Moving Load - Shear Moment for beam

Shear +ve থেকে -ve হবে যেই wheel এর জন্য negative হবে সেই wheel এর জন্য wheel max shear দিবে

Shear

$$\Delta V = \frac{\Sigma P d}{L} + \frac{P' e}{L} + \frac{P_2 e_1}{L} - P_1 .$$

$\Sigma P \rightarrow$ summation of wheel load stays on the span before and after movement.

$d \rightarrow$ distance travelled.

$P' \rightarrow$ wheel comes on the span during movement

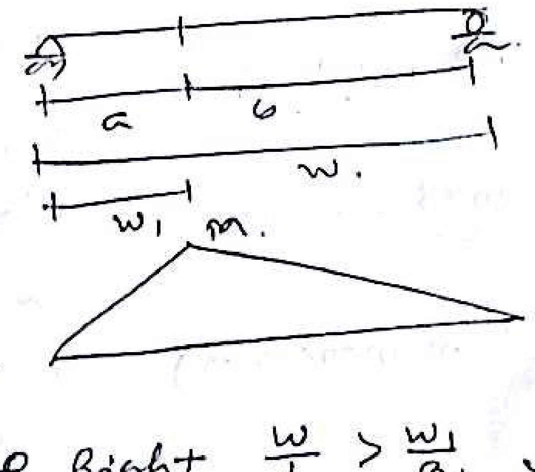
$e \rightarrow$ distance travelled by P'

$P_2 \rightarrow$ wheel that moves off the span.

$e_1 \rightarrow$ distance travelled by P_2 before moving off the span.

$P_1 \rightarrow$ wheel crosses the point ← (Control point)

Moment:



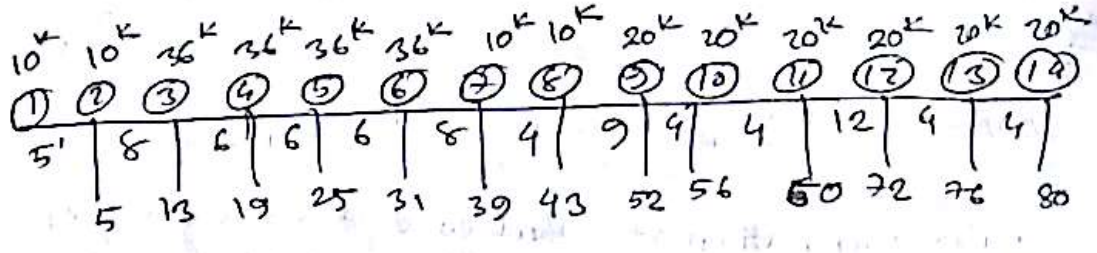
$\frac{W_1}{a} = \frac{W}{L}$ ↳ max moment.

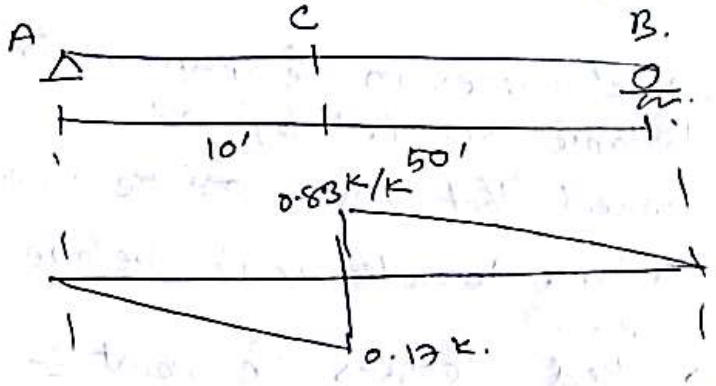
Just to ~~left~~ Right $\frac{W}{L} > \frac{W_1}{a}$

" " left $\frac{W_2}{L} < \frac{W_1}{a}$

} has to be satisfied.

Assignment (Shear) Shear → beam





$\frac{50}{50+10} = 0.83$

$1 - 0.83 = 0.17$

Trial-1

move wheel ① to ② at c. [fore 50']

$\Delta V = \frac{\Sigma P d}{L} + \frac{P' e}{L} + \frac{P_2 e_1}{L} - P_1$

$= \frac{184 \times 5}{60} + \frac{20 \times 3}{60} + 0 - 10.$

$= 6.33^K.$ (shear increasing)

ΣP = ① – ⑧ wheel.
= 184K.

$d = 5'$

P' = wheel ⑨
= 20K.

$e = 3'$

$P_2 = 0.$

$e_1 = 0.$

P_1 = wheel ①
= 10K

Trial-2

move wheel ② to ③ at C.

$$\Delta V = \frac{\Sigma P d}{L} + \frac{P' e}{L} + \frac{P_2 e_1}{L} - P_1$$

$$= \frac{194 \times 8}{60} + \frac{20 \times 7 + 20 \times 3}{60} + \frac{10 \times 5}{60} - 10$$

$$= 20.03$$ increase

ΣP = ② − ⑨

= 194K.

d = 8'

P' = wheel ⑩

= 20K

e_9 = 13 − 6 = 7'

P'' = wheel ⑪

e' = 13 − 10

= 3.

P_2 = wheel ①

= 10K.

e_1 = 5'

P_1 = wheel 2

= 10K.

Trial-3

wheel 3 to 4 @ C.

$$\Delta V = \frac{\Sigma P d}{L} + \frac{P' e}{L} + \frac{P_2 e_1}{L} - P_1$$

$$= \frac{224 \times 6}{60} + \frac{0}{60} + \frac{10 \times 9}{60} - 36$$

$$= -12.1 K.$$

decreasing

ΣP = ③ − ⑪

= 224K.

d = 6'

P' = 0.

e = 0.

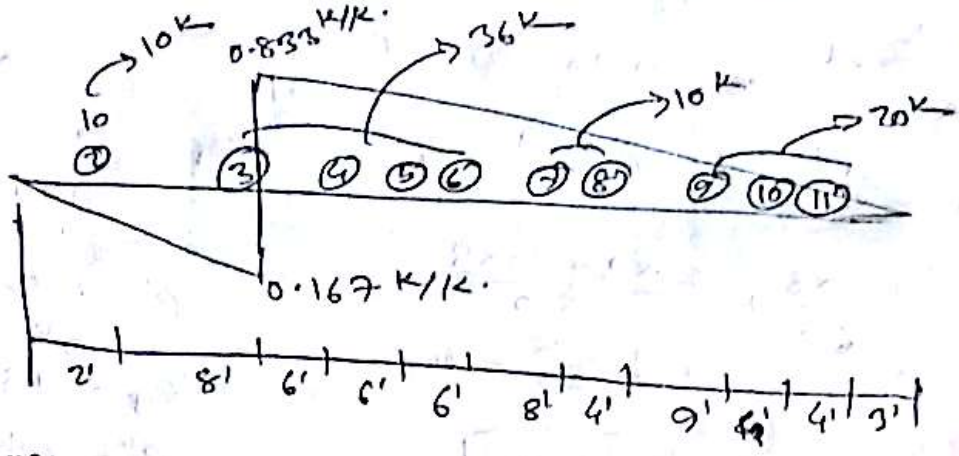
P_2 = ②

= 10K

e_1 = 9'

P_1 = 36K ←③

So, wheel ③ at C gives max shear.

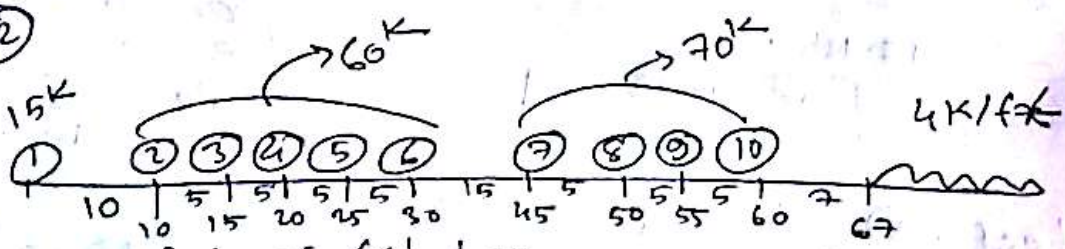


$$\text{Shear} = \frac{0.833}{50.} \times [36\times50 + 36\times44 + 36\times38 + 36\times32 + 10\times24 + 10\times20 + 20\times11 + 20\times7 + 20\times3] - \frac{0.167}{10}[10\times2].$$

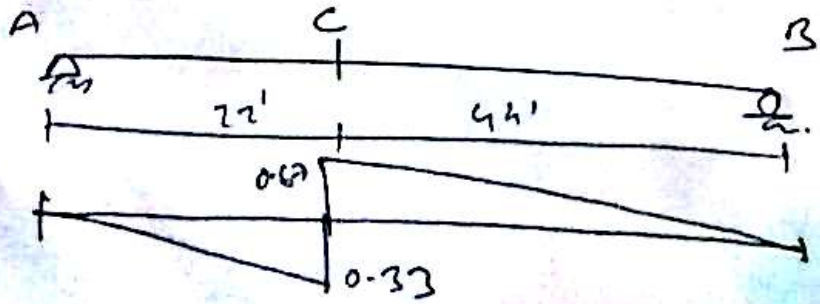
$$= 112.4\text{K}.$$

2015-16

(12)



1/3 point of 66' beam.



$\frac{44}{66} = 0.67$

$\frac{22}{66} = 0.33$

Trial-1 move wheel 1 to 2 @ C.

$$\Delta V = \frac{\Sigma P d}{L} + \frac{P' e}{L} + \frac{P_2 e_1}{L} - P_1$$

$$= \frac{315 \times 10}{66} + \frac{70 \times 9 + 70 \times 4}{66} + 0 - 15$$

$$= 46.515$$ (shearing increasing)

ΣP = ① to ⑥.
= 315K.
$d = 10'$
P' = wheel ⑦
= 70K.
$e = 9'$
P'' = wheel ⑥
= 70.
$e'' = 4'$
$P_2 = 0$.
$e_1 = 0$
P_1 = wheel ①
= 15K

Trial-2 move wheel 2 to 3 @ C.

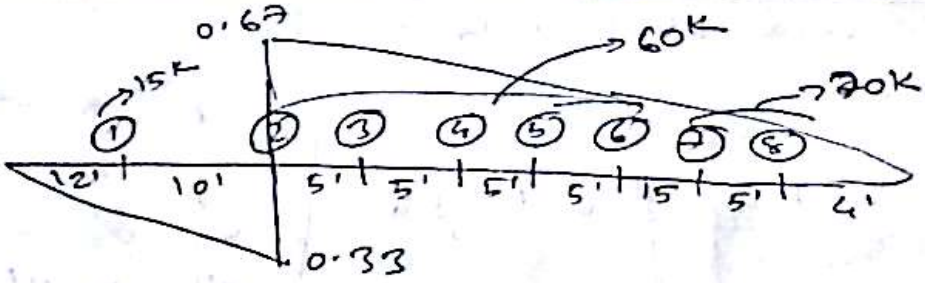
$$\Delta V = \frac{\Sigma P d}{L} + \frac{P' e}{L} + \frac{P_2 e_1}{L} - P_1.$$

$$= \frac{455 \times 5}{66} + \frac{70 \times 4}{66} + 0 - 60.$$

$$= -21.28K$$ [Shear decreasing]

ΣP = ① to ⑤
= 455K
$d = 5'$
P' = wheel ⑨
= 90K
$e = 4'$
$P_2 = 0$
$e_1 = 0$.
P_1 = wheel ②
= 60K

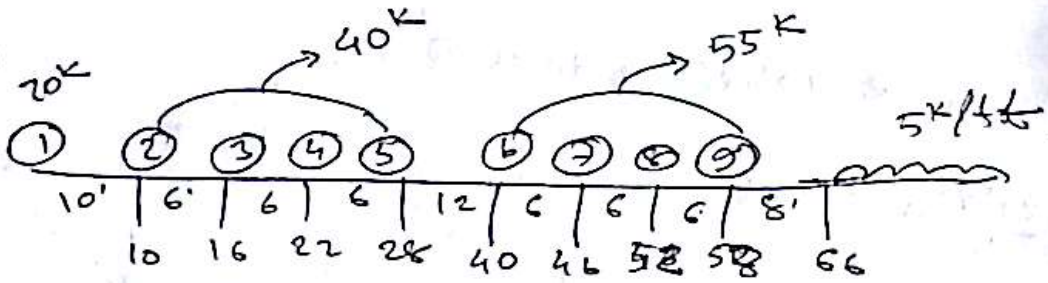
Wheel 2 @ C gives max shear.



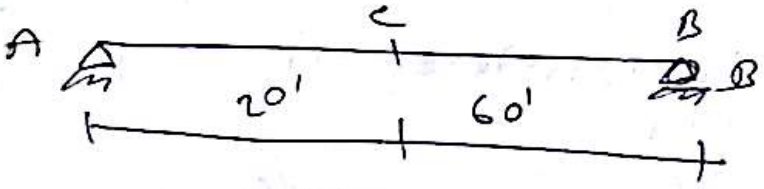
$$\text{max shear} = \frac{0.67}{44} \times [70\times4 + 70\times9 + 60\times(24+29+34+39+44)] - \frac{0.33}{22}[15\times12]$$

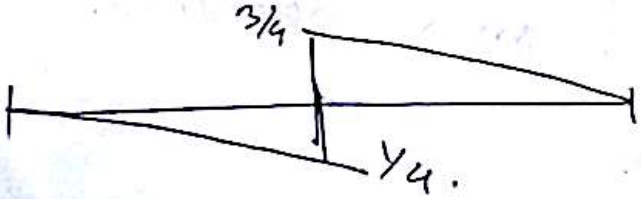
$$= 169.175 - 3.375 = 165.8\ \text{K}.$$

14-15



at quarter point





Trial-1 move wheel 1 to 2 @ c.

$$\Delta V = \frac{\Sigma Pd}{L} + \frac{P'e}{L} + \frac{P_2 e_1}{L} - P_1$$

$$= \frac{400\times10}{60} + \frac{20\times2}{60} + 0 - 20.$$

$$= 30.5^K.$$

[Shear increasing]

ΣP = ① to ⑨
$= 400^K.$
$d = 10'$
P' = 4' of UDL.
$= 4\times5$
$= 20^K.$
e' = 2' (middle point.)
$P_2 = 0$
$e_1 = 0.$
P_1 = wheel ①
$= 20^K.$

Trial-2

wheel 2 to 3 @ c.

$$\Delta V = \frac{\Sigma Pd}{L} + \frac{P'e}{L} + \frac{P_2 e_1}{L} - P_1$$

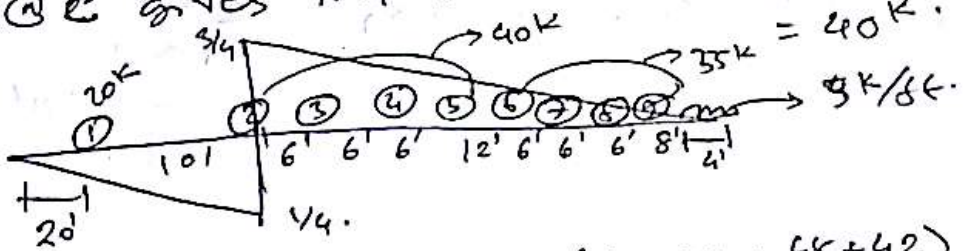
$$= \frac{420\times6}{60} + \frac{30\times3}{60} + 0 - 40.$$

$$= -7.375^K.$$

[decreasing]

$\Sigma P = 400 + 4'\times5$
$= 420^K.$
$d = 6'$
P' = 6' of UDL.
$= 6\times5 = 30^K.$
$e = 3'$
$P_2 = 0.$
$e_1 = 0.$
P_1 = wheel ②
$= 40^K.$

Wheel 2 @ c gives max shear.



max shear = $\frac{3/4}{60} \times [40\times(60+54+48+42) + 55\times(30+24+18+12) + 0.5\times4\times5] - \frac{1/4}{20.}[20\times20]$

$\frac{1}{2}\times$ UDL $\times$ length

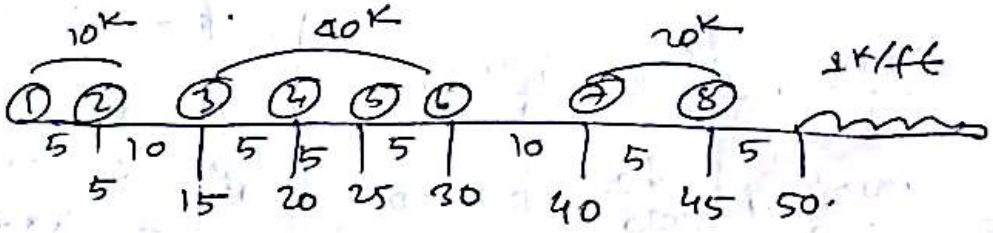
10 hobe

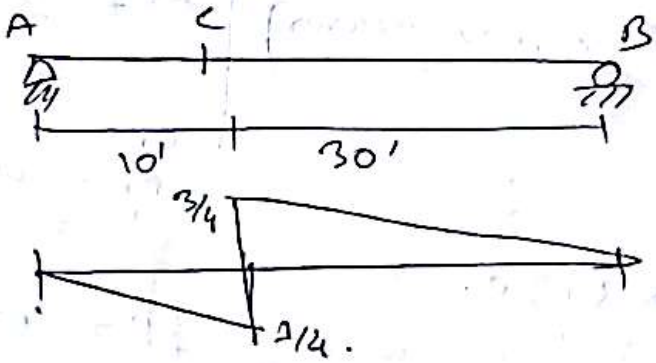
$= 159.875 - 5$
$= 154.87$

2013-14
~~2014-15~~

at quarter point of 40' beam.

①





Trial-1

wheel 1 to 2 @ C.

$$\Delta V = \frac{\Sigma P d}{L} + \frac{P' e}{L} + \frac{P_2 e_1}{L} - P_1$$

$$= \frac{180 \times 5}{40} + \frac{0 \times 0}{40} + 0 - 10$$

$$= 12.5$$ Shear increasing.

ΣP = ① to ⑥
= 180K
$d = 5'$
$P' = 0.$
$e = 0.$
$P_2 = 0$
$e_1 = 0.$
P_1 = wheel ①
= 10K

Trial-2 wheel 2 to 3 @ C.

$$\Delta V = \frac{\Sigma P d}{L} + \frac{P' e}{L} + \frac{P_2 e_1}{L} - P_1$$

$$= \frac{170 \times 10}{40} + \frac{20 \times 10 + 20 \times 5}{40} + \frac{10 \times 5}{40} - 10.$$

$$= 41.25 \quad \text{Shear (increasing)}$$

ΣP = wheel ③ - ⑥
= 170K.
d = 10'
P' = wheel ⑦
= 20K.
e = 10'
P'' = wheel ⑧
= 20K
e' = 5'
P_2 = wheel ①
= 10K
e_1 = 5'.
P_1 = wheel ②
= 10K

Trial-3

wheel 3 to 4 @ C.

$$\Delta V = \frac{200 \times 5}{40} + 0 + \frac{10 \times 0}{40} - 40$$

$$= -15$$

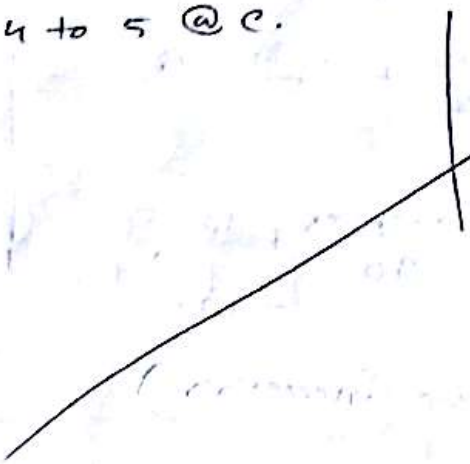
decreasing.

wheel 3 @ C gives more shear.

ΣP = wheel ③ - ⑥
= 200K
d = 5'
P' = 0.
e = 0.
P_2' = wheel ②
= 10K.
e_1 = 0'
P_1 = wheel ③
= 40K

Trial-4

wheel 4 to 5 @ c.



$P = ④ - ⑤$

$= 200K$

$d = 5'$

$P' = 5'$ of 2002

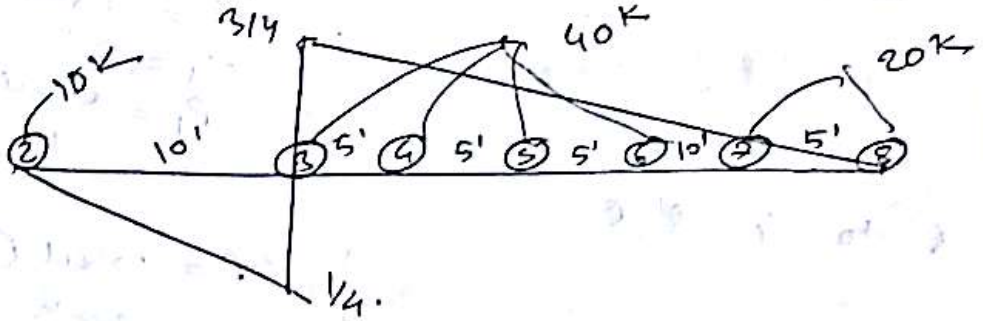
$= 5K.$

$e = 2.5'$

$P_2 = 0.$

$e_1 = 0$

$P_1 =$ wheel ④



max shear

$$= \frac{3/4}{30} \times [20 \times (0+5) + 40 \times (15+20+25+30)] - \frac{1/4}{10} [2 \times 0].$$

$= 92.5K$

Ans

12-13 – NA

11-12 – NA.

10-11 – ③

9-10 – ①

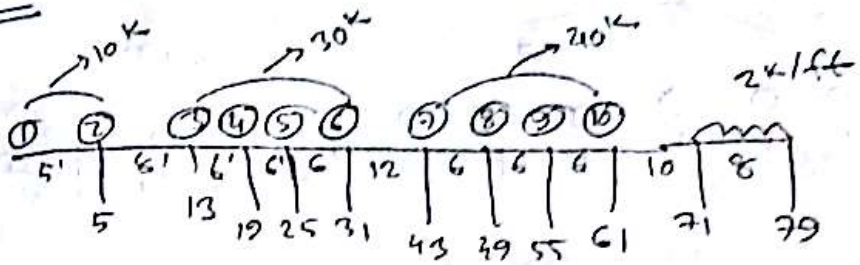
8-9 – ③

} 3 same type

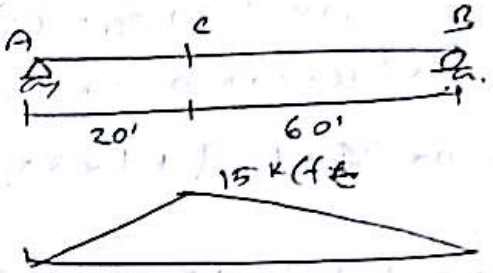
Moment → beam

JTR $\frac{W}{L} > \frac{W_1}{a}$.
JTL $\frac{W}{L} < \frac{W_1}{a}$.

Assignment



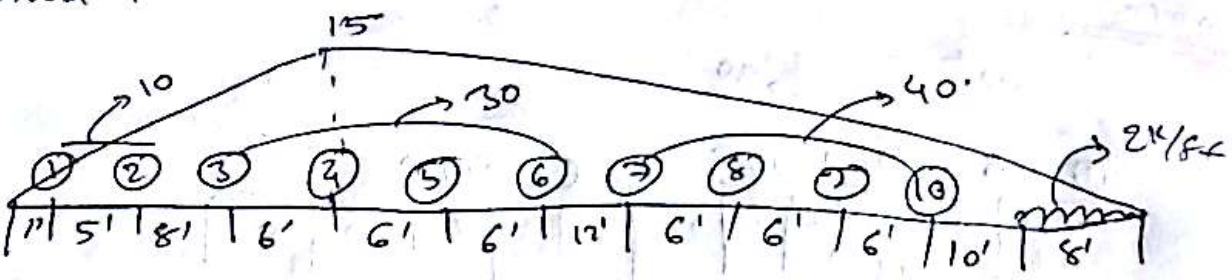
JTL - just to left
JTR - just to right



$\frac{Pab}{L} = \frac{20 \times 50 \times 1}{50} = 15$

Trial	Position of wheel at C.	remark	Calculation.
1.	wheel ③ ~~JTL~~ $\frac{W}{L} > \frac{W_1}{a}$. JTR $= \frac{304}{80} > \frac{20}{20}$. JTL $\frac{304}{80} > \frac{50}{20}$.	not satisfied	JTL W = ① - ② + 2' of UDL = 300 + 4 = 304K W_1 = ① - ② = 20K (JTR) W_1 = ① - ③ = 50K (JTL)
2	wheel ④ JTR $\frac{316}{80} > \frac{50}{20}$. JTL $\frac{316}{80} < \frac{80}{20}$.	Satisfied.	W = ~~①~~ ① ⑩ + 8' of UDL = 316K W_1 = ① - ③ = 50K (JTR) W_1 = ① - ④ = 80K (JTL)

Wheel 4 @ c- gives max. moment.



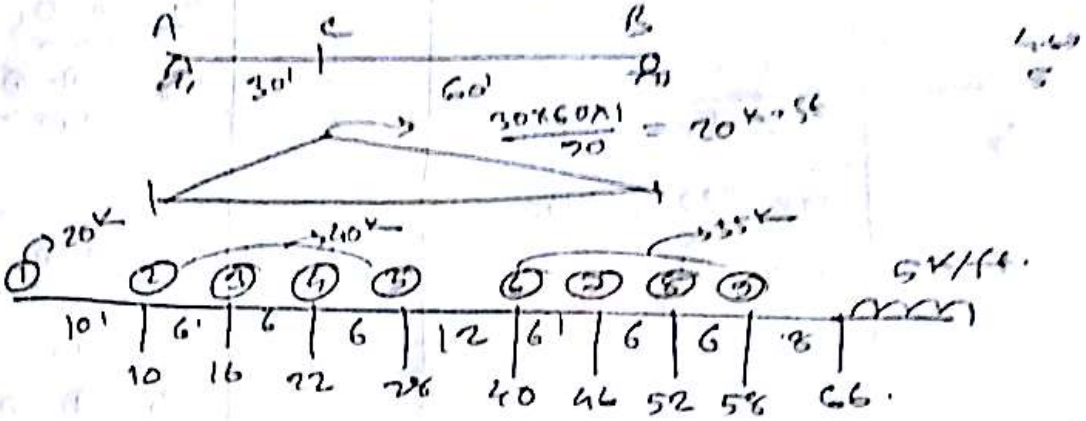
∴ Max moment = $\frac{15}{60} \times [30 \times (60 + 54 + 48) + 40 \times (36 + 30 + 24 + 18)] + \frac{15}{20} \times [30 \times 14 + 10 \times (6 + 1)] + \frac{1}{2} \times 8 \times \left(\frac{15}{60} \times 8\right) \times 2$

$= 2295 + 367.5 + 16 = 2678.5$ k-ft

15-16 → (13)
14-15 → (13)
13-14 → (2)
12-13 → (5)
11-12 → (14)

14-15

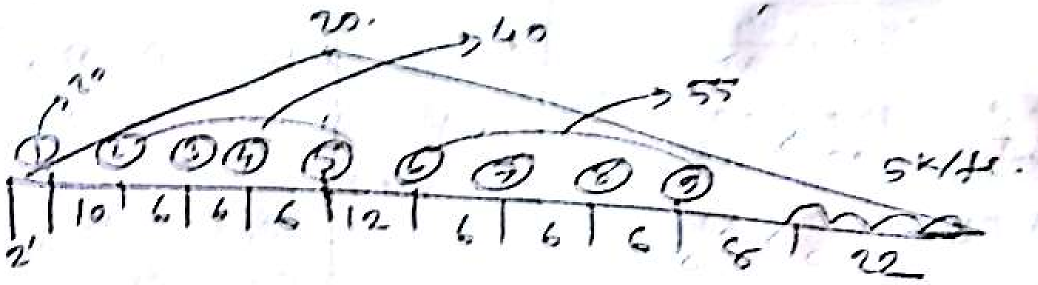
(15) 1/3 point of 90 ft Simply supported beam.



Trial	Position of wheel at C	remark	calculation.
1	② $\frac{W}{L}$ $\frac{W_1}{a}$ 2nd C. JTR $\frac{420}{90} > \frac{20}{30}$ JTL $\frac{420}{90} > \frac{60}{30}$	not satisfied	$W = ① - ② + 4' UDL$ $= 400 + 4\times5$ $= 420.$ $W_1 = 20^K$ (JTR) $W_1 = 20+40$ (JTL) $= 60^K.$
2	wheel 3 at C. JTR $\frac{450}{90} > \frac{60}{30}$ JTL $\frac{450}{90} > \frac{100}{30}$	not satisfied	$W = ① - ③ + 10' UDL$ $= 400 + 50.$ $= 450.$ $W_1 = ① - ②$ (JTR) $= 20+40 = 60^K$ $W_1 = ① - ③$ (JTL) $= 20 + 40 + 40$ $= 100^K$

3	wheel 4 at C TTR $\frac{480}{90} > \frac{120}{30}$ TTL $\frac{480}{90} > \frac{140}{30}$	not satisfied	W = ①-⑨ + 16' of UDL = 400 + 80 = 480 k. W_1 = ①-③ (TTR) = 120 k W_1 = ①-④ = 140 (TTL)
4	5 at C TTR $\frac{510}{90} > \frac{140}{30}$ TTL $\frac{510}{90} < \frac{180}{30}$	Satisfied	W = ①-⑨ + 22' of UDL = 510. W_1 = ①-④ (TTR) = 140 ~~(TTL)~~ W_1 = 180 (TTL)

wheel 5 at C gives max moment



Max moment

$$= \frac{20}{60} \times [40 \times 60 + 55 \times (54 + 48 + 42 + 36)]$$

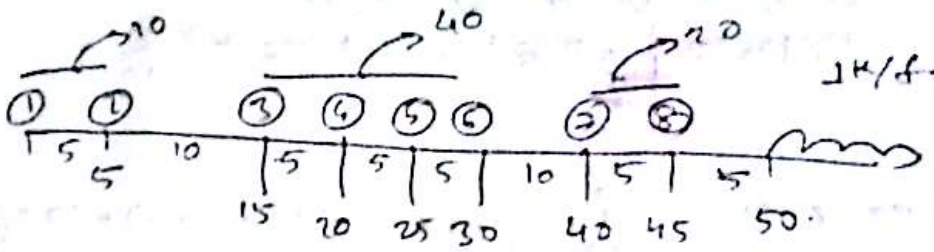
$$+ \frac{20}{30} \times [40 \times (24 + 18 + 12) + 20 \times 2]$$

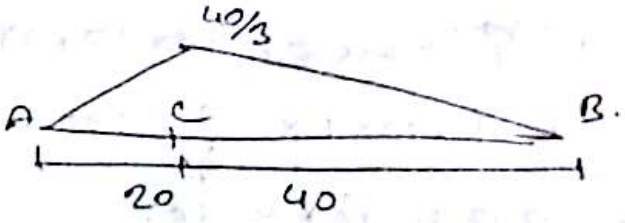
$$+ \frac{20}{60} \times \frac{1}{2} \times 22 \times 5 \times 22$$

$$= 3300 + 1466.67 + 403.33 = 5170 \text{ k-ft.}$$

2013-14

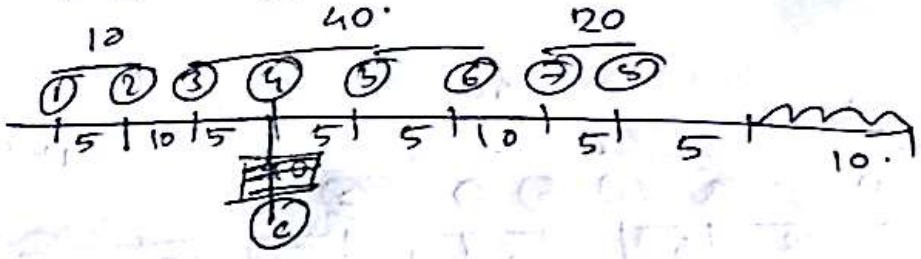
(2)





Trial	Position of wheel	Remark	Calculation.
1	3 at C. $\frac{W}{2}$ $\frac{W_1}{2}$. JTR $\frac{225}{60} > \frac{20}{20}$. JTL $\frac{225}{60} > \frac{60}{70}$	not satisfied	$W = 1 - 7 + 5' UDL$ $= 220 + 5 \times 1$ $= 225$ $W_1 = 20^K$ (JTR) $W_1 = 60^K$ (JTL)
2	4 at C. JTR $\frac{230}{60} > \frac{60}{20}$. JTL $\frac{230}{60} < \frac{100}{20}$.	Satisfied.	$W = 1 + 6 + 10' UDL$ $= 230$. $W_1 = 60^K$ (JTR) $W_1 = 100^K$ (JTL)

Wheel 4 @ C gives max. moment



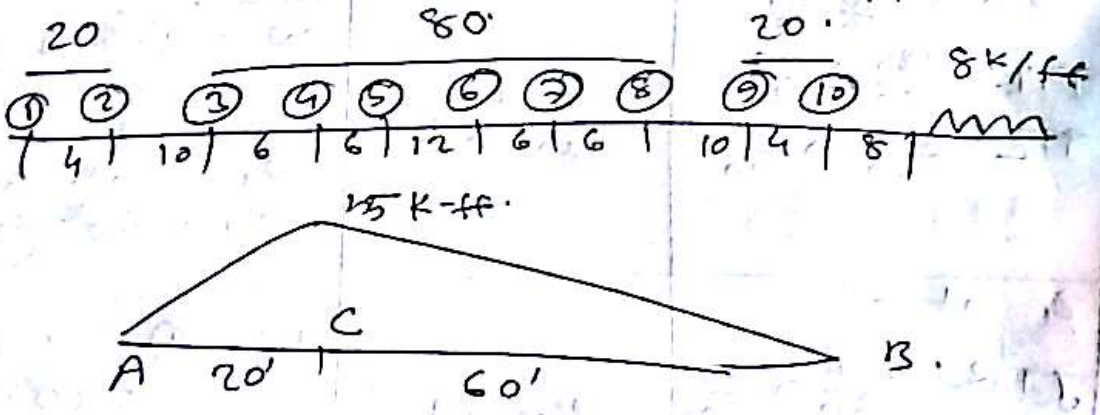
$$\text{Max moment} = \frac{\frac{40}{3}}{40.}\left[40\times(40+35+30)+20\times(20+15)\right]$$

$$+ \frac{\frac{40}{3}}{20.}\left[40\times15+10\times(5+0)\right]$$

$$+ \frac{1}{2}\times10\times1\times\frac{\frac{40}{3}}{40.}\times10.$$

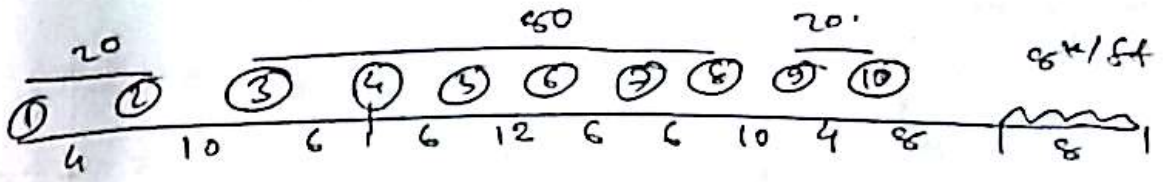
$$= 2083.3267 \text{ K-ft.}$$

2012-13 (5)



Trial.	Position of wheel	Remark	Calculation
1	3 @ C $\frac{W}{L}$ $\frac{W_1}{L}$ JTR $\frac{576}{60} > \frac{40}{20}$. JTL $\frac{576}{60} > \frac{120}{20}$	Not Satisfied	$W = ① - ⑩ + 7' UDL$ $= 560 + 2 \times 8$ $= 576.$ $W_1 = 40^k$ (JTR) $W_1 = 120^k$ (JTL)
2	4 @ C JTR $\frac{624}{60} > \frac{120}{20}$. JTL $\frac{624}{60} < \frac{200}{20}$	Satisfied	$W = ① ⑩ + 8' UDL$ $= 624$ $W_1 = 120$ (JTR) $W_1 = 200$ (JTL)

Wheel 4 @ C gives max moment.



max moment = $\frac{15}{60} \times [80 \times (60 + 54 + 42 + 36 + 30) + 20 \times (20 + 16)]$.

$+ \frac{15}{20} \times [80 \times 14 + 20 \times (14 + 0)]$

$+ \frac{15}{60} \times 8 \times \frac{1}{2} \times 8 \times 8$

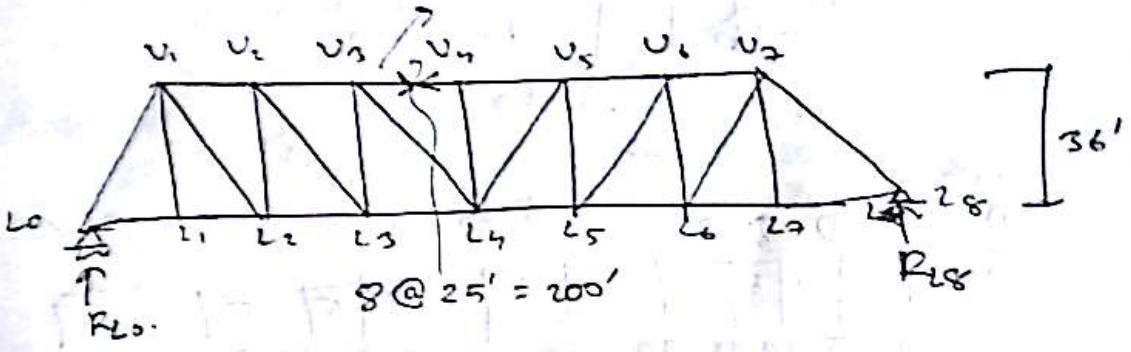
$= 5584$ k-ft. Ans

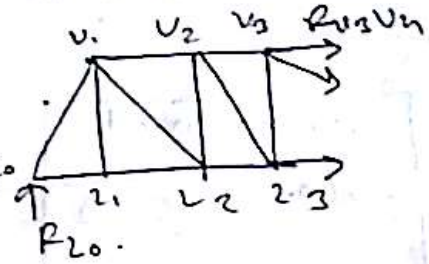
11-12 (14) Same type.

Moving load problem for truss.

Road Site पर post valuable dekhte hobe

max stress at U_3U_4.



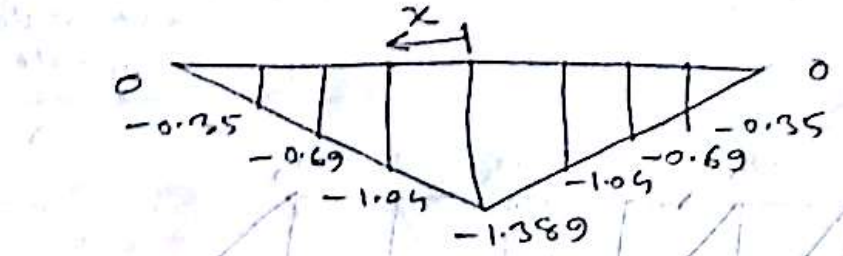


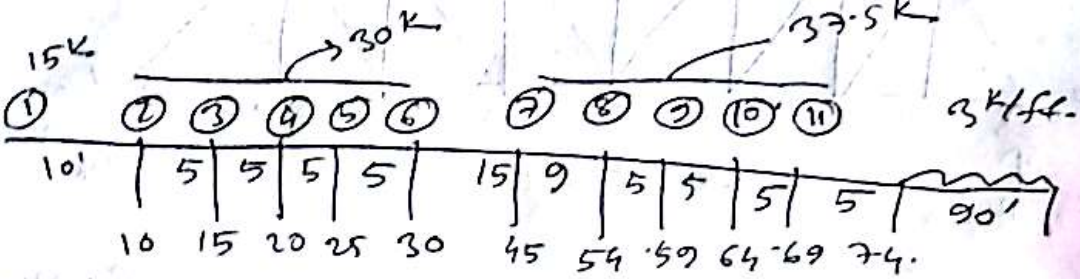
$\Sigma M_{L_4} = 0$

$\Rightarrow R_{L_0} \times 100 - 1 \times x + R_{U_3U_4} \times 36 = 0$

$\Rightarrow$

Position of load.	R_{L_0}.	$R_{U_3U_4}$.
L_0.	1	0.
L_1	7/8	-0.347
L_2	6/8	-0.69
L_3	5/8	-1.04
L_4	4/8	-1.389
L_5	3/8	-1.04
L_6	2/8	-0.69
L_7	1/8	0.347
L_8	0	0.





Trial	position of wheel		Remark	calculation
1	wheel 7	$\frac{W}{L}$ $\frac{W_1}{a}$		$W = ① - ⑪ + 71'$ of UDL
	JTR	$\frac{565.5}{200} > \frac{165}{100}$	not Satisfied.	$= 565.5$ K.
	JTL	$\frac{565.5}{200} > \frac{202.5}{100}$		$W_1 = 165$ (JTR)
				$W_1 = 165 + 37.5 = 202.5$ (JTL)
2	wheel 8			$W = ① - ⑪ + 80'$ UDL
	JTR	$\frac{592.5}{200} > \frac{202.5}{100}$	not Satisfied	$= 592.5$
	JTL	$\frac{592.5}{200} > \frac{240}{100}$		$W_1 = 202.5$ (JTR)
				$W_1 = 240$ (JTL)
3	wheel 9			$W = ① - ⑪ + 85'$ UDL
	JTR	$\frac{607.5}{200} > \frac{240}{100}$	not Satisfied.	$= 607.5$ K
	JTL	$\frac{607.5}{200} > \frac{272.5}{100}$		$W_1 = 240$ (JTR)
				$W_1 = 272.5$ (JTL)

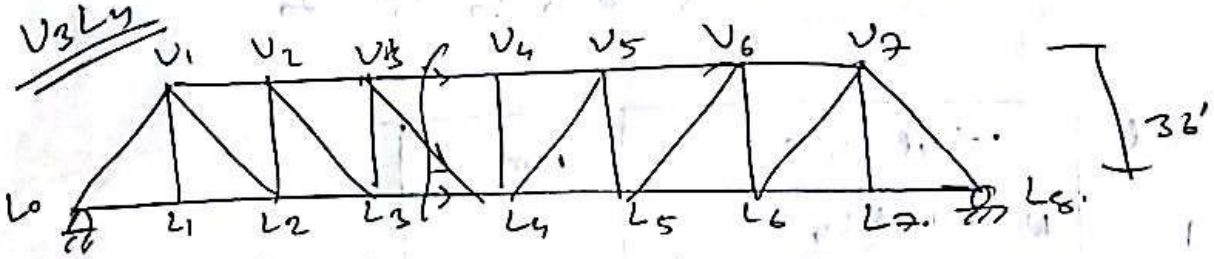
4	Wheel 10 JTR $\frac{622.5}{200} > \frac{277.5}{100}$ JTL $\frac{622.5}{200} < \frac{315}{100}$	Satisfied	$w = ⑩ - ⑪ + 90' \text{ UDL}$ $= 622.5K$ $w_1 = 277.5$ (JTR) $w_1 = 315$ (JTL)

$$\text{max. stress} = \frac{1.38}{100}\left[37.5 \times (100+95)\right] + \frac{1}{2} \times 90 \times \frac{1.38}{100} \times 90$$

$$+ \frac{1.38}{100}\left[37.5(75+90+85) + 30 \times (70+65+60+35+50) + 15 \times 40\right]$$

$$= 515.94 \text{ K-ft.}$$

U_3L_4



8 @ 25 = 200'

When load moves from $L_0 - L_3$.

$\uparrow^+ \Sigma F_y = 0$. [Load at L_3].

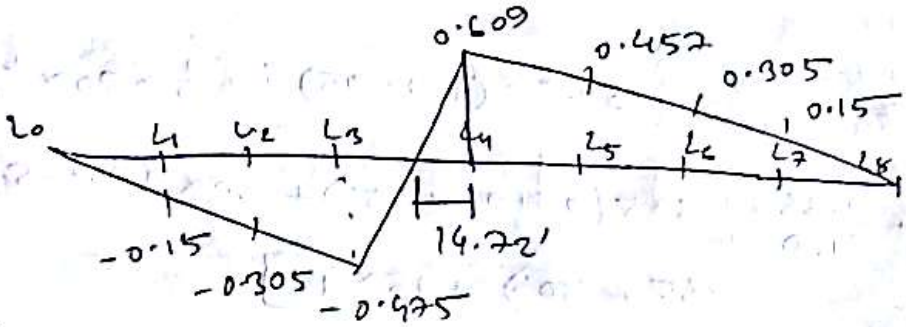
$$\Rightarrow R_{L_0} - 1 + U_3L_4 \times \frac{36}{\sqrt{36^2+25^2}} = 0.$$

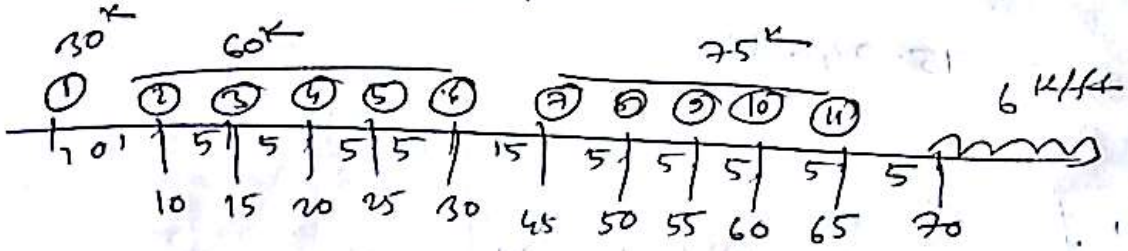
$$\Rightarrow \frac{5}{6} - 1 = \frac{U_3L_4 \times 36}{\sqrt{36^2+25^2}} \Rightarrow U_3L_4 = -0.457 \text{ K/K.}$$

1K at L_4.

$$V_3L_4 = (1-0.5) \times \frac{\sqrt{36^2+25^2}}{36}$$

$$= 0.609 \text{ K/K}$$





Trial	Wheel position	Remark	
1	Wheel 1 at L_4 $\frac{W}{L}$ $\frac{W_1}{P}$ JTR $\frac{885}{200} > \frac{0}{25}$ JTL $\frac{885}{200} > \frac{30}{25}$	not satisfied	$W = ① - ⑪ + 30'$ UDL $= 885$ K $W_1 = 0$ (JTR) $W_1 = 30$ (JTL)
2	wheel 2 at L_4. JTR $\frac{945}{200} > \frac{30}{25}$ JTL $\frac{945}{200} > \frac{90}{25}$	not satisfied	$W = ① ⑪ + 40'$ $= 945$K UDL $W_1 = 30$ (JTR) $W_2 = 90$ (JTL)

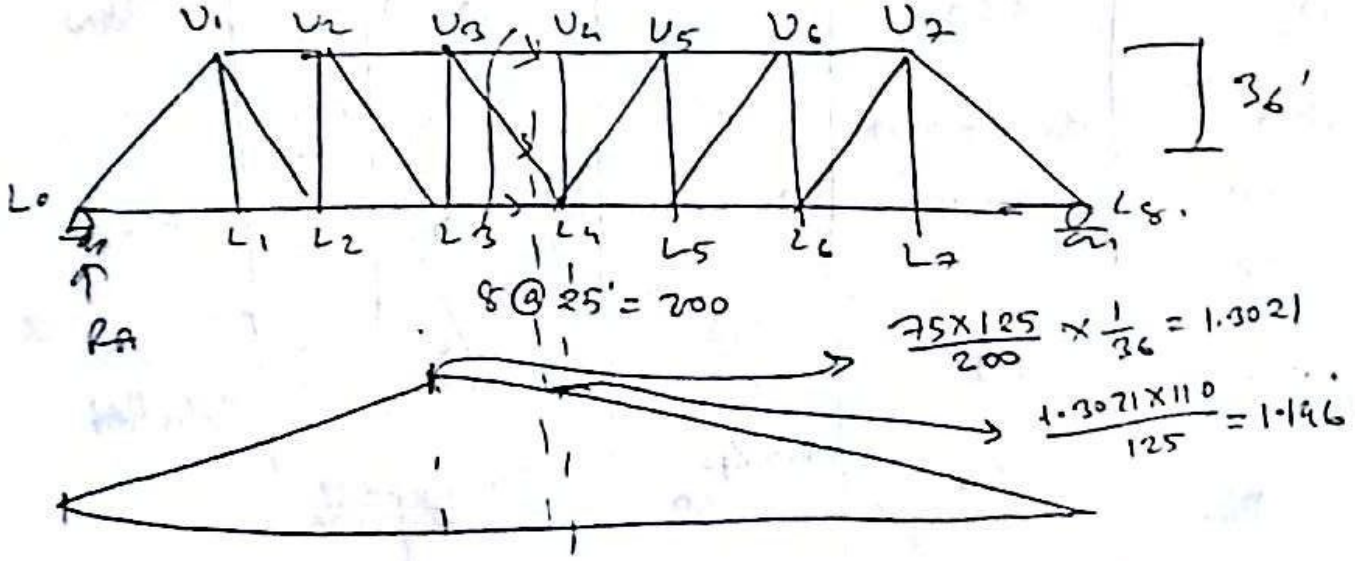
3	wheel 3 at L_4. STL $\frac{225}{100} > \frac{90}{85}$ STL $\frac{225}{100} < \frac{150}{75}$	Satisfied.	I_0 = ① - ⑪ + 45'UDL = 375 k. I_1 = 90 (STL) I_1 = 150 (STL)

wheel 3 @ L_4 will produce max tension.

$$\sigma_{max} = \frac{0.609}{100}\left[60\times(100+95+90+85)+75\times(70+65+60+55+50)\right] + \frac{0.609}{14.72}\times[60\times9.72] - \frac{0.457}{10.25}[30\times10] + \frac{1}{2}\times45\times6\times\frac{0.609}{100}\times45$$

$$= 319.703\ k$$

L_3L_4



$0 + 30 \times 10 + 30 \times (15+20+25+30) +$
$37.5 \times (45+50+55+60+65) =$
$\overline{x} \times (15 + 30\times5 + 37.5\times5)$
$\Rightarrow x = 37.8'$

↳ we can start from this distance.

$\sum M_{Wh} = 0.$

$R_A \cdot \times 75$ − Wh load x distance − $2_3 2_4 \times 3620$

$\Rightarrow 2_3 2_4 = \frac{R_A \times 75}{36.}$

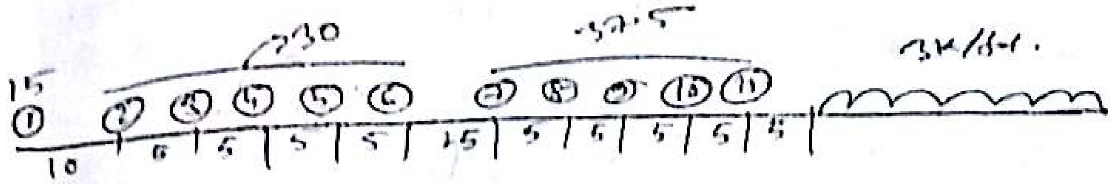
Loa

	Span.	left of L_4.	on span. W/L.	$\frac{W}{L}$.	remark
Wh2	$70\times8 = 560$	70.	$\frac{560}{250}$ >	$\frac{70}{100}$	not
JR.	70	$70\times2 = 140$	$\frac{560}{250}$ >	$\frac{140}{100}$	Satisfied
JL	560				
Wh3	$70\times8 = 560$	140	$\frac{560}{250}$ >	$\frac{140}{100}$	
JR	560.	$70\times3 = 210$	$\frac{560}{25}$ >	$\frac{210}{100}$	not satisfied
JL					
Wh4	560	210	$\frac{560}{250}$ >	$\frac{210}{100}$	Satisfied
JR	560	$70\times4 =$ $= 280.$	$\frac{560}{250}$ <	$\frac{280}{100}$	
JL					

wheel 4 @ L_4' will give max compression

force at bar A.

$F_A = -1.58$



	Load on span	Load on left of L3.	on span W/L	on left of L3 $\frac{W_1}{a}$.	Remark
Wh 7. JR JL.	① - ⑪ + 100' UDL = 652.5	① - ⑥ + = 165 ① - ⑦ = 202.5	$\frac{625.5}{200}$ > $\frac{625.5}{200}$ >	$\frac{165}{75}$ $\frac{208.5}{75}$	not satisfied.
Wh 8 JR JL	① - ⑪ + 105' UDL = 667.5	① - ⑦ = 202.5 ① - ⑧ = 240.	$\frac{667.5}{200}$ > $\frac{667.5}{200}$ >	$\frac{202.5}{75}$ $\frac{240}{75}$	not satisfied
Wh 9 JR JL	① - ⑪ + 110' UDL = 682.5	① - ⑧ = 240. ① - ⑨ = 277.5	$\frac{682.5}{200}$ > $\frac{682.5}{200}$ <	$\frac{240}{75}$ $\frac{277.5}{75}$	Satisfied.

wh 9 at L_3 will give max. member force

$$L_3L_4 = \frac{1.3021}{75} \times [15 \times 20 + 30 \times (30+35+40+45+50) + 37.5 \times (65+70+75)] + \frac{1.3021}{125} [37.5 (120+115)] + \frac{1}{2} \times 110 \times 1.146 \times 3$$

$$= 2.527 \text{ K}.$$

more coming soon