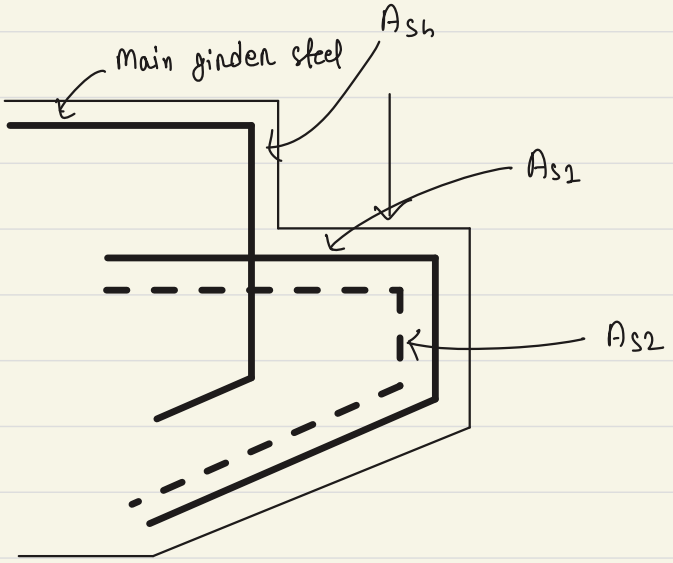
$d_a = h_a - 3.5$

$$b_A = \frac{V_a}{0.9 \times 0.2 \times f_c' \times d_a}$$

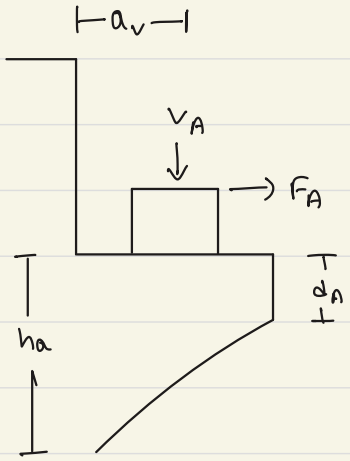
↳ 4ksi

$\therefore b_A$ = max b_A from both criterion

Reinforcement



Area;



$$M_A = V_A \times a_v + F_A \times \frac{d_A}{2}$$

$$A_{s1} = \frac{M_a}{\phi f_y (d_a - a/2)} \quad ; \text{ Trial on let } a = 1"$$

ϕ: 60 → 0.9

$= \square \ in^2$ #9 / #10 / #11

$$A_{sh} = \frac{V_a}{\phi f_y}$$

$$A_{s2} = \frac{F_a}{\phi f_y}$$

Check: $\frac{a_v}{d_a} < 1 \longrightarrow A_{vf} = 0$

$\frac{a_v}{d_a} > 1 \longrightarrow$ Shear reinforcement : Shear area $= b_A d_A$

$10^3 \times V_A = \phi [c A_{cv} + M A_{vf} f_y] \longrightarrow A_{vf}$ = Shear steel

ϕ: 0.9 ; f_y: 145 ksi ; M: 1.4

Stirrup;

4 leg #4

$$S = \frac{\phi A_v f_y d_A}{V_A - \phi V_c}$$

$A_v = 4 \times 0.2 = 0.8\ in^2$

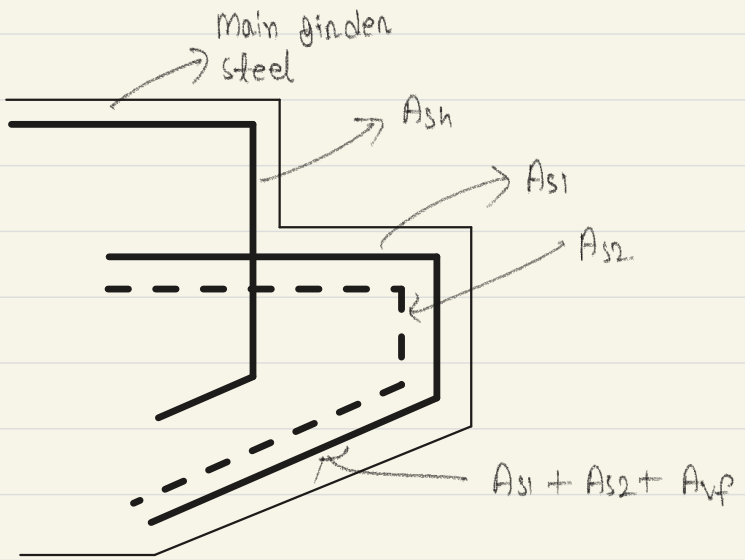
$\phi V_c = \phi (0.0316 \beta \sqrt{f_c'}\ b_A d_A)$

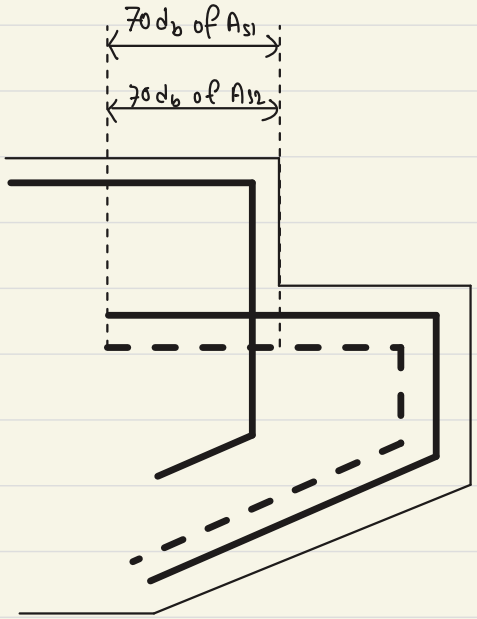
$= \square^{K}$

$S_{max} = \min(12" \text{ or } \frac{d_A}{2})$

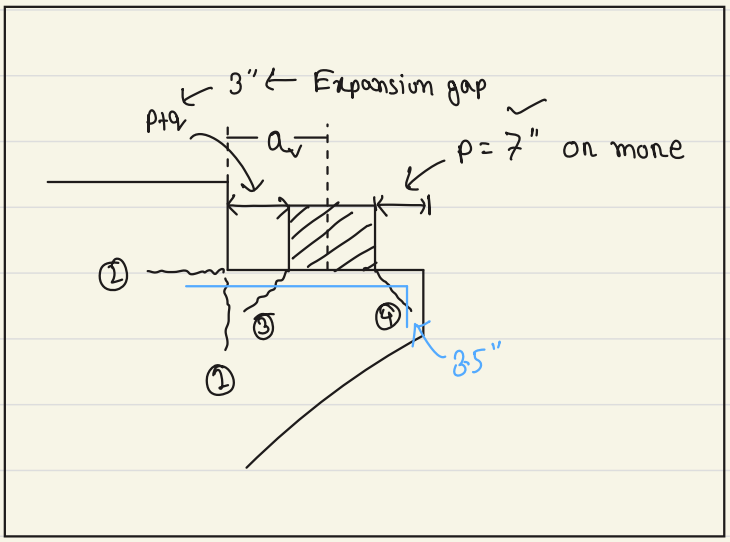
$S > / < S_{max} \longrightarrow \sim 35{:}00$

Detailing

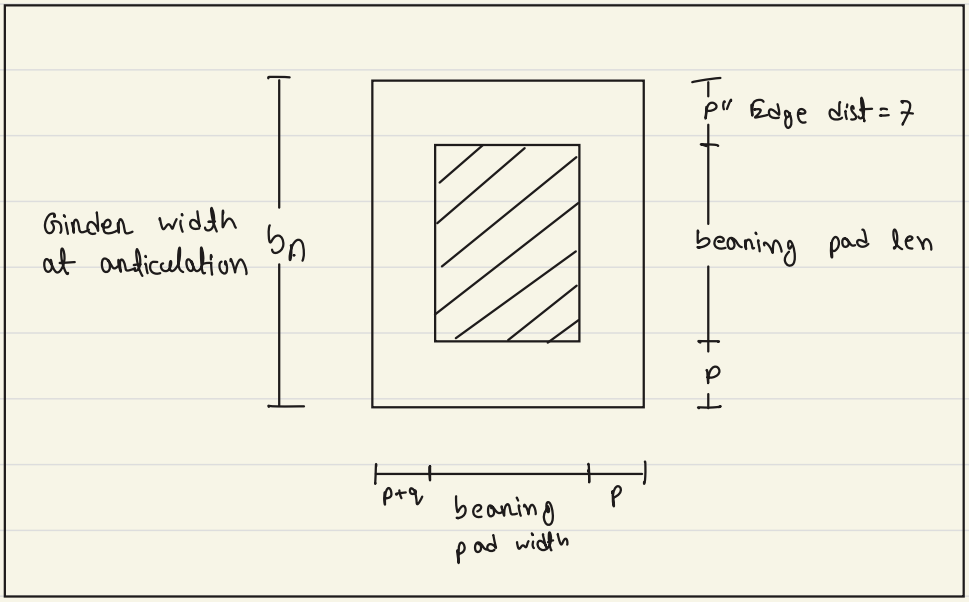




Question pattern



Understand thoroughly



Lab report : 14th wk sunday

Viva

Va → 2% inc. why

figure → explain, value

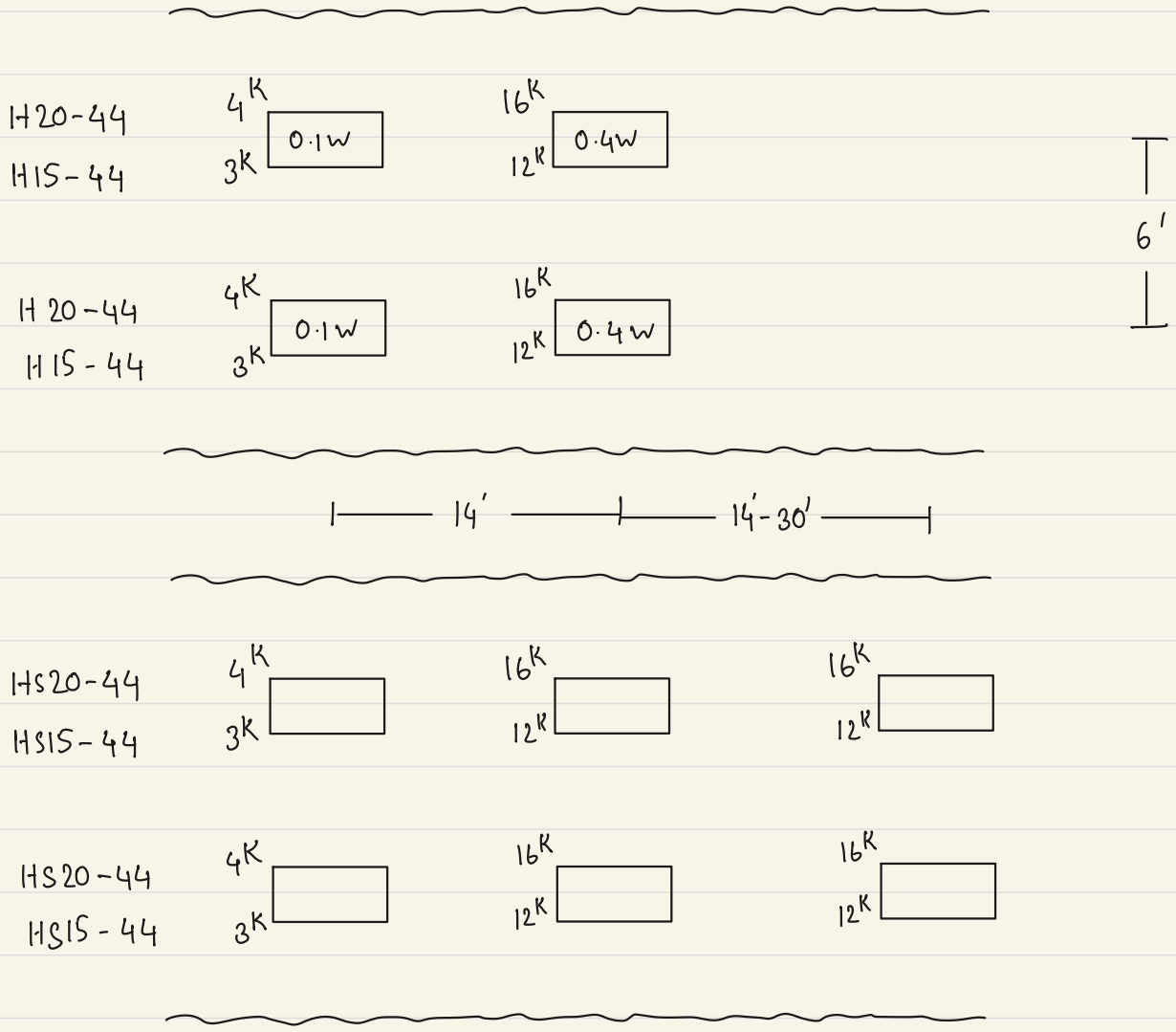
Rough / Final quiz 27/03

AASHTO Live Loading

Design truck loading: (single veh) 1 ton = 2000 lb

1. H loading → H15-44; 15 ton, 1944
   H20-44;
2. Heavier HS → Semi-trailer loading → HS15-44; 15 ton (carried by axles of the tractor); 1944
   HS20-44;

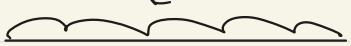
Diagram:



Design lane load: (cont. veh)

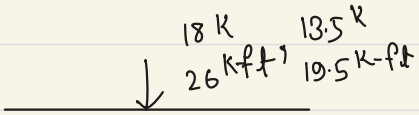
H20 / HS20 → 0.640 K/ft, 0.480 K/ft ← H15 / HS15

- UDL →



+

- Concentrated →



Design of slab Bridge

2. Slab thickness :

Eff. span, S_1 = clear span + $\left(\frac{b_w}{2} + \frac{b_w}{2}\right)$

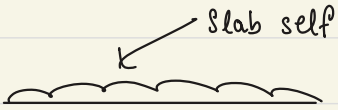
thickness, $t = 1.2\left(\frac{S_{1,\text{feet}} + 10}{30}\right) \geq 8''$ (upper rounding to 1")

Eff. span, S_2 = clear span + thickness

$S = \min(S_1, S_2)$

2. Moment calculation :

Due to DL :



Self wt = $0.150 \times t_{ft}$ → □ K/ft per ft width

w.c = □ K/ft per ft width

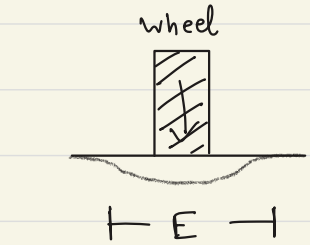
} += w_{DL}

$m_{DL} = \frac{w_{DL} S^2}{8}$ [simply supported]

Due to LL :

$E = 4 + 0.06S \leq 7'$

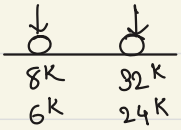
Scenario → Single vehicular loading



$P' = \frac{P}{E}$ [lb/ft per ft width]

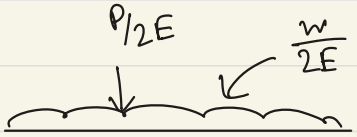
$m = \frac{(P/E)\,S}{4}$

P = 16K, 12K



Scenario → Continuous veh (lane ld)

$$M_{LL(Lane)} = \frac{(P/2E)S}{4} + \frac{(W/2E)S^2}{8}$$



$P = 18^K, 13.5^K$

$w = 0.640$ K/ft, 0.480 K/ft

$M_{LL} = \max M_{LL}$

Due to impact

$$IF = \frac{50}{S+125} \leq 0.3$$

$$M_I = IF \times M_{LL}$$

$$M_{Design} = M_{DL} + M_{LL} + M_I$$

3. Reinforcement detailing

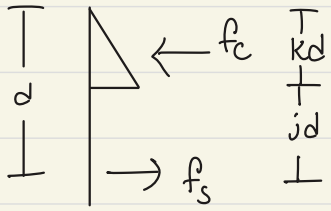
Main reinf: (along longitudinal dir)

$f_s = 0.4\ f_y$

$f_c = 0.45\ f_c'$

$$n = \frac{E_s}{E_c} = \frac{29000}{57000\sqrt{f_c'}} \geq 6$$

$$k = \frac{n}{n+r}; \qquad r = \frac{f_s}{f_c}$$



$j = 1 - k/3$

$M = (f_c \times \frac{1}{2} b\, kd) \times jd \rightarrow d_{req} = \square$ $\quad [d_{prov} = t - 1.5"]$

Again, $M = f_s A_s \times jd \Rightarrow A_{s,main} = \frac{M}{f_s\, jd}$ → Choose bar

Spacing →

Distribution reinf:

$$\left(100/\sqrt{S} \leq 50\right)\% \text{ of } A_{s,main}$$

Temp & shrinkage reinf:

$$1/8 \text{ in}^2/\text{ft}$$

Check for min reinf.

$$f_r = 7.5\sqrt{f_c'} \qquad \text{[rupture stress]}$$

$$f_r = \frac{M_{cr}\, y}{I} \Rightarrow M_{cr} = \frac{f_r\, I}{h/2}$$

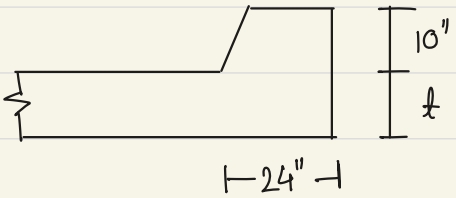
$$M_{Design} > 1.2\, M_{cr} \rightarrow \text{OK}$$

---

4. Reinf. placement

Main → longitudinal (parallel to traffic)
Temp → both
Distribution → lateral

5. Design of edge beam:



DL = self wt + nailing wt

$$m_{DL} = \frac{w_{DL} \times s^2}{8}$$

$m_{LL} = 0.2 PS$ $\quad [P = 12^K, 16^K]$

$m_{Design} = m_{DL} + m_{LL}$

D-check: $m = f_c \, 1/2 \, bKd \times jd \Rightarrow d_{req} = \square$; $d_{prov} = (t + 10") - 2.5"$

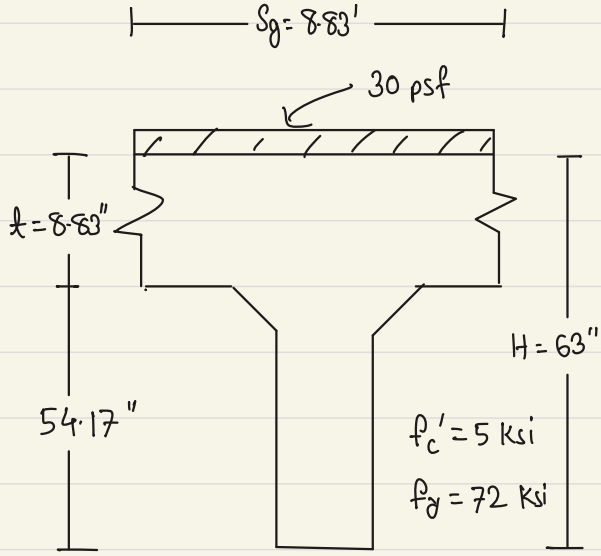
$m = A_s f_s \times jd \Rightarrow A_s = \frac{m}{f_s jd}$ → choose reban

Rough / Design of interior Ginder 28/03

Section 11-11

$m_{(+ve)} = 4149.94 \simeq 4150$ K·ft

$m_{(-ve)} = 1098.14 \simeq 1099$ K-ft



Main reinf., pos:

$M_{u(+ve)} = 4150$ K-ft

H = 63"

Check T-beam: (a > t)

Let, $a = t = 8.83"$

$$A_s = \frac{M_u}{\phi f_y (d - a/2)} = \frac{4150 \times 12}{0.9 \times 72 (58 - \frac{8.83}{2})} = 14.32 \text{ in}^2$$

$d = H - 5"$

$= 63" - 5" = 58"$

$$a = \frac{f_y A_s}{0.85 f_c' b} = \frac{72 \times 14.32}{0.85 \times 5 \times (8.83 \times 12)} = 2.29 \text{ in} < (t = 8.83")$$

∴ Rectangular

Min reinf:

$$A_{s,min} = \frac{200}{f_y} b_w d$$

$$= \frac{200}{72000} \times 18 \times 58 = 2.9 \text{ in}^2$$

Calculated reinf:

$$A_s = \frac{M_u}{\phi f_y (d - a/2)} \; ; \quad a = \frac{A_s f_y}{0.85 f_c' b}$$

a	A_s	a
1"	13.37	2.14
2.14	13.50	2.16
2.16	13.50	2.16

$$= \frac{4150 \times 12}{0.9 \times 72 (58 - a/2)} \; ; = \frac{72 A_s}{0.85 \times 5 \times 8.83 \times 12}$$

$$= \frac{768.52}{58 - a/2} \; ; \; = 0.160 A_s$$

$\therefore A_s = 13.50 \text{ in}^2 \geq (A_{s,min} = 2.9 \text{ in}^2)$ [14 #9]

$A_{s,prov} = 14 \text{ in}^2$

Check tension controlled:

$$c = \frac{a}{\beta_1} = \frac{2.16}{0.80} = 2.7"$$

$3/8 d = 3/8 \times 58 = 21.75"$

$$\beta_1 = 0.85 - \frac{0.85 - 0.65}{8 - 4}(5 - 4) = 0.80$$

$\therefore (c = 2.7") < (3/8 d = 21.75")$ [OK]

Main reinf, neg :

$M_{u(-ve)} = 1099$ k-ft

$H = 63"$

Assume single layer of tension bars, $d = H - 2.5" = 60.5"$

Min reinf :

$$A_{s,min} = \frac{200}{f_y} b_w d$$

$$= \frac{200}{72000} \times 18 \times 60.5 = 3.03 \text{ in}^2$$

calculated reinf. : $A_s = \frac{M_u}{\phi f_y (d - a/2)}$; $a = \frac{A_s f_y}{0.85 f'_c b}$

a	A_s	a
1	3.39	3.19
	3.46	3.25
	3.46	3.25

$$= \frac{1099 \times 12}{0.9 \times 72 (60.5 - a/2)} ; = \frac{72 A_s}{0.85 \times 5 \times 18}$$

$$= \frac{203.52}{60.5 - a/2} ; = 0.94 A_s$$

$\therefore A_s = 3.46 \text{ in}^2$ (4 #9)

$A_{s,prov} = 4 \text{ in}^2$

check tension controlled:

$$c = \frac{a}{\beta_1}$$

$$= \frac{3.25}{0.80} = 4.06 \text{ in}$$

$3/8\, d$

$= 3/8 \times 60.5$

$= 22.69$ in

$(c = 4.06) < (3/8\, d = 22.69)$ [ok]

Shear reinf. :

$V_u = 150.29^K$

$0.25 \phi f_c' b_w d = 0.25 \times 0.9 \times 5 \times 18 \times 58 = 1174.5^K > (V_u = 150.29^K)$ [ok]

$\phi V_c = \phi\, 0.0316 \beta \sqrt{f_c'}\, b_w d$

$= 0.9 \times 0.0316 \times 2 \sqrt{5} \times 18 \times 58$ kip

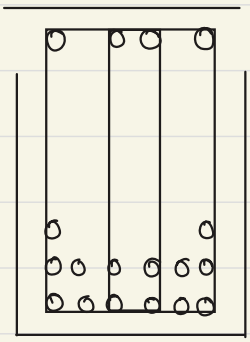
$= 132.78^K$

$1/2 \phi V_c = 66.39^K$

$(V_u = 150.29) > (1/2 \phi V_c = 66.39) \rightarrow$ stirrup reqs

Assume #3, 4 legged stirrup

max spacing :



$(0.125 f_c' b_w d = 0.125 \times 5 \times 18 \times 58 = 652.5) > (V_u = 150.29)$

$$\therefore S_{max} = \begin{cases} \dfrac{A_v f_y}{0.0316 \times \sqrt{f_c'}\, b_w} = \dfrac{(4 \times 0.11) \times 72}{0.0316 \times \sqrt{5} \times 18} = 24.9'' \\ 0.8d = 0.8 \times 58 = 46.4'' \\ 24'' \end{cases}$$

$= 24''$

$V_u = \phi V_c + \phi n A_v f_y$

$= \phi V_c + \phi \dfrac{A_v f_y d}{s}$

$\Rightarrow 150.29 = 132.78 + 0.9 \dfrac{0.44 \times 72 \times 58}{s}$

$\Rightarrow s = 94''$

$\therefore s = 24''$

Skin reinf., pos:

$d_l = 58''$

$A_{sk} \geq 0.012(d_l - 30) \leq \frac{A_s}{4}$

$\geq 0.012(58-30) \leq \frac{14}{4}$

$\geq 0.336 \leq 3.5$

$\therefore 0.336 \leq A_{sk} \leq 3.5 \quad in^2/ft$

$S_{max} = \frac{d_l}{6} \leq 12\ in$

$= \frac{58}{6} \leq 12 = 9.67 \simeq 9.5\ in$

Let, #6 @ 9 in C/C

$A_{sk,prov} = \frac{0.44}{9} \times 12 = 0.59\ in^2/ft$ (> 0.336 & < 3.5) [OK]

Haunch reinf.:

#3 @ 6" C/C

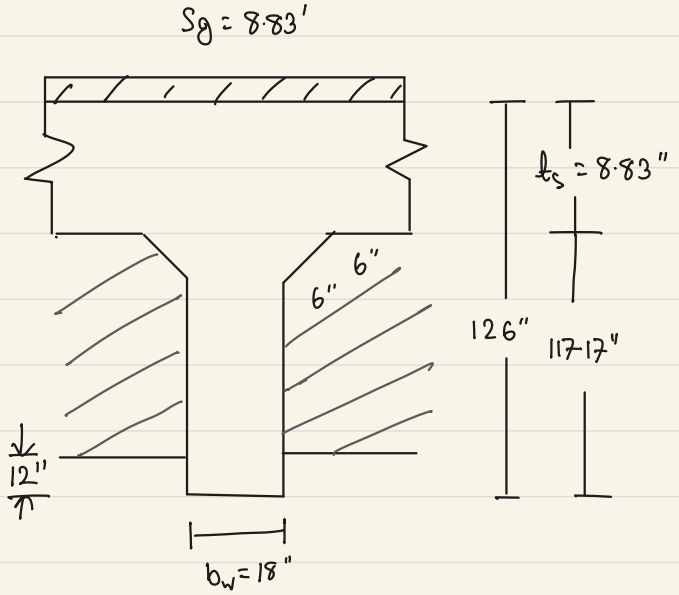
Link reinf:

#3

Rough / Design of Diaphragm

29103

At pier



Width = 18"

Depth = 117.17" − 12" = 105.17"

Longitudinal steel: (two layer)

$$A_{SL} = \frac{200}{f_y} bd$$

$$= \frac{200}{72000} \times 18 \times (105.17 - 4)$$

$$= 5.06 \text{ in}^2 \qquad (3\#9,\ 3\#8)$$

$$A_{SL,prov} = 3 \times 2 + 3 \times 0.79 = 5.37 \text{ in}^2$$

Skin reinf.:

$$A_{SK} = 0.002\, bt = 0.002 \times 18 \times 105.17 = 3.79 \text{ in}^2 \qquad (5\#8)$$

$$A_{SK,prov} = 5 \times 0.79 = 3.95 \text{ in}^2$$

$$\text{Spacing} = \frac{105.17 - (4 \times 2)}{6} = 16.20 \simeq 16"$$

Stirrup: #4 @ 18" c/c

Link reinf.: #3 @ 16" c/c

Suggestion for final

Deck slab :

Distibution bar spacing | Cracking control spacing

min

- Cracking distribution check
- moment calculation, slab thickness

DL analysis

- DC calc
- Diaphragm calc

Live load

- V_{LL}, V_{Design}
- M_{LL}, M_{design}

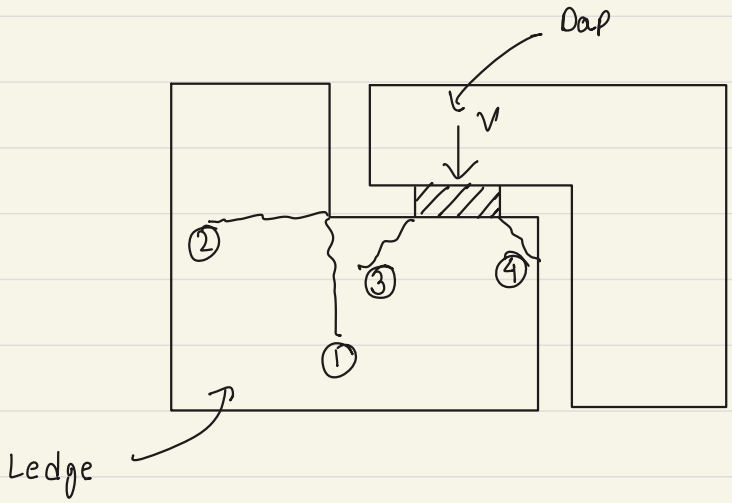
Design

- Full
- Diagram
- ...

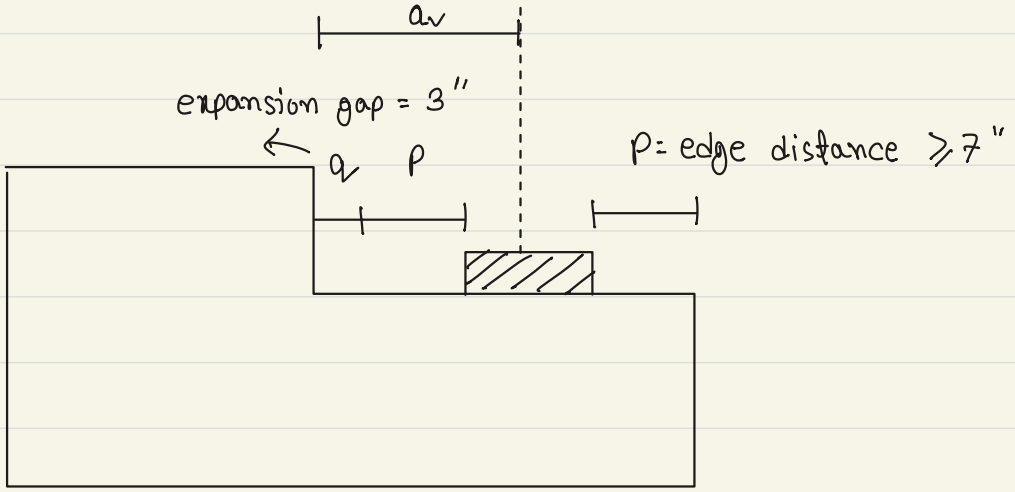
Rough / Articulation 04/04

Def^n Connection between suspended span & cantilever span.

Bearings → allows multi-directional horizontal movements as opposed to rollers, which gives unidirectional



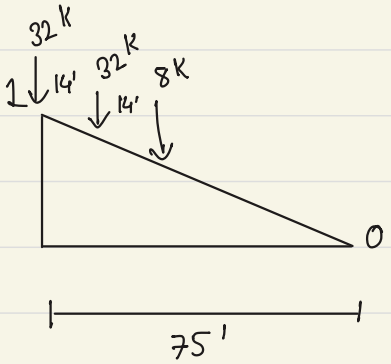
① Due to flexural, shear, and hor. forces
② Due to tension → potential of splitting
③ Punching shear
④ Bearing force



$a_v = p + q + \frac{1}{2}$(bearing pad width)

Section 4-4 (shear):

Truck ld:

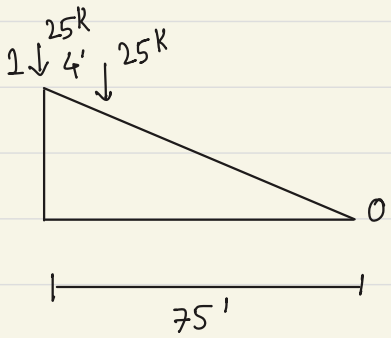


$$V_{truck(+ve)} = \frac{1}{75}(32\times75 + 32\times61 + 8\times47)$$

$$= 63.04^{K}$$

$$V_{truck(-ve)} = 0^{K}$$

Tandem ld:

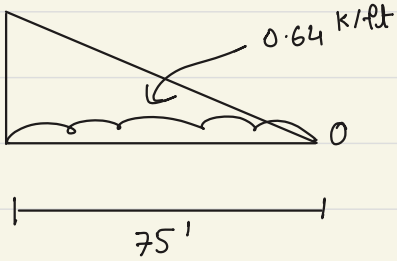


$$V_{tandem(+ve)} = \frac{1}{75}(25\times75 + 25\times71)$$

$$= 48.67^{K}$$

$$V_{tandem(-ve)} = 0^{K}$$

Lane ld:



$$V_{lane(+ve)} = 0.64\times\frac{1+0}{2}\times75$$

$$= 24^{K}$$

$$V_{lane(-ve)} = 0$$

Section 4-4 (moment) : 0

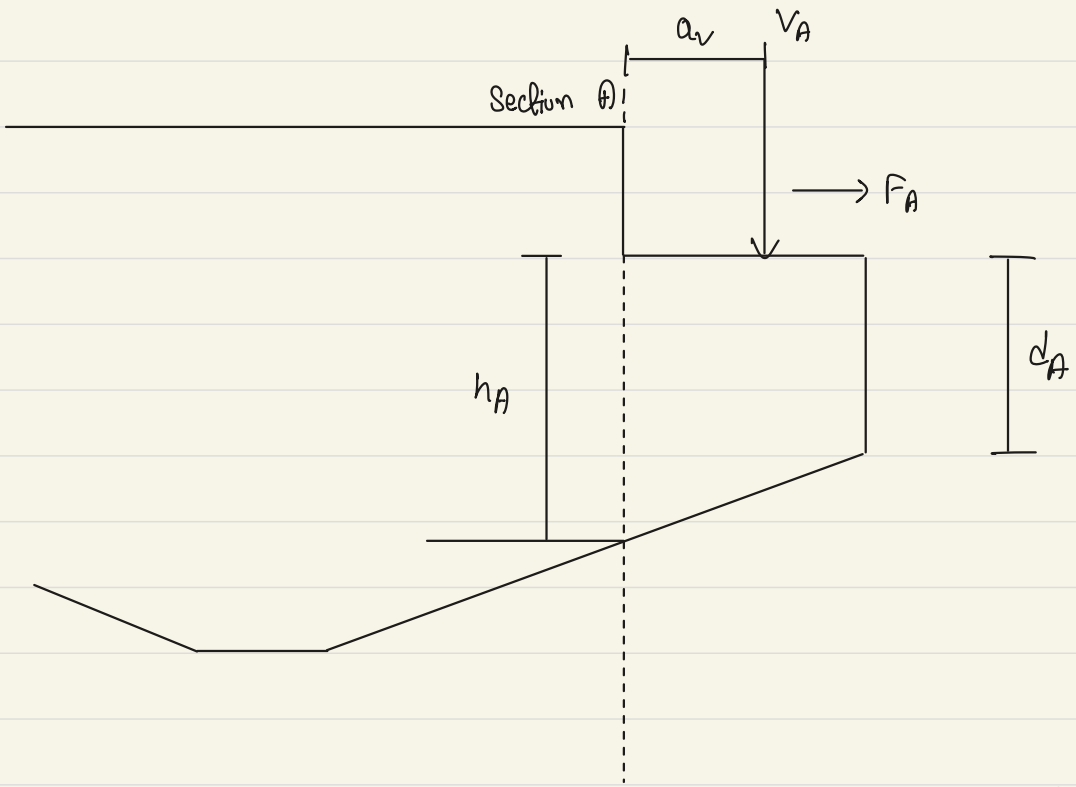
Distribution factor, $\alpha_{i,v} = 0.2 + \frac{S}{12} - \left(\frac{S}{35}\right)^2$

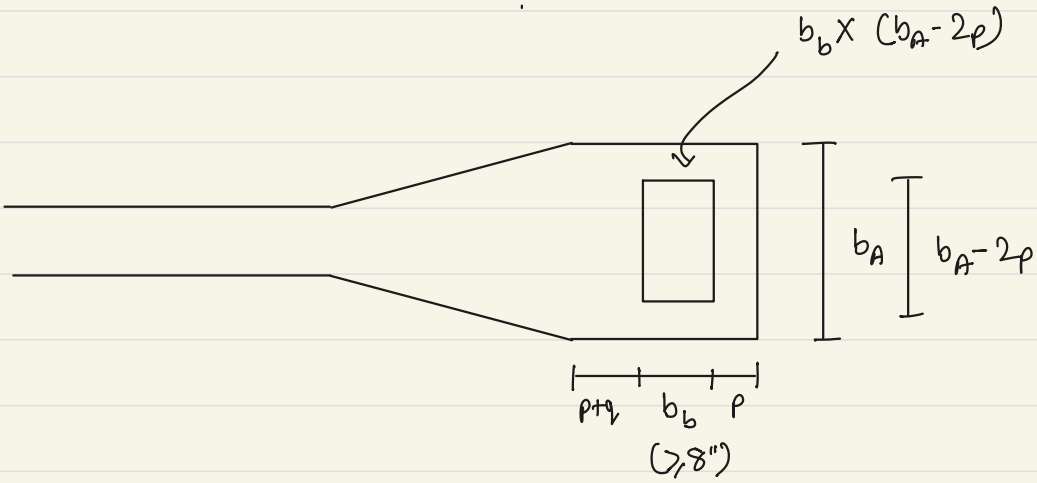
$= 0.2 + \frac{8.83}{12} - \left(\frac{8.83}{35}\right)^2 = 0.872$

$V_{LL} = \alpha \, IM \times \max(V_{truck}, V_{tandem}) + V_{lane}$

$= 0.872 \times 1.33 \times 63.04 + 24 = 97.111 \, K$

$V_{4,design} = 1.25DC + 1.5DW + 1.75 V_{LL}$


a_v
V_A
Section A
F_A
h_A
d_A


$b_b \times (b_A - 2p)$
b_A
$b_A - 2p$
$p+q$
b_b
p
(7,8")

Formula:

$V_A = 1.02\, V_4$

$F_A = 0.5\, V_{4,LL} \geq 0.2 V_A$

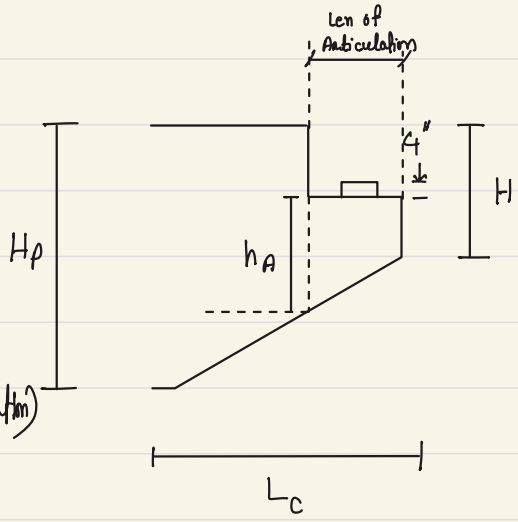
$d_A = d$ at sec A

Bearing criteria:

$b_b \times (b_A - 2p)$

$V_A \leq f_b (= \phi 0.85 f_c') \times A_B \longrightarrow b_A$

Shear criteria:



Length of articulation

$= 2p + q + b_b$

$h_A = \left(\frac{H}{2} - 2\right) + \left(\frac{H_p - H}{L_c} \times \text{Len of articulation}\right)$

$d_A = h_A - 3.5''$

$V_A \leq \phi V_n (= \phi 0.2 f_c' b_A d_A) \longrightarrow b_A$

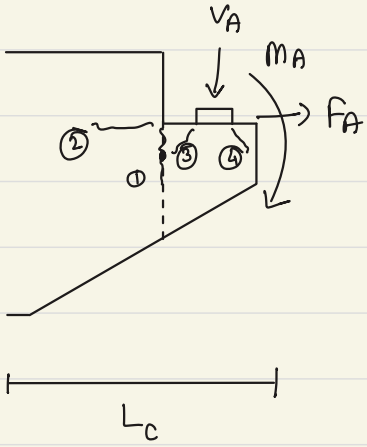
$b_A \rightarrow$ max b_A

Reinforcement:

$$M_A = V_A a_v + F_A \frac{d_A}{2}$$ ← ①, ③, ④

$$A_{s1} = \frac{M_A}{\phi f_y (d_A - \frac{a}{2})} \quad ; \quad \phi = 0.9$$

$$a = \frac{f_y A_{s1}}{0.85 f_c' b_A}$$



Due to V_A: $\phi f_y = \frac{V_A}{A_{sh}}$ ← ②

Due to F_A: $\phi f_y = \frac{F_A}{A_{s2}}$ ← ①, ③, ④

A_{vf}: if $\frac{a_v}{d_A} < 1 \rightarrow A_{vf} = 0$

else: $V_A = \phi [c A_{cv} + \mu A_{vf} f_y]$ ($A_{cv} = b_A \times d_A$ ← shear area; $c = 0.145$ ksi; $\mu = 1.4$)

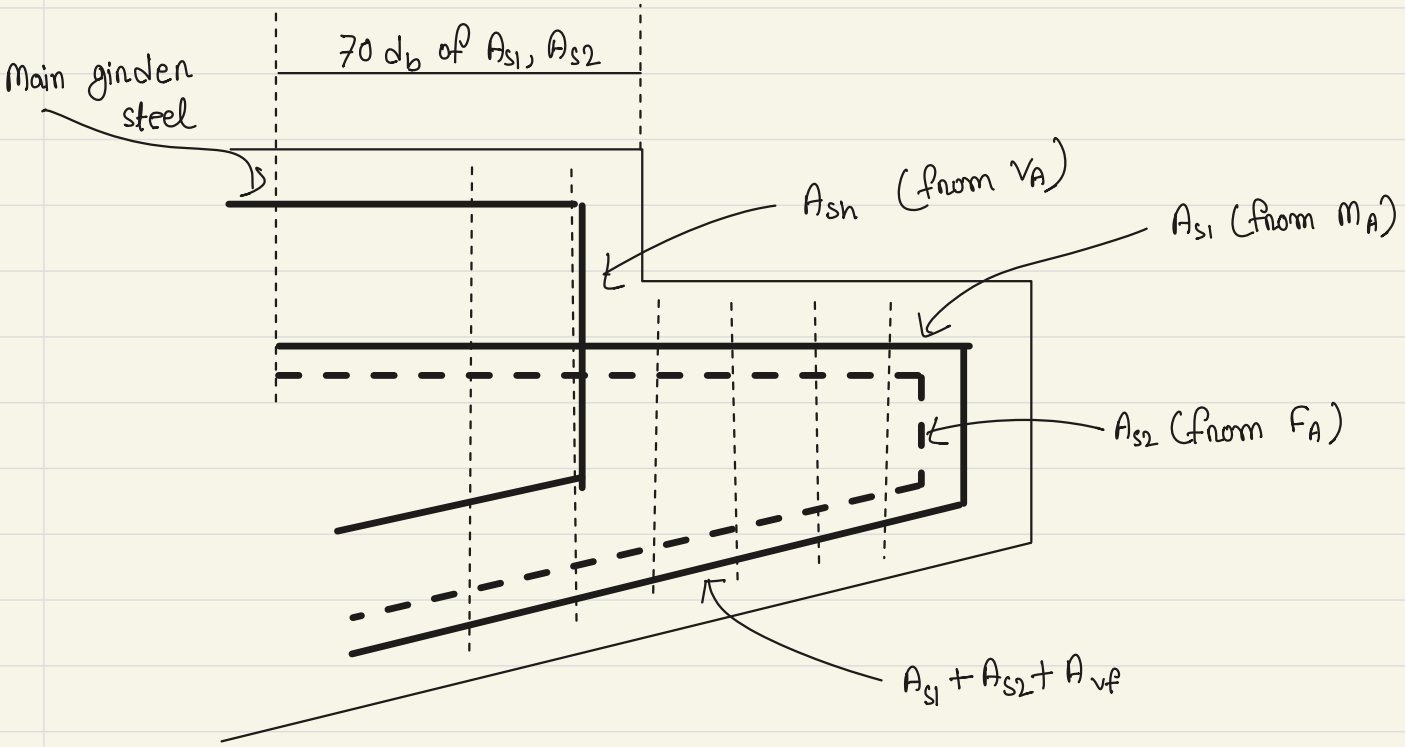
Stirrup:

4 leg, #4

$$s_{max} = \min(12'', \frac{d_A}{2})$$

$$s = \frac{\phi A_v f_y d_A}{V_u - \phi V_c} \quad ; \quad V_c = 2\sqrt{f_c'} b_A d_A$$

Detailing :


70 d_b of A_{s1}, A_{s2}
Main ginder steel
A_{sh} (from V_A)
A_{s1} (from M_A)
A_{s2} (from F_A)
$A_{s1} + A_{s2} + A_{vf}$

Rough / Final quiz

05/04

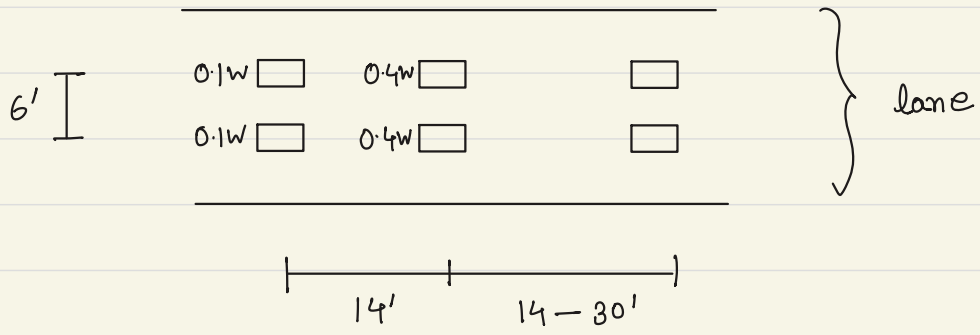
Design of slab bridge

Design truck loading :

1 tone = 2000 lb

H15, HS15 → 15 ton

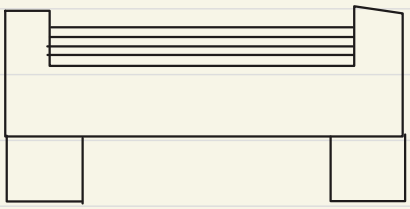
H20, HS20 → 20 ton



Design lane loading :

UDL → 0.640 K/ft ; 0.480 K/ft | 16K, 12K

Conc. → 18K, 26 K-ft ; 13.5K, 19.5 K-ft



1. Slab thickness

Eff span = clear span + $2 \times \frac{bw}{2}$

= " + thickness } min, S

Thickness = $1.2 \times \frac{S_{feet} + 10}{30} \geq 8"$

2. Moment calc

$M_{DL} = \frac{w_{DL} \times S^2}{8}$; w_{DL} = self wt + wearing course → per ft width

$= 0.150 \times t + 0.30$

M_{LL} → two scenarios ← 16^k, 12^k ← P $E = 4 + 0.06S \leq 7'$

→ single veh, $P' = \frac{P}{E}$

$$M = \frac{(P/E) \times S}{4}$$

→ cont. veh, $P' = P/2E$ ← 18^k, 13.5^k ← 0.64, 0.48 K/ft

$$M = \frac{(P/2E) \times S}{4} + \frac{(W/2E)\, S^2}{8}$$

→ M_{max}

M_{IM} → $IM = \frac{50}{S+125} \leq 0.3$

$M_I = IM \times M_{LL}$

$M_{Design} = M_{LL} + M_{DL} + M_{IM}$

3. Min reinf.

$M_{Design} > 1.2\, M_{CR}$

$f_r = 7.5\sqrt{f_c'}$

$f_r = \frac{M_{cr}\, y}{I}$ ← y = h/2

$I = \frac{bh^3}{12}$ ← b = 12", h = t

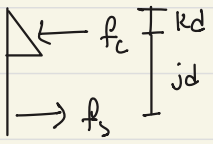
4. Reinf.

Main reinf: $f_s = 0.4 f_y$; $f_c = 0.45 f_c'$; $n = \frac{E_s\,(=29000\ ksi)}{E_c\,(=57000\sqrt{f_c'})} \geq 6$

$k = \frac{n}{n+r}$; $j = 1 - k/3$ $r = \frac{f_s}{f_c}$

$M = f_c \times \frac{1}{2} b\, kd \times jd$ → d → $\leq t - 1.5"$

$M = f_s A_s \times jd$ → A_s | spacing →



Distribution reinf. $\left(\frac{100}{\sqrt{S}} \leq 50\right)\%$ $A_{s,main}$

spacing → - - -

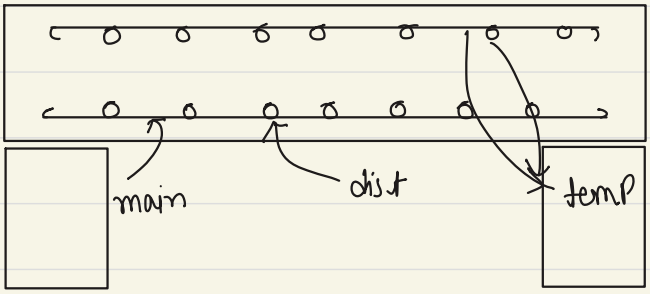
Temparature $1/8\ in^2/ft$

5. Placement

Main → longitudinal

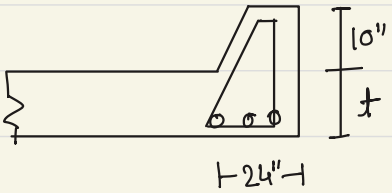
Dist → lateral

Temp → both



Edge beam :

$M_{DL} = \frac{wS^2}{8}$; $W_{DL} = \left(\frac{10+t}{12} \times \frac{24}{12} \times 150\right) + 15$ (ceiling)



$M_{LL} = 0.1\,PS$ ← 12K, 16K

$M_{design} = \cdots$

D-check : $f_c \frac{1}{2} b k d \times j d \rightarrow d$; $d_{prov} = (t + 10") - 2.5"$

$M = f_s A_s \times jd \rightarrow A_s$

Design of deck slab (BCB)

1. Length & thickness

Road width = 2x lane

Bridge width = 2x lane + 2x side-walk

Ginder c/c, S_g = $\frac{\text{Road width} - b_w/2}{\text{No. of ginder} - I}$

thickness = $\frac{S_g \text{ in}}{12} \geq 7''$

$L = 2L_E + L_m$; $L_m = 1.4 L_E$

$L_m = 2L_c + L_s$; $L_c = 0.3 L_s$

Ginder depth $\geq 0.07 L_s$

2. Load calc

$M_{DC} \rightarrow \frac{W_{self} \times S^2}{10}$

$M_{DW} \rightarrow \frac{W_{wc} \times S^2}{10}$

$+M_{LL}, -M \rightarrow$ from table

$M_{service} = \Sigma M$

$M_{strength} = 1.25 M_{DC} + 1.5 M_{DW} + 1.75 M_{LL}$

3. Control of cracking by distribution of reinf

$$s_{max} = \frac{700\,\gamma_e}{\beta_s f_{ss}} - 2d_c \quad \leftarrow \gamma_e = 1$$

$\leftarrow$ clear cover + $\frac{d_b}{2}$

$$f_{ss} = f_y \times \frac{M_{service}}{M_{strength}}$$

$$\beta_s = 1 + \frac{d_c}{0.7(h-d_c)}$$

4. Reinf. calc

i) Positive → $A_s \rightarrow a$; spacing

ii) Negative → - - -

iii) Temp → $A_s = \frac{1.3\,bh}{2(b+h)f_y}$

A_s btwn 0.11 & 0.60

iv) Dist. reinf →

$\frac{220}{\sqrt{s_c}} \leq 67\% \rightarrow A_s \rightarrow$ spacing

Analysis of interior girder - DL

1. Loads

i) $w_{wc} = 0.30 \times S_g$

ii) $w_{deck} = 0.150 \times t/12 \times S_g$

iii) $w_{web,const} = 0.150 \times \frac{b_w}{12} \times \frac{H-t}{12}$

iv) $w_{haunch} = \left(0.150 \times 1/2 \frac{6 \times 6}{144}\right) \times 2$

v) $w_{web,extra} = 0.150 \times \frac{H}{12} \times \frac{b_w}{12}$

DW →

DC →

2 Ld from diaphragm

w = 10" at intermediate bars

= 18" at supports

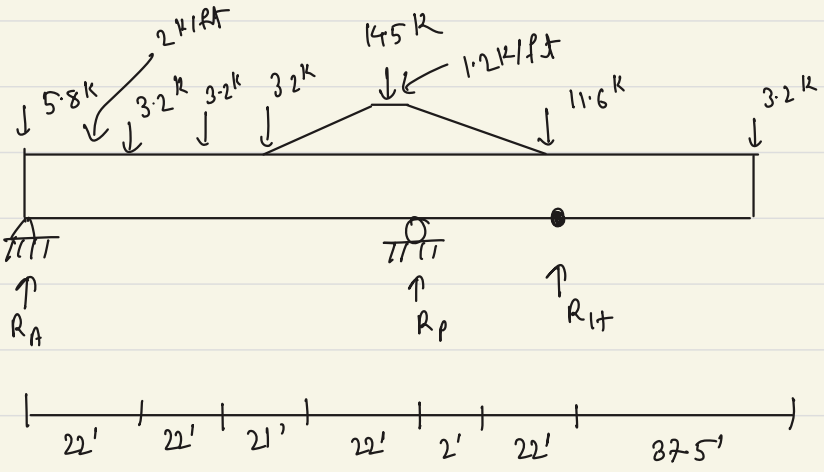
depth = H − t − 12" at intermediate

= Hp − t − 12" " supports

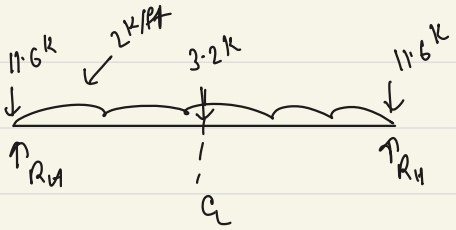
At pier: $0.150 \times \frac{w}{12} \times (S_g - b_w) \times \frac{depth}{12}$

3. Moment & shear

Reactions:



Suspended span →



$\overset{+}{\uparrow} \Sigma F_y = 0 \Rightarrow 2R_H - 2\times 11.6 - 2\times 75 - 3.2 = 0$

$\Rightarrow R'_H = 88.2 \;;\quad R_H = 88.2^k \downarrow$

End span + cantilever span →

$\overset{2+}{\curvearrowleft} \Sigma M_p = 0 \Rightarrow \ldots \Rightarrow R_A = \ldots$

$\overset{+}{\uparrow} \Sigma F_y = 0 \Rightarrow \ldots \Rightarrow R_p = \ldots$

Section 2–2:

$$\text{shear} = 76.6 - \frac{76.6 - 1.6}{37.5}(37.5 - 12.5) = 26.6^k$$

$$\text{Moment} = 0 + 76.6 \times 25 - \int_0^{25} 2x\,dx = 1290 \text{ k-ft}$$

Section 5–5:

$$\text{Shear} : 145.4 - \int_0^{14.3} \left(3.2 - \frac{1.2}{22}x\right) dx = 105.22^k$$

moment = - - —

Analysis of Exterior Girder — DL

Analysis of Interior Girder — LL

Distribution factor:

$$\alpha_{i,v} = 0.2 + \frac{S}{12} - \left(\frac{S}{35}\right)^2$$

$$\alpha_{i,m} = 0.075 + \left(\frac{S}{9.5}\right)^{0.6}\left(\frac{S}{L}\right)^{0.2} \times 1.05$$

$$\alpha_{e,v} = e\alpha_{i,v} \qquad e = 0.6 + \frac{d_e}{10}$$

$$\alpha_{e,m} = e\alpha_{i,m} \qquad d_e = \max(-1, \min(5.5, \frac{b_w}{2}))$$ (ft)

$$\rightarrow \frac{b_w}{2}$$

$$e = 0.77 + \frac{d_e}{9.1}$$

$$V_{LL} = \alpha \times IM \times \max(V_{truck}, V_{tandem})$$

$$V_{des} = 1.25\,DC + 1.5\,DW + 1.75\,V_{LL}$$

Design of interior girder

Main reinf:

M_u = ---

H = ---

b = ---

$A_{s,coeff} = \frac{M_u}{\phi f_y (d - a/2)}$; $a_{coeff} = \frac{f_y A_s}{0.85 f_c' b}$

Check T-beam: $a = t \rightarrow A_s \rightarrow a$; $a < t \rightarrow$ rect

Min reinf = $\frac{200}{f_y} b_w d$

Calculated reinf: A_s = ... ; a = ...

$A_{s,prov}$ = ...

check tension controlled:

$(c = \frac{a}{\beta_1}) < \frac{3}{8} d$

Shear reinf:

V_u = ---

$0.25 \phi f_c' b_w d > V_u$

$\phi V_c = \phi 2 \sqrt{f_c'} b_w d$ (in lb) | $\phi 0.0316 \beta \sqrt{f_c'} b_w d$

$1/2 \phi V_c$ = ---

Max spacing

$0.125 f_c' b_w d > V_u \longrightarrow 0.8d,\ 24''$

$S_{max} = \dfrac{A_v f_y}{0.0316 \sqrt{f_c'} b_w}$

} min

$$S = \frac{\phi A_v f_y d}{V_u - \phi V_c}$$

Skin reinf:

$d_l = \dots$

$A_{sk,min} = 0.012 (d_l - 30)$

max : $\dfrac{A_{s,prov}}{4}$

$S_{max} = \dfrac{d_l}{6} \leq 12''$

$S = \dots$

$A_{sk,prov} = \dots$

Design of diaphragm

width = 18", 16" → b

Depth = $H_p - 12"$, $H - 12"$

Longitudinal steel: # of layers

$$A_{SL} = \frac{200}{f_y} bd$$

Skin reinf: $0.002bt$

Str —

Lin —

Design of articulation: