Structural Analysis 2
Project

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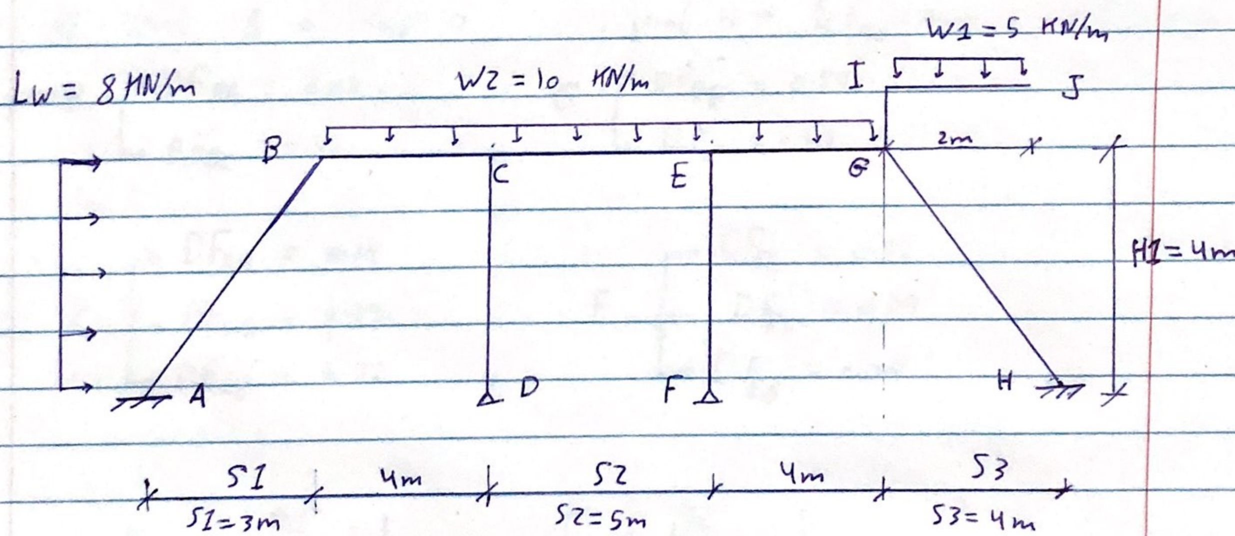
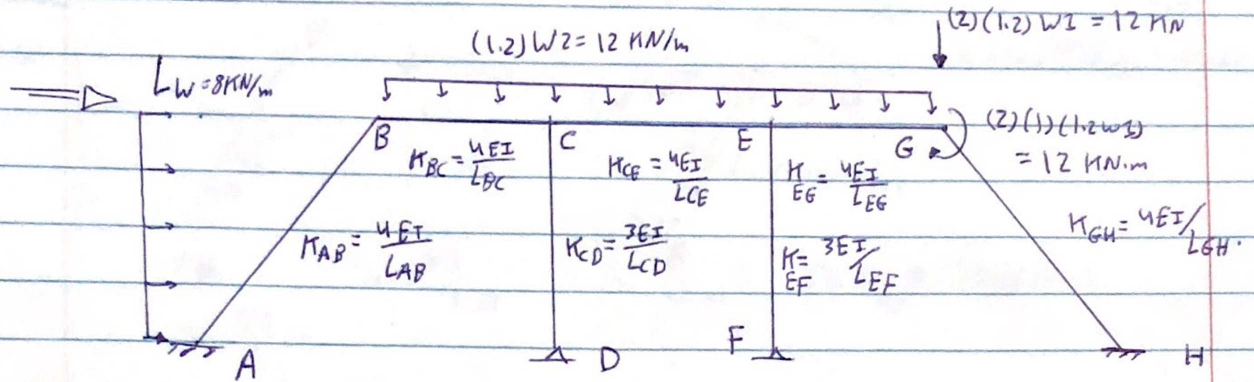


- Load Combination : 1.2 DL + 1.0 LW



$L_{AB} = \sqrt{S_1^2 + H_1^2} = 5m$, $L_{BC} = L_{EG} = 4m$, $L_{CD} = L_{EF} = H1 = 4m$

$L_{GH} = \sqrt{S_3^2 + H_1^2} = \sqrt{32}\ m$, $L_{CE} = S_2 = 5m.$

DF :

At joint A → $DF_{AB} = 0$, joint H → $DF_{HG} = 0$

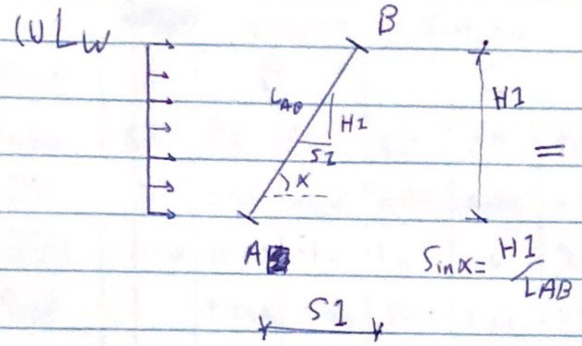
B → $DF_{BA} = 0.44$, $DF_{BC} = 0.56$, G → $DF_{GE} = 0.59$, $DF_{GH} = 0.41$

C → $DF_{CB} = 0.39$, $DF_{CD} = 0.29$, $DF_{CE} = 0.32$, E → $DF_{EC} = 0.32$, $DF_{EF} = 0.29$, $DF_{EG} = 0.39$

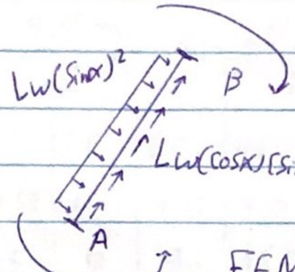
D → $DF_{DC} = 1$, F → $DF_{FE} = 1.$

Stage I:

FEM:



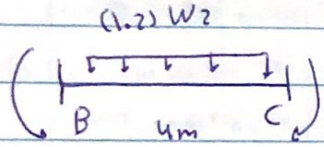
$\sin x = \frac{H1}{LAB}$



$FEM_{BA} = w(L_{AB})^2/12 = Lw(\sin x)^2 (L_{AB})^2/12$

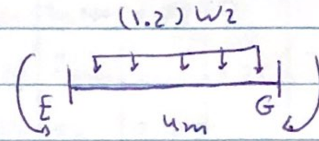
$= Lw\,(H1)^2/12 = 10.66\ KN.m$

$FEM_{AB} = -10.66\ KN.m$



$FEM_{BC} = -(1.2)\,W2(L_{BC})^2/12 = -16\ KN.m$

$FEM_{CB} = (1.2)\,W2\,(L_{BC})^2/12 = 16\ KN.m$

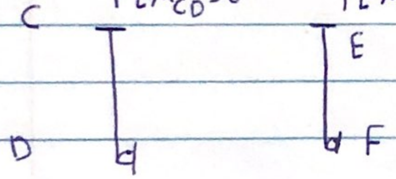


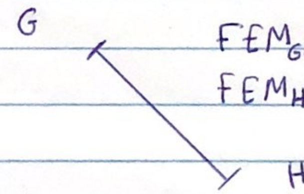
$FEM_{EG} = -16\ KN.m$

$FEM_{GE} = 16\ KN.m.$

$FEM_{CD} = 0$

$FEM_{EF} = 0$

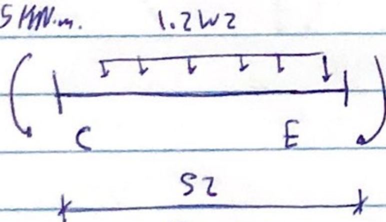




$FEM_{GH} = 0$

$FEM_{HG} = 0$

$FEM_{CE} = -25\ KN.m.$



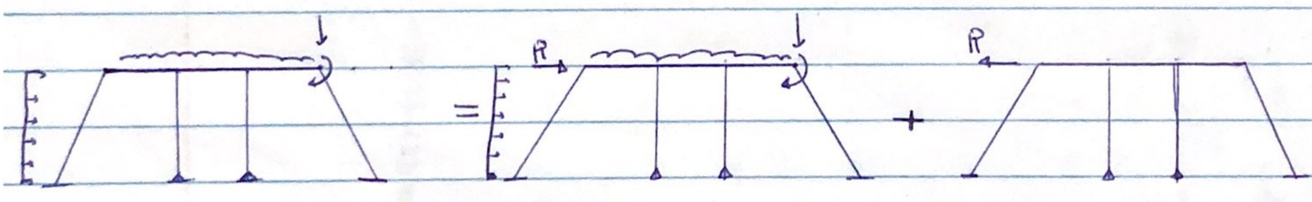
$S2 = 5m$

$FEM_{EC} = (1.2)\,W2(L_{CE})^2/12 = 25\ KN.m.$

Stage 1:

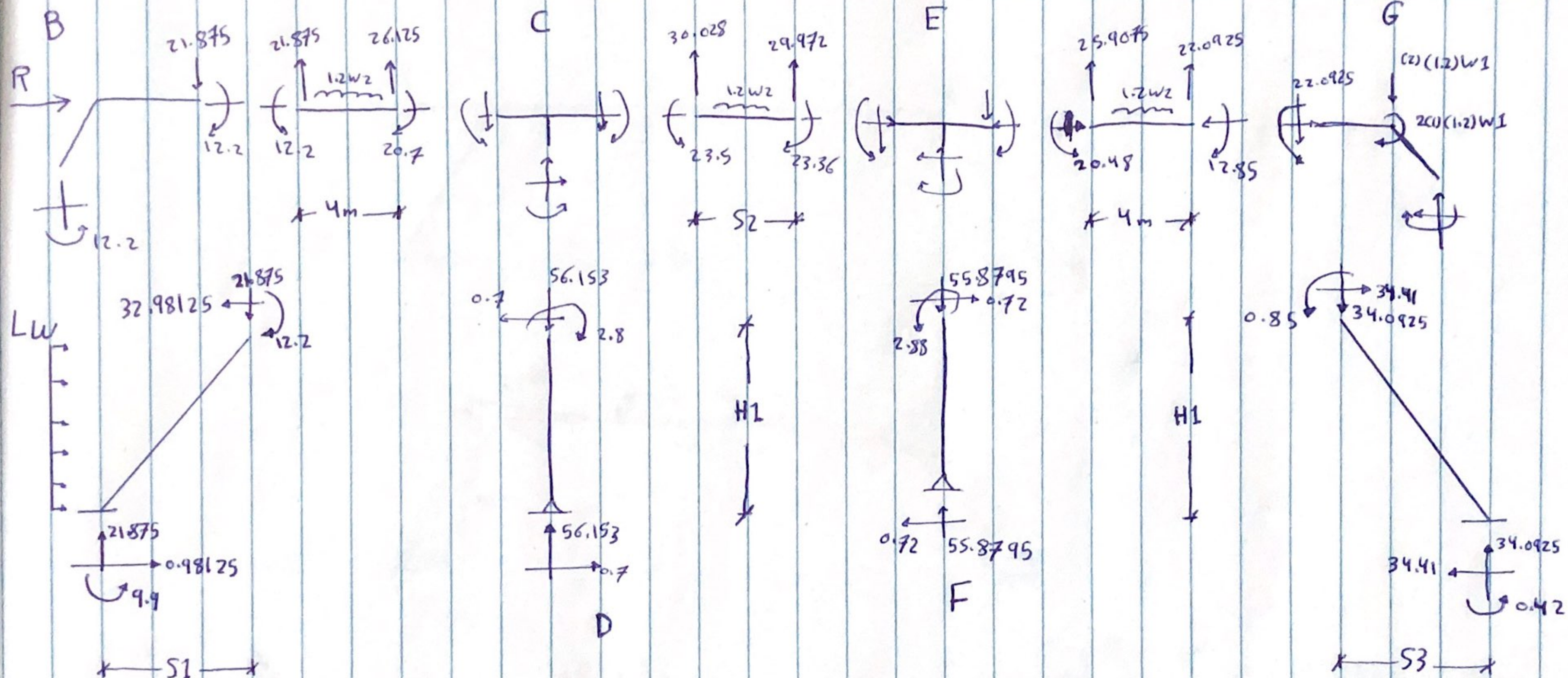
$\Sigma M_B = 0$ $\Sigma M_C = 0$ $\Sigma M_E = 0$ $\Sigma M_G = 12$ ← external moment.

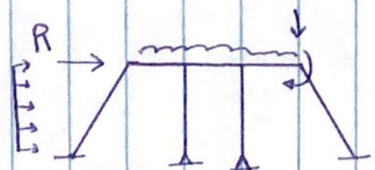
Joint	A	B		C			E			G		H	D	F
Member	AB	BA	BC	CB	CD	CE	EC	EF	EG	GE	GH	HG	DC	FE
DF	0	0.44	0.56	0.39	0.29	0.32	0.32	0.29	0.39	0.59	0.41	0	1	1
FEM	-10.66	10.66	-16	16	0	-25	25	0	-16	16	0	0	0	0
Dist.		2.3496	2.99	3.51	2.61	2.88	-2.88	-2.61	-3.51	-2.36	-1.64			
CO	1.1748		1.755	1.4952		-1.44	1.44		-1.18	-1.18		-0.82		
Dist.		-0.772	-0.983	-0.0215	-0.016	-0.0176	-0.083	-0.0754	-0.101	1.0355	0.72			
CO	-0.386		-0.01076	-0.4914		-0.0416	-0.0088		0.5177	-0.0507		0.36		
Dist.		0.0047	0.00603	0.20787	0.1546	0.17056	-0.163	-0.1476	-0.1985	0.03	0.0208			
Co	0.0237		0.104	0.003		-0.0814	0.0853		+0.01496	-0.099		0.0104		
Dist.		-0.046	-0.058	0.0306	0.0227	0.0251	-0.0321	-0.0291	-0.0391	0.0586	0.0467			
M_I	-9.9	12.2	-12.2	20.7	2.8	-23.5	23.36	-2.88	-20.48	12.85	-0.85	-0.42	0	0



Stage I Stage II

Stage 1



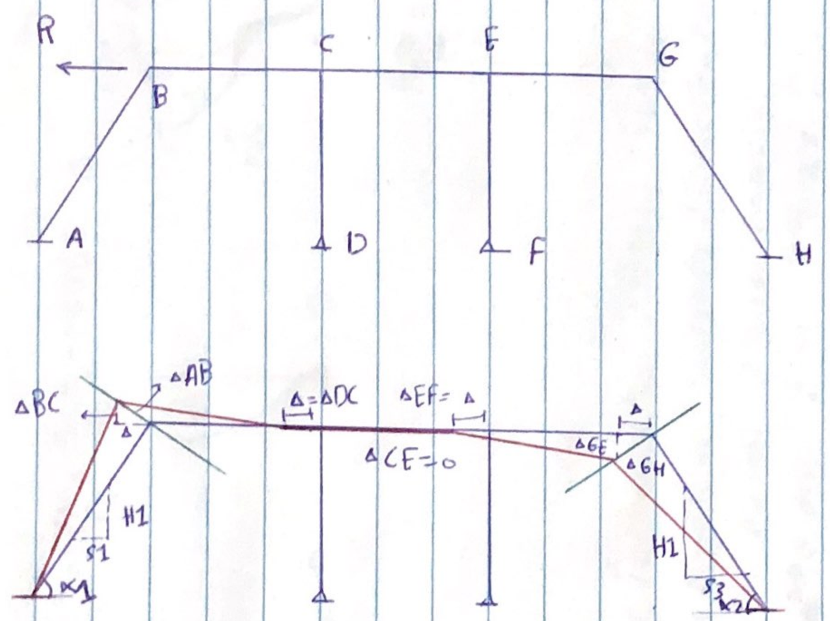


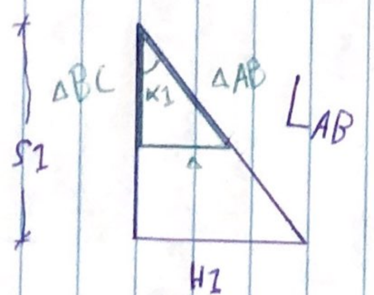
$\Sigma F_{x\,(system)} = 0 \Rightarrow R = 34.41 + 0.72 - 0.7 - 0.98125 - (8)(4)$

$R = 1.44875$ KN →

- Check: $\Sigma M_H = 0$ ✓

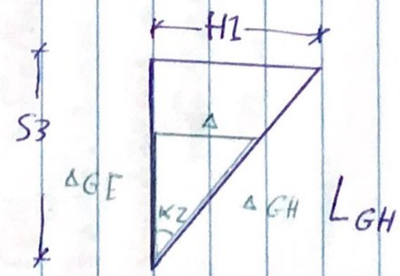
Stage II





$\Delta BC = \frac{S1}{H1} (\Delta)$

$\Delta AB = \frac{L_{AB}}{H1} (\Delta)$

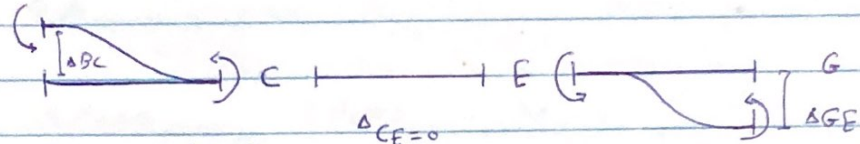


$\Delta GE = \frac{S3}{H1} (\Delta)$

$\Delta GH = \frac{L_{GH}}{H1} (\Delta)$

Stage II

FEM:

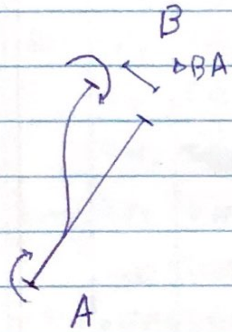


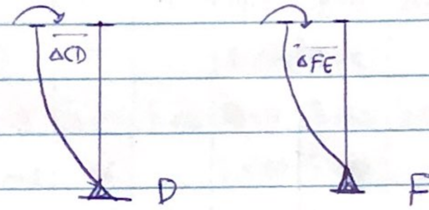
$\Delta_{CE}=0$

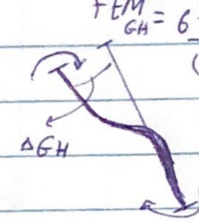
$\frac{-6EI\,S1\,\Delta}{H1\;L_{BC}^2} = FEM_{BC} = \frac{-6EI\,\Delta_{BC}}{(L_{BC})^2}$ $\quad FEM_{CE}, FEM_{EC} = 0 \quad FEM_{EG} = -0.375\,EI\Delta = \frac{-6EI\,S3\,\Delta}{H1(L_{EG})^2}$

$FEM_{CB} = -0.28125\,\Delta EI \quad FEM_{GE} = -0.375\,EI\Delta$

$FEM_{CD} = \frac{3EI\Delta}{(L_{DC})^2} = FEM_{FE} = \frac{3EI\Delta}{(H1)^2} = 0.1875\,EI\Delta$







$FEM_{GH} = \frac{6EI\,\Delta_{HG}}{(L_{HG})^2} = FEM_{HG}$

$FEM_{AB} = FEM_{BA} = \frac{6EI\,\Delta_{AB}}{(L_{AB})^2} = \frac{6EI\Delta}{(H1)(L_{AB})}$

$= 0.3\,\Delta EI$

$FEM_{GH} = \frac{6EI\,\Delta}{(H1)(L_{HG})}$

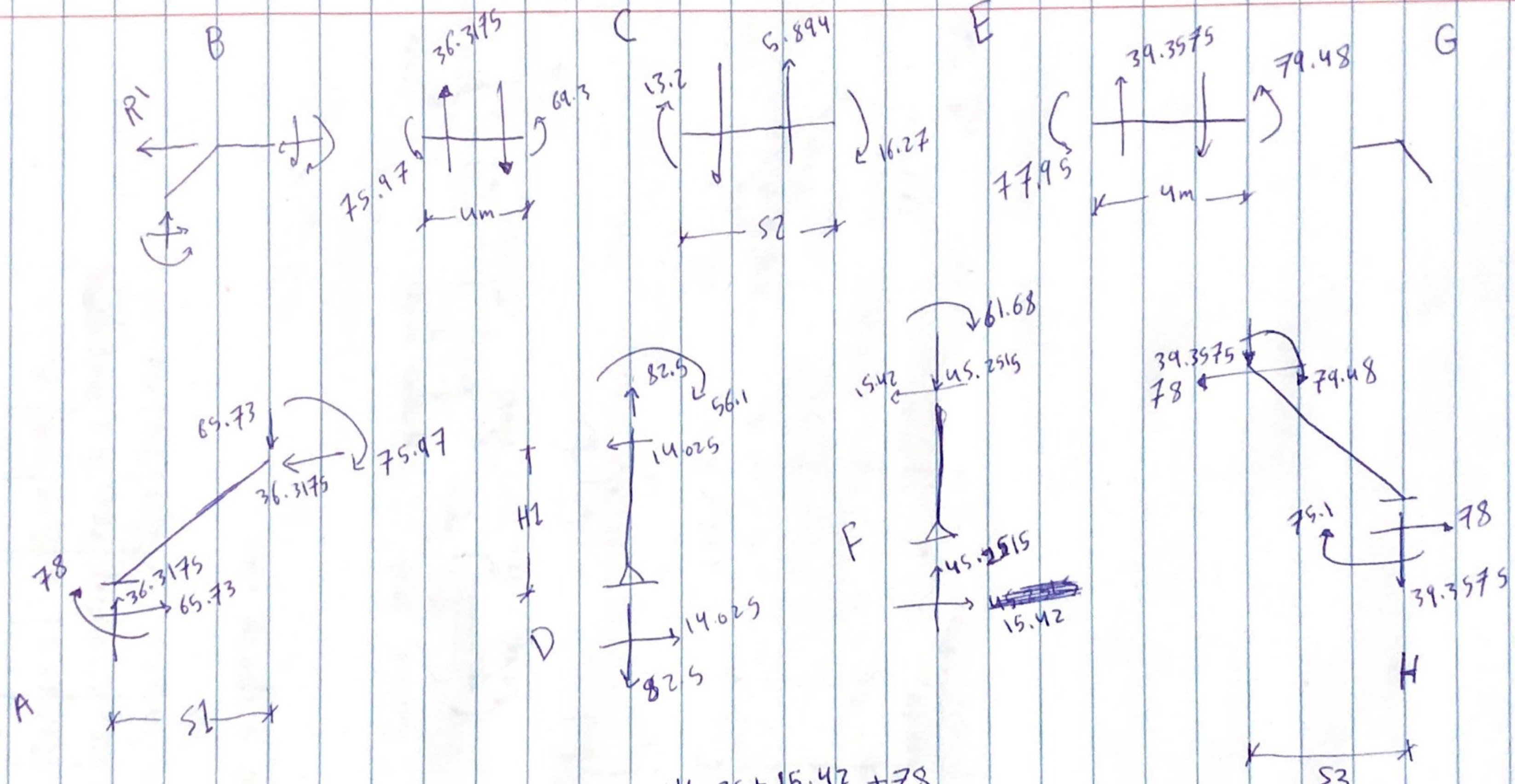
$= 0.26516\,EI\Delta$

	FEM_{AB}	FEM_{BC}	FEM_{CD}	FEM_{EF}	FEM_{EG}	FEM_{GH}
	$0.3\Delta EI$	$-0.28125\,\Delta EI$	$0.1875\,\Delta EI$	$0.1875\,\Delta EI$	$-0.375\,EI\Delta$	$0.26516\,\Delta EI$
	0.3	-0.28125	0.1875	0.1875	-0.375	0.26516
(÷0.375)	0.8	-0.75	0.5	0.5	-1	0.707
Assume $FEM_{EG} = 100$	80	-75	50	50	-100	70.7

Stage II : $\Sigma M_{at\ any\ joint} = 0.$

		$\Sigma M_B=0$		$\Sigma M_C=0$			$\Sigma M_E=0$			$\Sigma M_G=0$				
Joint	A	B		C			E			G		H	D	F
Member	AB	BA	BC	CB	CD	CE	EC	EF	EG	GE	GH	HG	DC	FE
DF	0	0.44	0.56	0.39	0.29	0.32	0.32	0.29	0.39	0.59	0.41	0	1	1
FEM	80	80	-75	-75	50	0	0	50	-100	-100	70.7	70.7	0	0
Dist.		-2.2	-2.8	9.75	7.25	8	16	14.5	19.5	17.287	12.013			
CO	-1.1		4.875	-1.4		8	4		8.6435	9.75		6		
Dist.		-2.145	-2.73	-2.574	-1.914	-2.112	-4.046	-3.6666	-4.931	-5.7525	-3.9975			
CO	-1.0725		-1.287	-1.365		-2.023	-1.056		-2.87625	-2.4656		-1.99575		
Dist.		0.5663	0.75933	1.321	0.98252	1.0842	1.258	1.14	1.5336	1.45465	1.0108			
CO	0.283		0.66066	0.3796		0.6292	0.5421		0.7273	0.766788		0.5054		
Dist.		-0.29	-0.37	-0.393	-0.2926	-0.323	-0.406	-0.368	-0.495	-0.4524	-0.3144			
CO	-0.145		-0.197	-0.185		-0.203	-0.161		-0.2262	-0.2475		-0.1572		
Dist.		0.08668	0.11	0.15	0.1125	0.1242	0.124	0.112788	0.151	0.146	0.101473			
CO	0.04334		0.075	0.055		0.062	0.0621		0.073	0.0755		0.0507375		
Dist.		-0.033	-0.042	-0.0456	-0.03393	-0.03744	-0.0432	-0.0392	-0.0527	-0.04455	-0.030955			
ΣM	78	75.97	-75.97	-69.3	56.1	13.2	16.27	61.68	-77.95	-79.48	+79.48	75.1	0	0

Stage II:



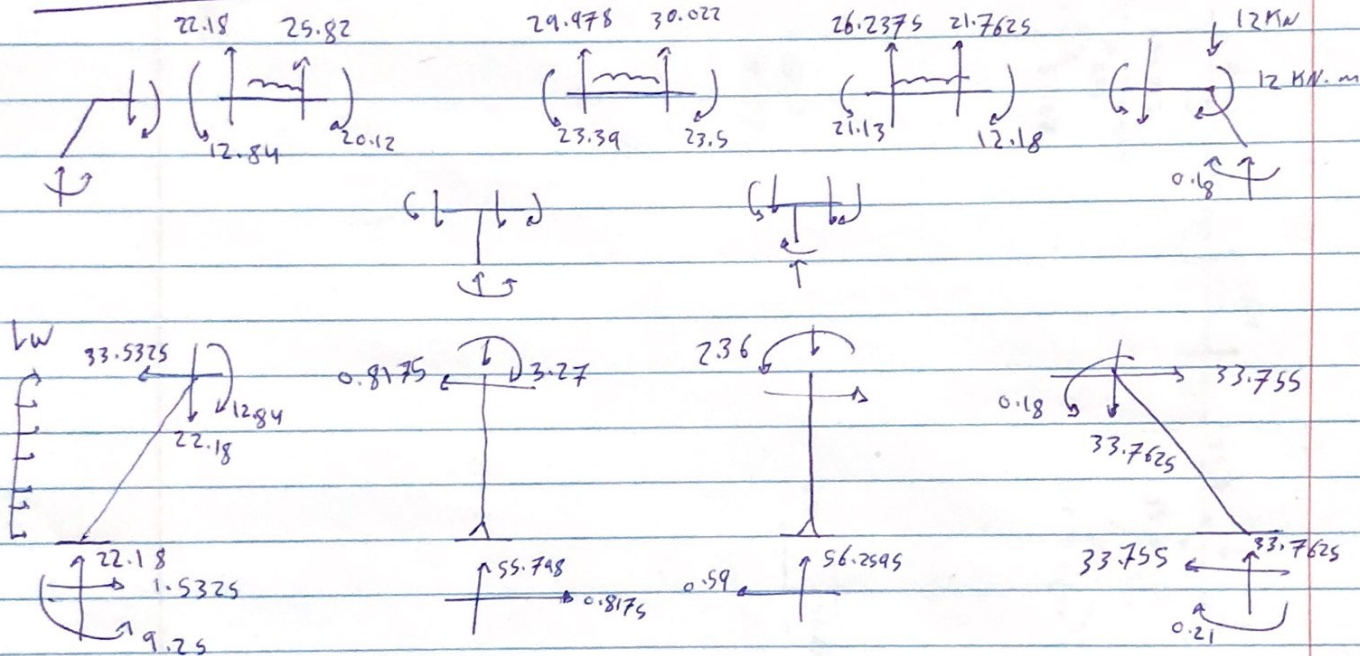
$R' = 65.73 + 14.025 + 15.42 + 78$

$R' = 173.18\ KN$

Member	AB	BA	BC	CB	CD	CE	EC	EF	EG	GE	GH	HG	DC	FE
M_I	-9.9	12.2	$\overline{12.2}$	20.7	2.8	$\overline{23.5}$	23.36	$\overline{2.88}$	$\overline{20.48}$	12.85	$\overline{0.85}$	$\overline{0.42}$	0	0
M_{II}	78	75.97	$\overline{75.97}$	$\overline{69.3}$	56.1	13.2	16.27	61.68	$\overline{77.95}$	$\overline{79.48}$	79.48	$\overline{75.1}$	0	0
$M_I + \frac{R}{R'}(M_{II})$	$\overline{9.25}$	12.84	$\overline{12.84}$	20.12	3.27	$\overline{23.39}$	23.5	$\overline{2.36}$	$\overline{21.13}$	12.18	$\overline{0.18}$	0.21	0	0

$R = 1.44875$ KN , $R' = 173.18$ KN.

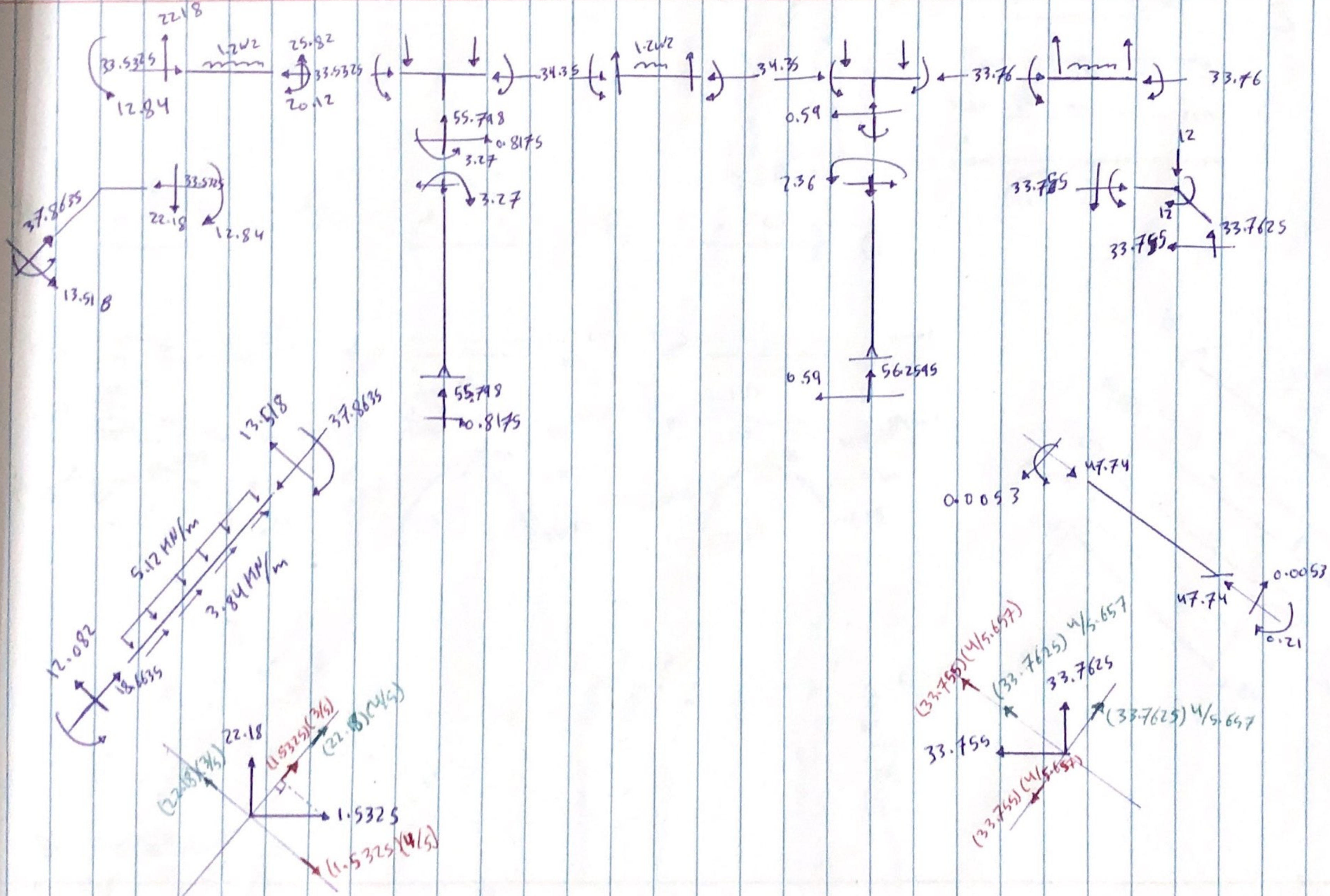
REAL System:

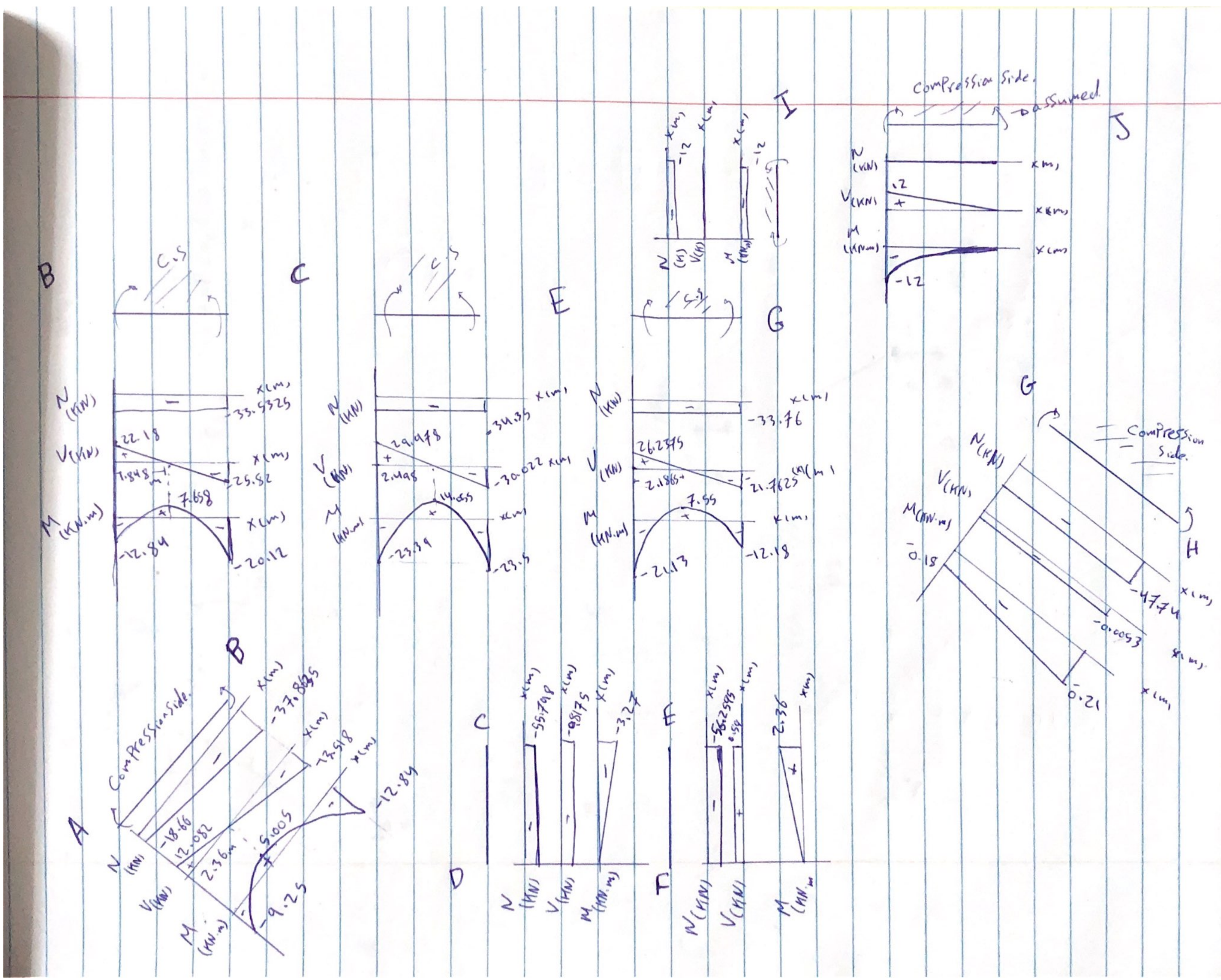


Check:

$\Sigma F_x = 0$ ✓

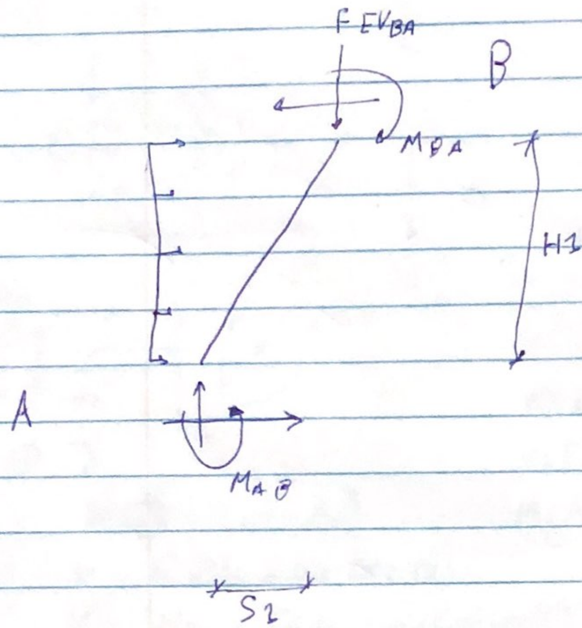
$\Sigma F_y = 0$ ✓


22.18
33.5325
12.84
1.2w2
25.82
20.12
55.798
0.8175
3.27
34.35
0.59
2.36
56.2545
33.76
12
33.7625
37.8635
13.518
5.12 kN/m
3.84 kN/m
12.082
1.5325
47.74
0.0053
0.21
33.755

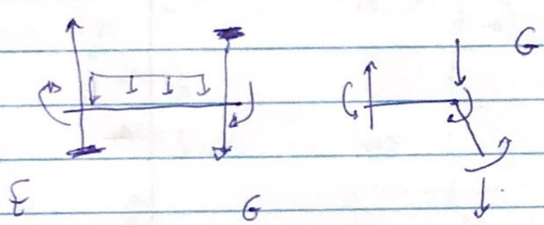


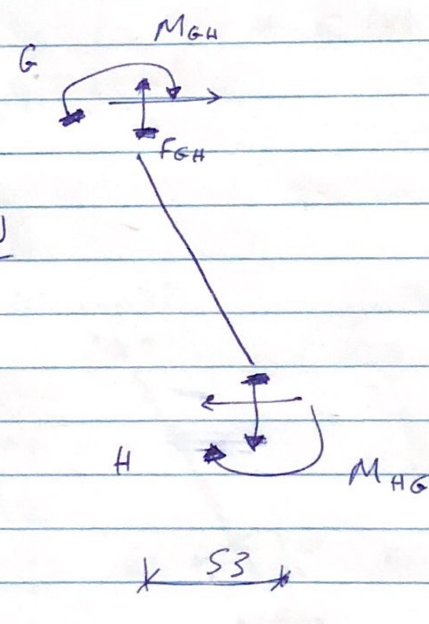
A
B
Compression side.
N (KN)
V (KN)
M (KN.m)
-18.66
12.082
2.36m
5.005
-9.25
-37.8635
-23.518
-12.84
x(m)
C.S
22.18
7.848
7.658
-12.84
-33.9325
-25.82
-20.12
C
29.978
2.998
14.655
-23.39
-34.35
-30.022
-23.5
E
G
26.2375
2.1865
7.55
-21.13
-33.76
-21.7625
-12.18
D
-55.798
-.08175
-3.27
F
-56.2595
0.58
2.36
I
-12
J
Compression Side.
assumed.
.12
H
Compression Side.
0.18
-0.21
-0.0053
-47.74

- Find A_x, H_x:



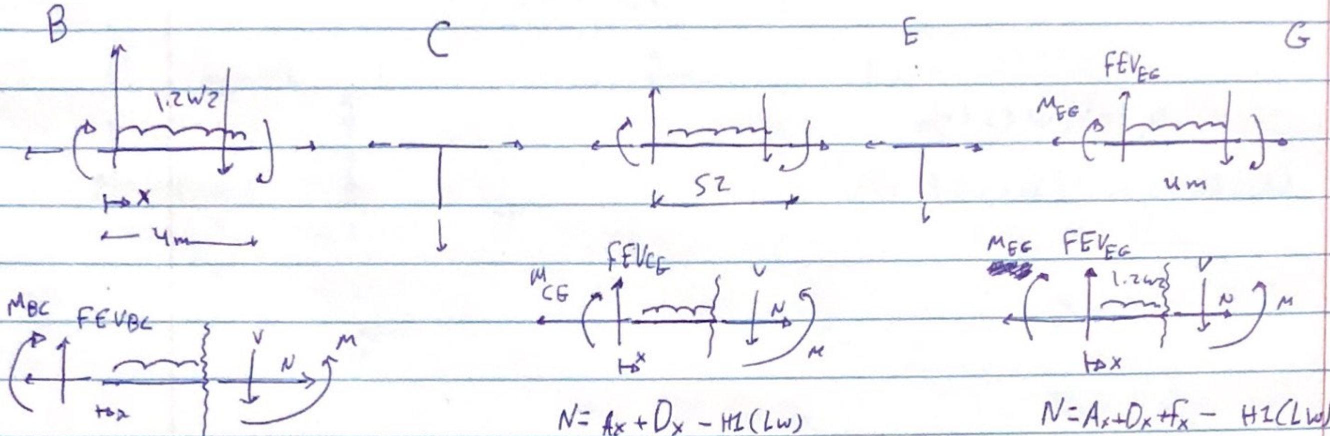
$$R_{A,x} = \frac{-(\Sigma M + F E V_B (S1) - Lw (H2)^2/2)}{H1}$$





$$R_{H,x} = \frac{-(\Sigma M + F_{GH}(S3))}{H1}$$

To find axial, Shear and bending moment diagrams:



$N = A_x + D_x - H1(Lw)$

$V = FEV_{CE} - (1.2W2)\,X$

$M = M_{CE} + FEV_{CE}(X) - 1.2W2(X^2/2)$

$N = A_x + D_x + F_x - H1(Lw)$

$V = FEV_{EG} - (1.2W2)(X)$

$M = M_{EG} + FEV_{EG}(X) - 1.2W2(X^2/2)$

(+) ↻

$N = -((H1 * Lw) - A_x)$

$V = FEV_{BC} - (1.2)W2\,(X)$

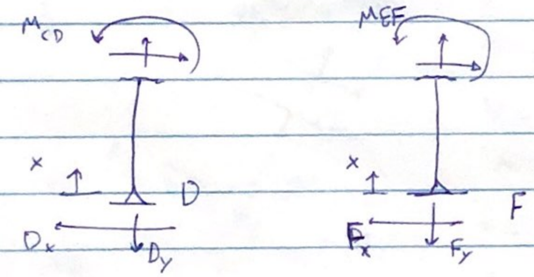
$M = M_{BC} + FEV_{BC}\,(X) - (1.2)\,W2\,(X^2/2)$

(+) ↻

$N = -D_y$

$V = D_x$

$M = D_x(X)$

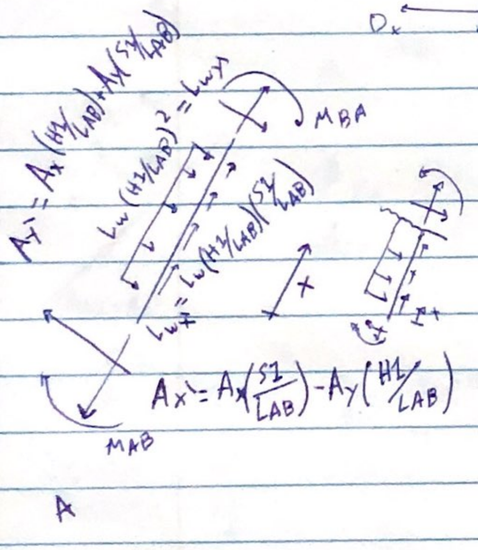


$N = -F_y$

$V = F_x$

$M = F_x\,(X)$

(+) ↻

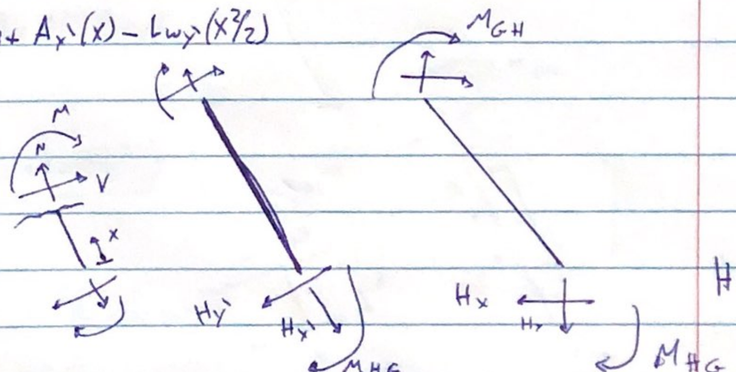


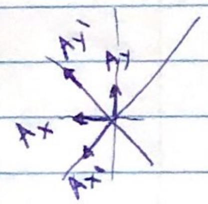
$A_x' = A_x\left(\frac{S1}{LAB}\right) - A_y\left(\frac{H1}{LAB}\right)$

$N = A_x' - (Lw_x')\,X$

$V = A_y' - Lw_y'(X)$

$M = M_{AB} + A_x'(X) - Lw_y'(X^2/2)$





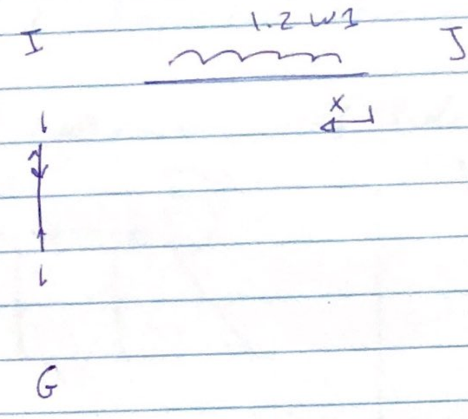
$N = H_x'$

$V = H_y'$

$M = -M_{HG} - H_y'(X)$

$H_x' = H_y\left(\frac{H1}{L_{HG}}\right) - H_x\left(\frac{S3}{L_{HG}}\right)$

$H_y' = H_y\left(\frac{S3}{L_{HG}}\right) + H_x\left(\frac{H1}{L_{HG}}\right)$



$N = (-1.2)(2)W1$

$V = 0$

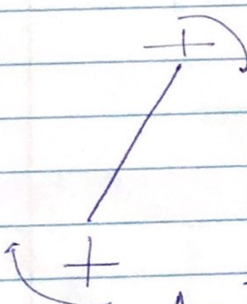
$M = 1.2(2)W1$

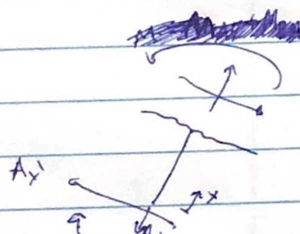
$N = 0$

$V = (-1.2)\,W1(2)\,X$

$M = 1.2W1(X^2/2) - 1.2W1(2X)$

For load Combination 2: $1.2D + 1.0\,Lw$
(Wind load Right side).



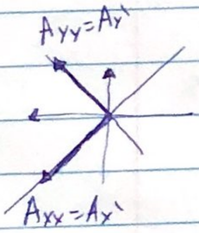


$M = M_{AB} + A_y`(x)$

$V = A_y`$

$N = A_x`$

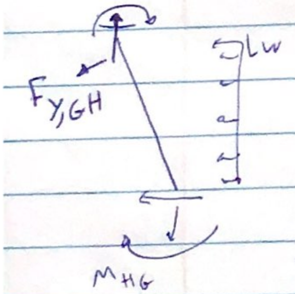
$A_x = -(M_{AB} + M_{BA} + V_{BC}(S1)) / H1$



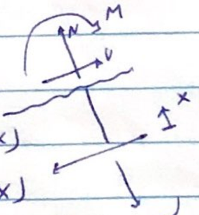
G

$A_{yy} = A_y(S1/L_{AB}) + A_x(H1/L_{AB})$

$A_{xx} = -A_y(H1/L_{AB}) + A_x(S1/L_{AB})$



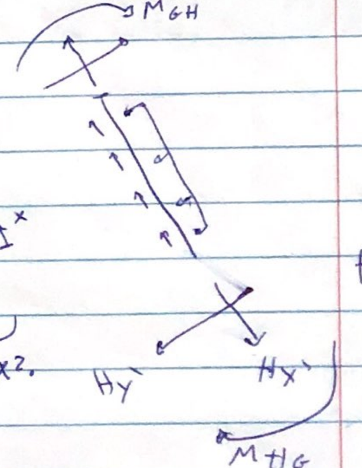
$$H_x = \frac{-(M_{GH} + M_{HG} + F_{y,GH}(S3) + L_w(H1)^2/2)}{H1}$$



$N = H_x` - L_w`x(x)$

$V = H_y` + L_w y`(x)$

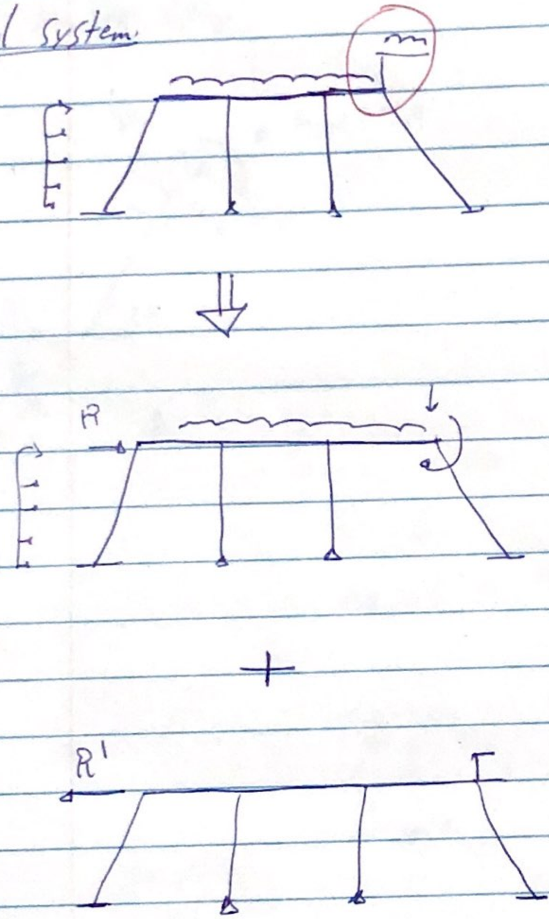
$M = -H_y`(x) - M_{HG} - 0.5L_w y` x^2.$



- to find Horizontal drift:

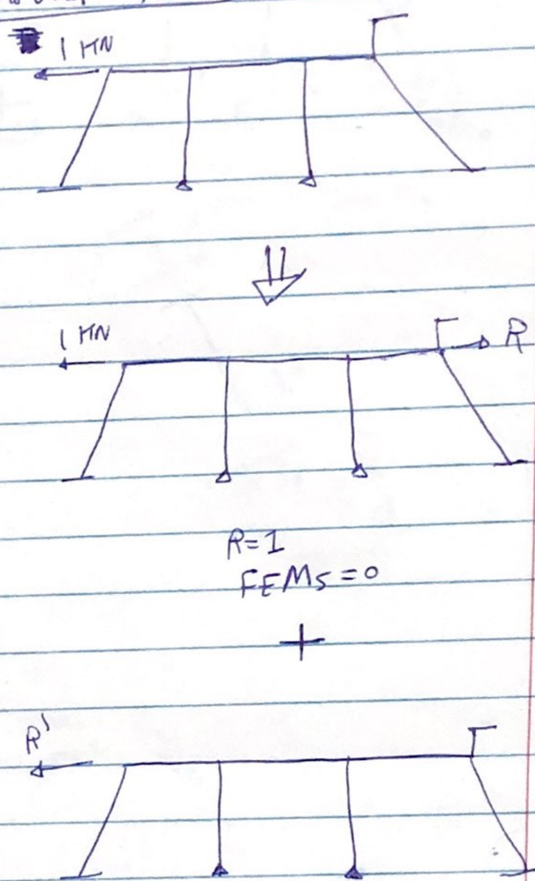
L.C 3 : (1)D + (1)W. (left side.

Real system.



R , R' → M , reactions.

Virtual system.



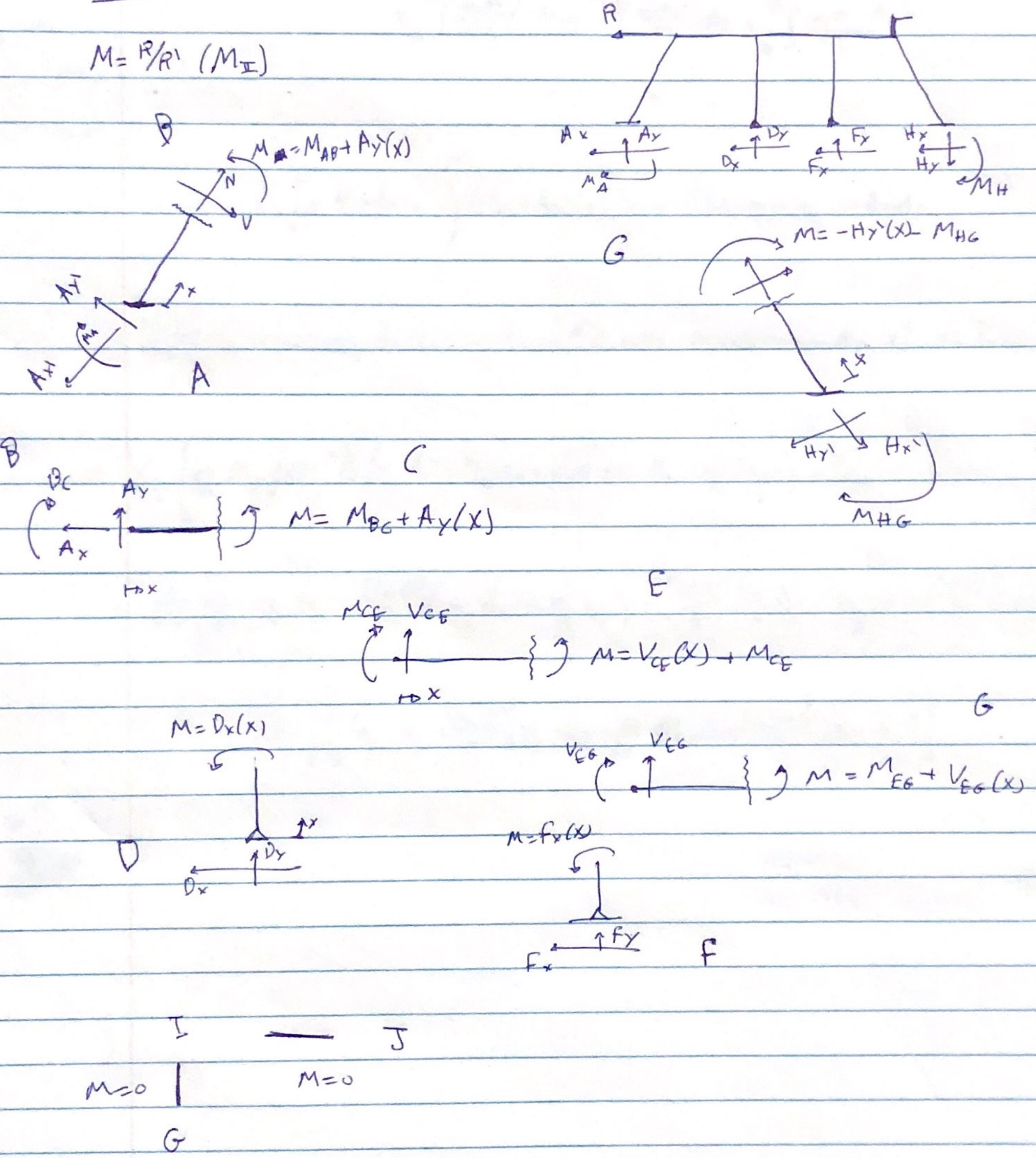
R=1, R' → M → reactions

$M_I = 0$

$M = R/R' (M_{II}) = M_2/R'$

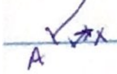
Virtual Systems:

$M = R/R' (M_{II})$



$$1 \cdot \Delta = \int_A^B \frac{mM\,dx}{EI} + \int_B^C \frac{mM\,dx}{GI} + \int_C^D \frac{mM\,dx}{EI} + \int_C^E \frac{mM\,dx}{EI} + \int_E^G \frac{mM\,dx}{EI} + \int_F^E \frac{mM\,dx}{EI}$$

$$+ \int_G^I \frac{mM}{EI}\,dx \;(\to 0) + \int_I^J \frac{mM}{EI}\,dx \;(\to 0) + \int_G^H \frac{mM\,dx}{EI}$$



$$\int_0^{L_{AB}} \frac{mM\,dx}{EI}$$

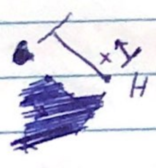
$$= \frac{1}{EI} \int mM\,dx = \int \left(M_{ab} + A_y'(x) - Lw_y' \, x^2/2\right)\left(m_{ab} + a_y'(x)\right) dx$$

$$= \frac{1}{EI} \int \left[M_{ab}(m_{ab}) + m_{ab} A_y'(x) - m_{ab} Lw_y' \, x^2/2 + M_{ab} a_y'(x) + a_y' A_y' x^2 - a_y' Lw_y' \, x^3/2 \right] dx$$

$$= \frac{1}{EI} \left[m_{ab} M_{ab}(x) + \frac{x^2}{2}\left(m_{ab} A_y' + M_{ab} a_y'\right) + \frac{x^3}{3}\left(a_y' A_y' - m_{ab}\frac{Lw_y'}{2}\right) - \frac{x^4}{4}\left(a_y' Lw_y'/2\right) \right] \Bigg|_0^{L_{AB}}$$

$$= \frac{1}{EI} \left[L_{AB}\, m_{ab} M_{ab} + \frac{(L_{AB})^2}{2}\left(m_{ab} A_y' + M_{ab} a_y\right) + \frac{(L_{AB})^3}{3}\left(a_y A_y - \frac{m_{ab} Lw_y'}{2}\right) - \frac{(L_{AB})^4}{4}\left(\frac{a_y' Lw_y'}{2}\right) \right]$$

$$\int_0^{L_{GH}} \frac{mM\,dx}{EI} = \frac{1}{EI} \left[L_{GH}\, m_{HG} M_{HG} + \frac{(L_{GH})^2}{2}\left(m_{HG} H_y + M_{HG} h_y'\right) + \frac{(L_{HG})^3}{3}\left(h_y' H_y'\right) \right]$$



BC

$$\int_0^{L_{BC}} \frac{mM\,dx}{EI} = \frac{1}{EI}\int (m_{bc} + v_{bc}(x))(M_{bc} + V_{bc}(x) - wz(x^2/2))\,dx$$

$\frac{B}{\Delta x}$

$$= \frac{1}{EI}\left[\int m_{bc}M_{bc} + x(v_{bc}M_{bc} + m_{bc}V_{bc}) + x^2\left(v_{bc}V_{bc} - \frac{wz\,m_{bc}}{2}\right) - x^3\left(v_{bc}\left(w^2/2\right)\right)\right]dx$$

$$= \frac{1}{EI}\left[4m_{bc}M_{bc} + 8(v_{bc}M_{bc} + m_{bc}V_{bc}) + \frac{(4)^3}{3}\left(v_{EG}V_{EG} - \frac{wz\,m_{EG}}{2}\right) - 64\left(v_{bc}\left(w^2/2\right)\right)\right]$$

$\frac{E}{\Delta x}$

EG

$$\int_0^{L_{EG}} \frac{mM\,dx}{EI} = \frac{1}{EI}\left[4m_{EG}M_{EG} + 8(v_{EG}M_{EG} + m_{EG}V_{EG}) + \frac{(4)^3}{3}\left(v_{EG}V_{EG} - \frac{wz\,m_{EG}}{2}\right) - 64\left(v_{EG}\left(w^2/2\right)\right)\right]$$

$\frac{C}{\Delta x}$

CE

$$\int_0^{L_{CE}} \frac{mM\,dx}{EI} = \frac{1}{EI}\left[L_{CE}\,m_{CE}M_{CE} + \frac{(L_{CE})^2}{2}(v_{CE}M_{CE} + m_{CE}V_{CE}) + \frac{(L_{CE})^3}{3}\left(v_{CE}V_{CE} - \frac{wz\,m_{CE}}{2}\right) - \frac{(L_{CE})^4}{4}\left(v_{CE}\,w^2/2\right)\right]$$

Δ_{Dx}

CD

$$\int_0^{L_{CD}} \frac{mM\,dx}{EI} = \frac{1}{EI}\int (xD_x)(d_x x)\cdot dx = \frac{1}{EI}\left[\frac{d_x D_x\,(L_{CD})^3}{3}\right]$$

Δ_{Fx}

EF

$$\int_0^{L_{EF}} \frac{mM\,dx}{EI} = \frac{1}{EI}\left[\frac{f_x F_x\,(L_{EF})^3}{3}\right]$$