

PROF. SÉRGIO CONCLI GOMES

EXERCÍCIOS DE ISOSTÁTICA

3ª edição 1982

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## EXERCÍCIOS DE ISOSTÁTICA

- 1) Calcular os graus de estaticidade total, externo e interno para as estruturas das figuras 1 a 10.
- 2) Calcular as reações externas na viga em balanço da figura 11.
- 3) Calcular as reações externas na viga simplesmente apoiada da figura 12.
- 4) Calcular as reações externas na viga simplesmente apoiada, com um balanço, da figura 13.
- 5) Calcular as reações externas na viga simplesmente apoiada, com dois balanços, da figura 14.
- 6) Calcular as reações externas no arco engastado da figura 15.
- 7) Calcular as reações externas no arco simplesmente apoiada da figura 16.
- 8) Calcular as reações externas no arco simplesmente apoiado da figura 17.
- 9) Calcular as reações externas no pórtico da figura 18.
- 10) Calcular as reações externas no pórtico da figura 19.
- 11) Calcular as reações externas no pórtico da figura 20.
- 12) Calcular as reações externas na estrutura plana da figura 21.
- 13) Calcular as reações externas na estrutura plana da figura 22.
- 14) Calcular as reações externas na estrutura plana da figura 23.
- 15) Calcular as reações externas na grelha engastada da figura 24.
- 16) Calcular as reações externas na grelha engastada da figura 25.
- 17) Calcular as reações externas na grelha apoiada da figura 26.

- 18) Calcular as reações externas na grelha apoiada da figura 27.
- 19) Calcular as reações externas no arco trirotulado da figura 28.
- 20) Calcular as reações externas no pórtico trirotulado da figura 29.
- 21) Calcular as reações externas no pórtico trirotulado da figura 30.
- 22) Calcular as reações externas na viga Gerber da figura 31.
- 23) Calcular as reações externas na viga Gerber da figura 32.
- 24) Calcular as reações mútuas na rótula interna do arco trirotulado da figura 33.
- 25) Calcular as reações mútuas na rótula interna do pórtico trirotulado da figura 34.
- 26) Calcular as reações mútuas nas rótulas internas da viga Gerber da figura 35.
- 27) Calcular as reações externas na estrutura rotulada internamente da figura 36.
- 28) Calcular as reações externas na estrutura rotulada internamente da figura 37.
- 29) Calcular as reações externas na estrutura rotulada internamente da figura 38.
- 30) Calcular as reações externas na estrutura rotulada internamente da figura 39.
- 31) Calcular as reações externas no pórtico trirotulado da figura 40.
- 32) Calcular as reações externas na viga Gerber da figura 41.
- 33) Calcular as reações mútuas nas rótulas A e B da viga Gerber da figura 42.
- 34) Calcular as reações externas na estrutura rotulada internamente da figura 43.

- 35) Calcular as reações mútuas na rótula interna do arco trirotulado da figura 44.
- 36) Calcular as reações externas na estrutura rotulada internamente da figura 45.
- 37) Calcular os módulos das solicitações na secção S da estrutura da figura 46.
- 38) Calcular os módulos das solicitações nas secções  $S_1$  e  $S_2$  da estrutura da figura 47.
- 39) Calcular, na estrutura da figura 48 os módulos das solicitações nas secções  $S_1$  e  $S_2$ .
- 40) A peça cilíndrica da figura 49 tem 40 cm de diâmetro e pesa 100 Kgf por metro de comprimento. Calcular os módulos das solicitações nas secções  $S_1$  e  $S_2$ .
- 41) Calcular os módulos das solicitações nas secções  $S_1$  e  $S_2$  da estrutura trirotulada da figura 50.
- 42) Calcular os módulos das solicitações nas secções  $S_1$  e  $S_2$  da estrutura da figura 51.
- 43) Calcular os módulos das solicitações nas secções  $S_1$  e  $S_2$  da estrutura da figura 52.
- 44) Calcular os módulos das solicitações nas secções  $S_1$  e  $S_2$  da estrutura da figura 53.
- 45) Calcular os esforços normais nas hastes da treliça plana da figura 54.



- 46) Calcular os esforços normais nas hastes da treliça plana da figura 55.
- 47) Calcular os esforços normais nas hastes da treliça plana da figura 56.
- 48) Calcular os esforços normais nas hastes da treliça plana da figura 57.
- 49) Calcular os esforços normais nas hastes da treliça plana da figura 58.
- 50) Calcular os esforços normais nas hastes da treliça plana da figura 59.
- 51) Calcular os esforços normais nas hastes A, B, C e D da treliça plana da figura 60.
- 52) Calcular os esforços normais nas hastes A, B, C e D da treliça plana da figura 61.
- 53) Calcular os esforços normais nas hastes A, B, C e D da treliça plana da figura 62.
- 54) Calcular os esforços normais nas hastes A, B, C e D da treliça plana da figura 63.
- 55) Calcular os esforços normais nas hastes A, B, C e D da treliça plana da figura 64.
- 56) Calcular os esforços normais nas hastes A, B, C e D da treliça plana da figura 65.
- 57) Calcular os esforços normais nas hastes A, B, C e D da treliça plana da figura 66.
- 58) Calcular os esforços normais nas hastes da treliça plana da figura 67.
- 59) Calcular os esforços normais nas hastes da treliça plana da figura 68.
- 60) Calcular os esforços normais nas hastes da treliça plana da figura 69.

- 61) Calcular os esforços normais nas hastes da treliça plana da figura 70.
- 62) Calcular os esforços normais nas hastes da treliça plana da figura 71.
- 63) Calcular os esforços normais nas hastes da treliça plana da figura 72.
- 64) Calcular os esforços normais nas hastes da treliça espacial da figura 73. A carga está contida no plano XOY.
- 65) Calcular os esforços normais nas hastes da treliça espacial da figura 74. A carga 2 tf é paralela a AX e a carga 3 tf é paralela a AY.
- 66) Calcular os esforços normais nas hastes da treliça espacial da figura 75. A carga 2 tf está sobre DZ e a carga 3 tf é paralela ao eixo Y.
- 67) Calcular os esforços normais nas hastes da treliça espacial da figura 76. A carga é paralela ao eixo Z.
- 68) Calcular os esforços normais nas hastes da treliça espacial da figura 77. A carga está no plano XOY.
- 69) Calcular os esforços normais nas hastes da treliça espacial da figura 78. A carga 2 tf está sobre o eixo Z e a carga 1 tf é paralela ao eixo X.
- 70) Calcular os esforços normais nas hastes da treliça espacial da figura 79. A carga é paralela ao eixo Y.
- 71) Calcular os esforços normais nas hastes da treliça espacial da figura 80. As cargas são paralelas ao eixo Z.
- 72) Calcular os esforços normais nas hastes da treliça espacial da figura 81.
- 73) Traçar os diagramas de esforços cortantes e momentos fletores para a viga da figura 82.
- 74) Traçar os diagramas de esforços cortantes e momentos fletores para a viga da figura 83.



- 75) Traçar os diagramas de esforços cortantes e momentos fletores para a viga da figura 84.
- 76) Traçar os diagramas de esforços cortantes e momentos fletores para a viga da figura 85.
- 77) Traçar os diagramas de esforços cortantes e momentos fletores para a viga da figura 86.
- 78) Traçar os diagramas de esforços cortantes e momentos fletores para a viga da figura 87.
- 79) Traçar os diagramas de esforços cortantes e momentos fletores para a viga da figura 88.
- 80) Traçar os diagramas de esforços cortantes e momentos fletores para a viga da figura 89.
- 81) Para a viga da figura 90 traçar o diagrama de esforços cortantes.
- 82) Para a viga da figura 91 traçar o diagrama de esforços cortantes.
- 83) Para a viga da figura 92 traçar o diagrama de esforços cortantes.
- 84) Para a viga da figura 93 traçar o diagrama de esforços cortantes.
- 85) Para a viga da figura 94 traçar o diagrama de esforços cortantes.
- 86) Para a viga Gerber da figura 95 traçar o diagrama de esforços cortantes.
- 87) Traçar os diagramas de esforços cortantes e momentos fletores para a viga da figura 96.
- 88) Traçar os diagramas de esforços cortantes e momentos fletores para a viga da figura 97.
- 89) Traçar os diagramas de esforços cortantes e momentos fletores para a viga da figura 98.
- 90) Traçar os diagramas de esforços cortantes e momentos fletores para a viga da figura 99.

- 91) Traçar o diagrama de momentos fletores para a viga da figura 100.
- 92) Traçar o diagrama de momentos fletores para a viga da figura 101.
- 93) Traçar o diagrama de momentos fletores para a viga Gerber da figura 102.
- 94) Traçar o diagrama de momentos fletores para a viga Gerber da figura 103.
- 95) Traçar os diagramas de esforços normais, esforços cortantes e momentos fletores para o pórtico da figura 104.
- 96) Traçar o diagrama de momentos fletores para o pórtico da figura 105.
- 97) Para o pórtico da figura 106 traçar o diagrama de momentos fletores referente ao trecho CDE.
- 98) Para a estrutura da figura 107 traçar o diagrama de momentos fletores.
- 99) Traçar os diagramas de esforços normais, esforços cortantes e momentos fletores para o pórtico trirotulado da figura 108.
- 100) Traçar o diagrama de momentos fletores para o trecho BC do pórtico trirotulado da figura 109.
- 101) Traçar os diagramas de esforços normais e esforços cortantes para o pórtico trirotulado da figura 110.
- 102) Traçar o diagrama de esforços cortantes para a estrutura rotulada internamente, da figura 111.
- 103) Traçar o diagrama de esforços cortantes para a estrutura trirotulada da figura 112.
- 104) Para o arco da figura 113, traçar o diagrama de esforços normais.

- 105) Para o arco da figura 114, traçar os diagramas de esforços normais e esforços cortantes.
- 106) Para o arco da figura 115, traçar o diagrama de momentos fletores.
- 107) Para o arco da figura 116, traçar os diagramas de esforços normais, esforços cortantes e momentos fletores.
- 108) Para o arco da figura 117, traçar os diagramas de esforços normais, esforços cortantes e momentos fletores.
- 109) Para o arco da figura 118, traçar os diagramas de esforços normais, esforços cortantes e momentos fletores.
- 110) Traçar os diagramas de esforços normais, esforços cortantes e momentos fletores para a estrutura da figura 119.
- 111) Traçar os diagramas de esforços normais, esforços cortantes e momentos fletores para a estrutura da figura 120.
- 112) Traçar os diagramas de esforços normais, esforços cortantes e momentos fletores para a estrutura da figura 121.
- 113) Traçar os diagramas de esforços normais, esforços cortantes e momentos fletores para a estrutura da figura 122.
- 114) Traçar os diagramas de esforços normais e esforços cortantes para a estrutura da figura 123.
- 115) Traçar os diagramas de esforços cortantes e de momentos fletores para a estrutura da figura 124.
- 116) Traçar o diagrama de momentos fletores para a estrutura da figura 125.
- 117) Para a grelha engastada da figura 126 traçar os diagramas de esforços cortantes, momentos fletores e momentos torçores.
- 118) Para a grelha engastada da figura 127 traçar os diagramas de esforços cortantes, momentos fletores e momentos torçores.

- 119) Para a grelha engastada da figura 128 traçar os diagramas de esforços cortantes, momentos fletores e momentos torçores.
- 120) Para a grelha apoiada da figura 129 traçar os diagramas de esforços cortantes, momentos fletores e momentos torçores.
- 121) Para a grelha apoiada da figura 130 traçar os diagramas de esforços cortantes, momentos fletores e momentos torçores.
- 122) Para a grelha apoiada da figura 131 traçar os diagramas de esforços cortantes, momentos fletores e momentos torçores.
- 123) Para a estrutura espacial da figura 132 traçar os diagramas das solicitações.
- 124) Para a estrutura espacial da figura 133 traçar os diagramas das solicitações.
- 125) Para a estrutura espacial da figura 134 traçar os diagramas das solicitações.

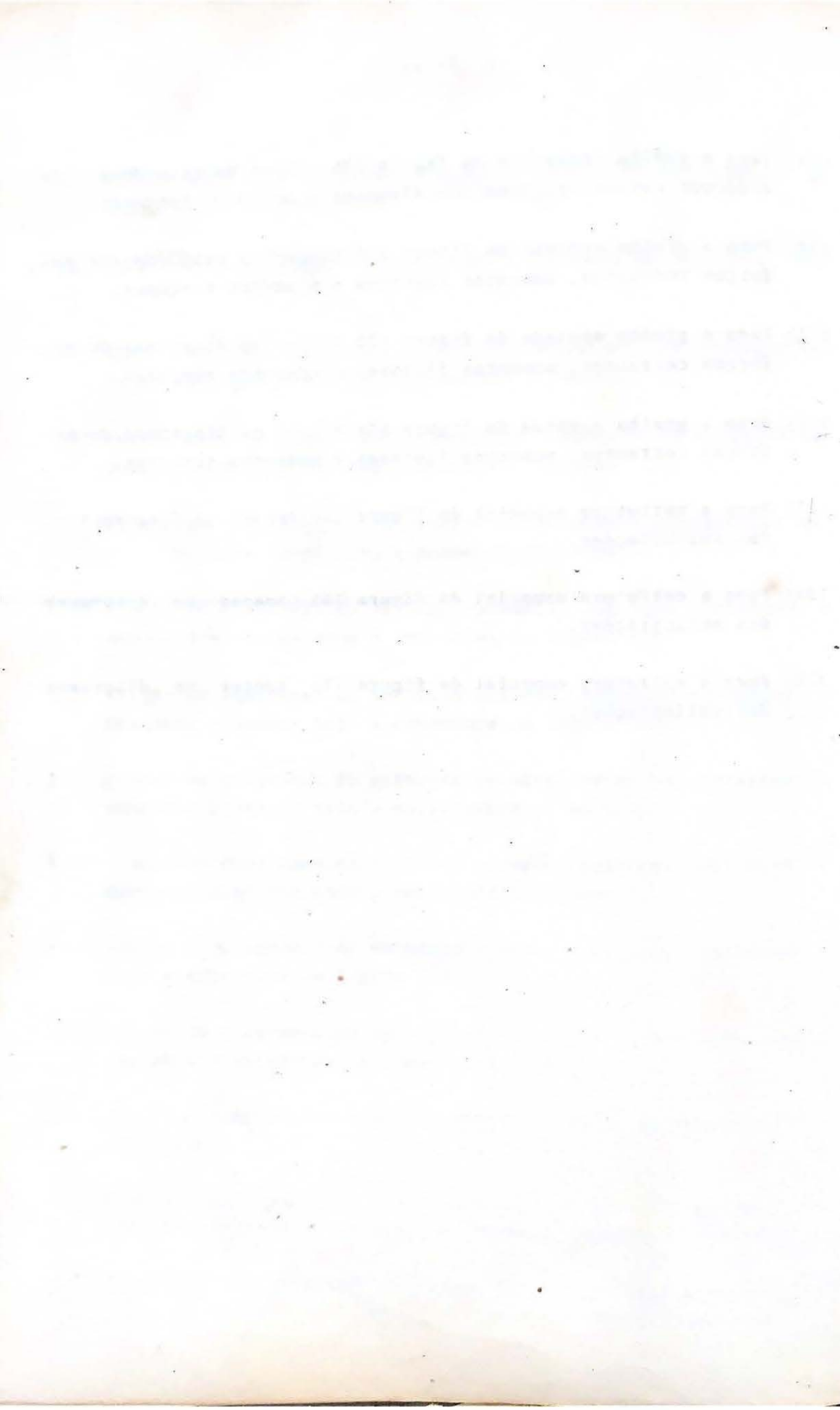






Fig. 1

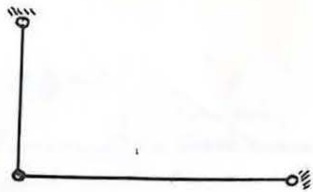


Fig. 2



Fig. 3



Fig. 4

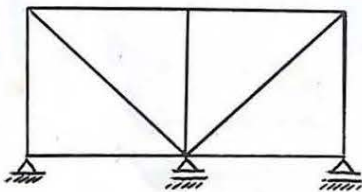


Fig. 5

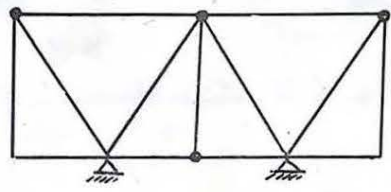


Fig. 6

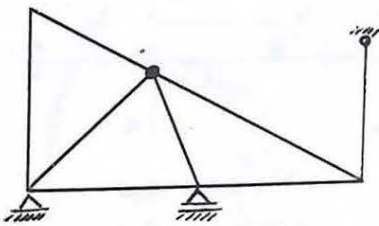


Fig. 7

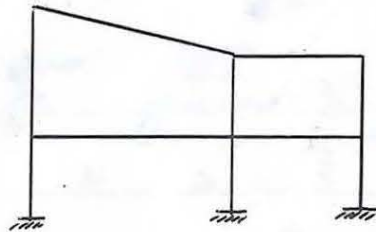


Fig. 8

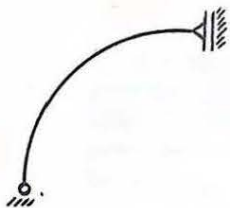


Fig. 9



Fig. 10

RESPOSTAS

Fig.	1	2	3	4	5	6	7	8	9	10
$g$	0	0	1	0	13	9	8	12	0	0
$g_e$	0	1	1	1	1	1	2	6	0	3
$g_i$	0	-1	0	-1	12	8	6	6	0	-3

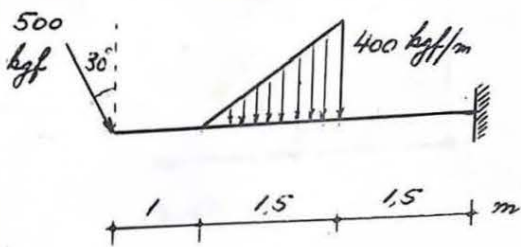
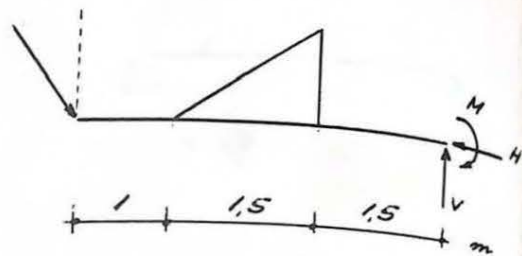


Fig. 11



$$M = 2332 \text{ kgf}\cdot\text{m}$$

$$V = 733 \text{ kgf}$$

$$H = 250 \text{ kgf}$$

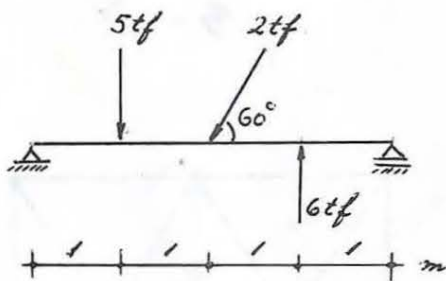
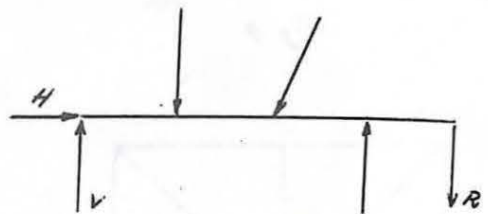


Fig. 12



$$H = 1000 \text{ kgf}$$

$$V = 3115 \text{ kgf}$$

$$R = 2385 \text{ kgf}$$

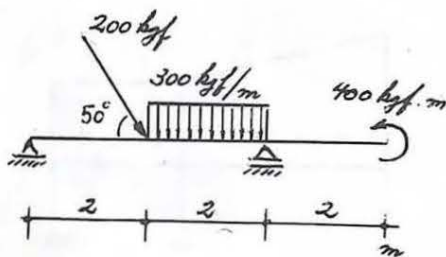
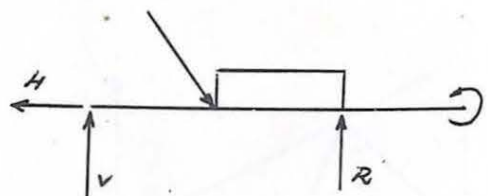


Fig. 13



$$H = 128,56 \text{ kgf}$$

$$V = 326,6 \text{ kgf}$$

$$R = 426,6 \text{ kgf}$$

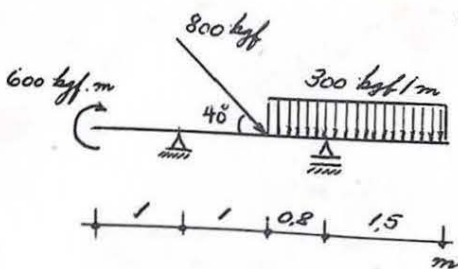
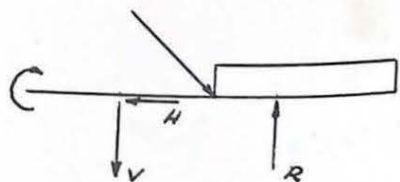


Fig. 14



$$H = 613 \text{ kgf}$$

$$V = 239 \text{ kgf}$$

$$R = 1443 \text{ kgf}$$

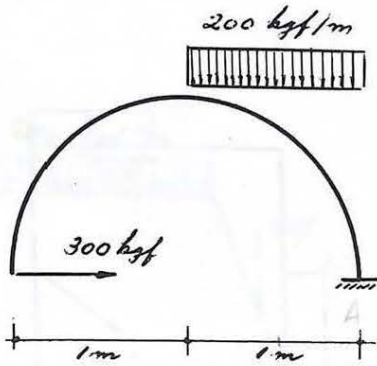


Fig. 15

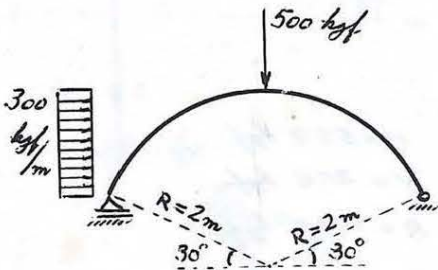
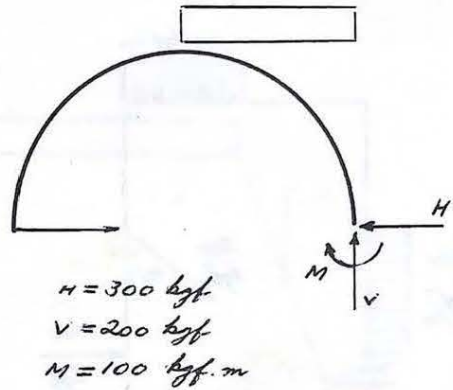


Fig. 16

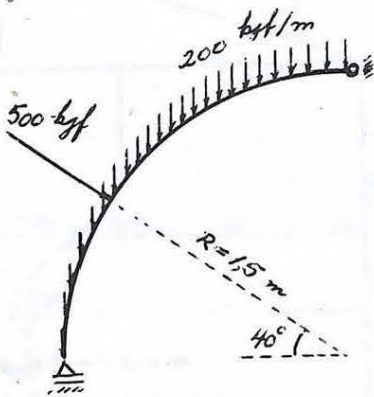
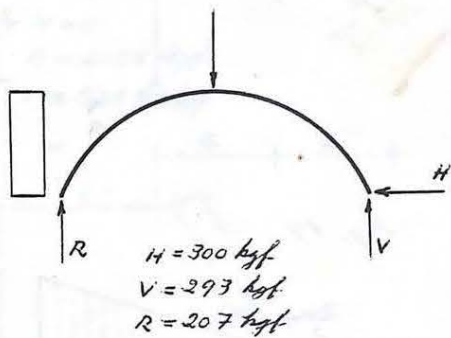


Fig. 17

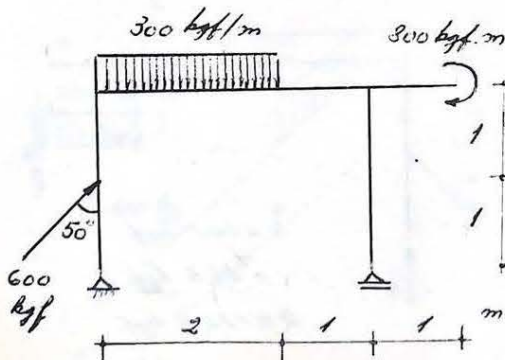
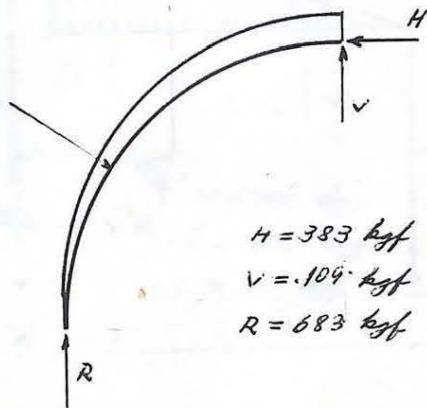
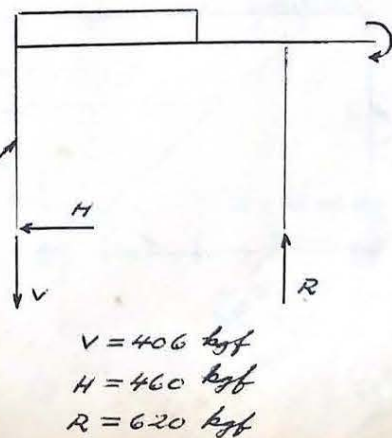


Fig. 18



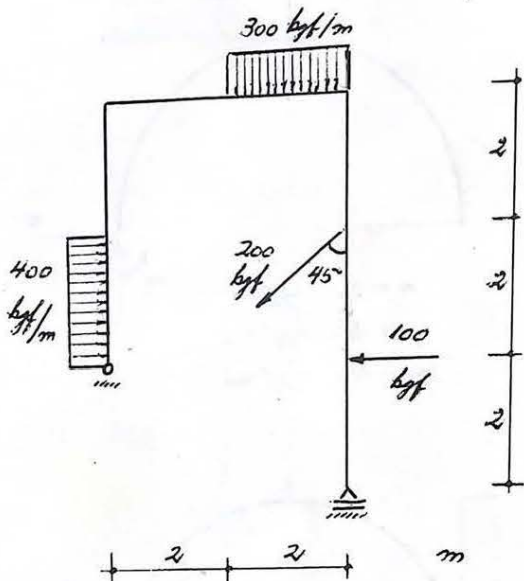
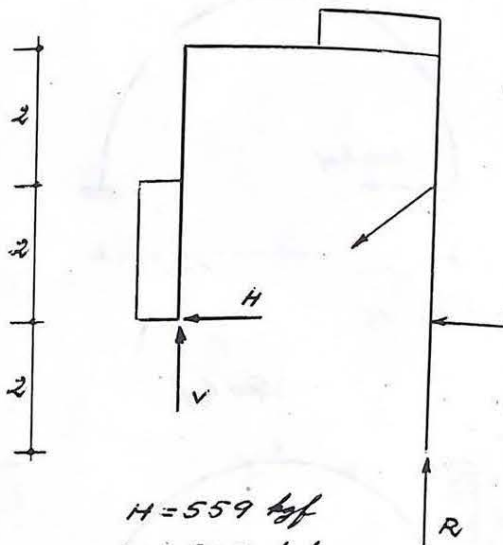


Fig. 19



$H = 559 \text{ kN}$   
 $V = 20,5 \text{ kN}$   
 $R = 720,5 \text{ kN}$

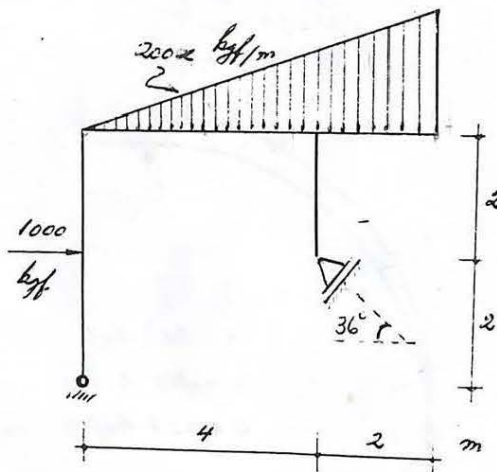
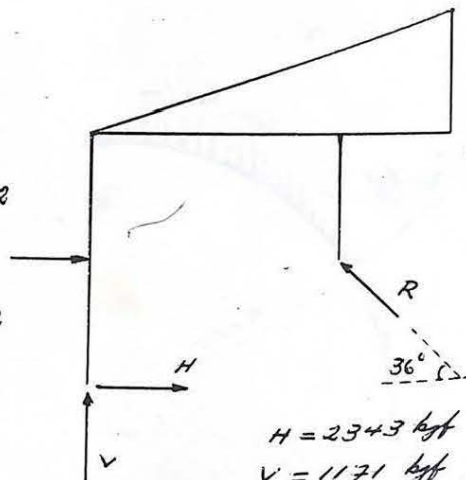


Fig 20



$H = 2343 \text{ kN}$   
 $V = 1171 \text{ kN}$   
 $R = 4132 \text{ kN}$

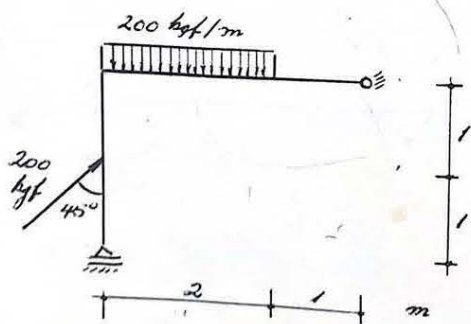
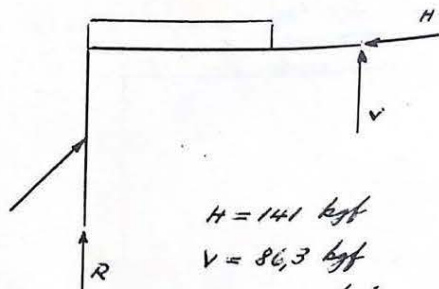


Fig. 21



$H = 141 \text{ kN}$   
 $V = 86,3 \text{ kN}$   
 $R = 172,7 \text{ kN}$

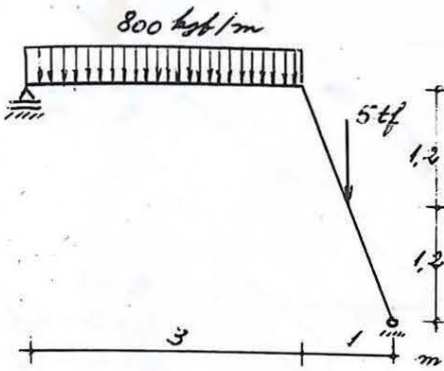
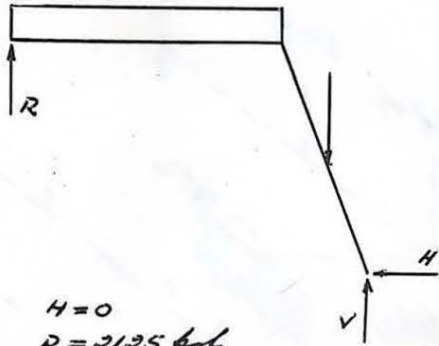


Fig. 22



$H = 0$   
 $R = 2125 \text{ kgf}$   
 $V = 5275 \text{ kgf}$

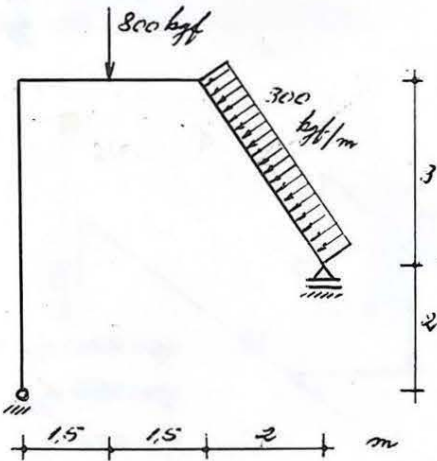
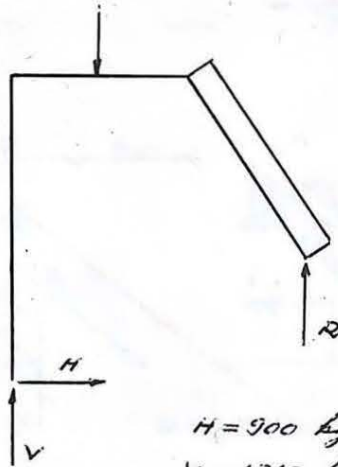


Fig. 23



$H = 900 \text{ kgf}$   
 $V = 1310 \text{ kgf}$   
 $R = 90 \text{ kgf}$

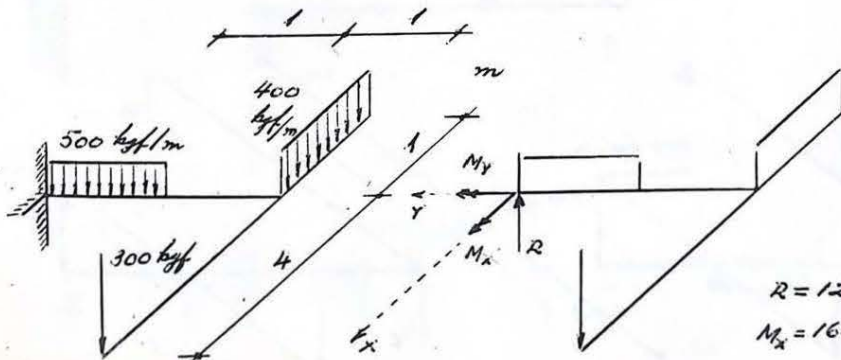


Fig. 24

$R = 1200 \text{ kgf}$   
 $M_x = 1650 \text{ kgf}\cdot\text{m}$   
 $M_y = 1000 \text{ kgf}\cdot\text{m}$



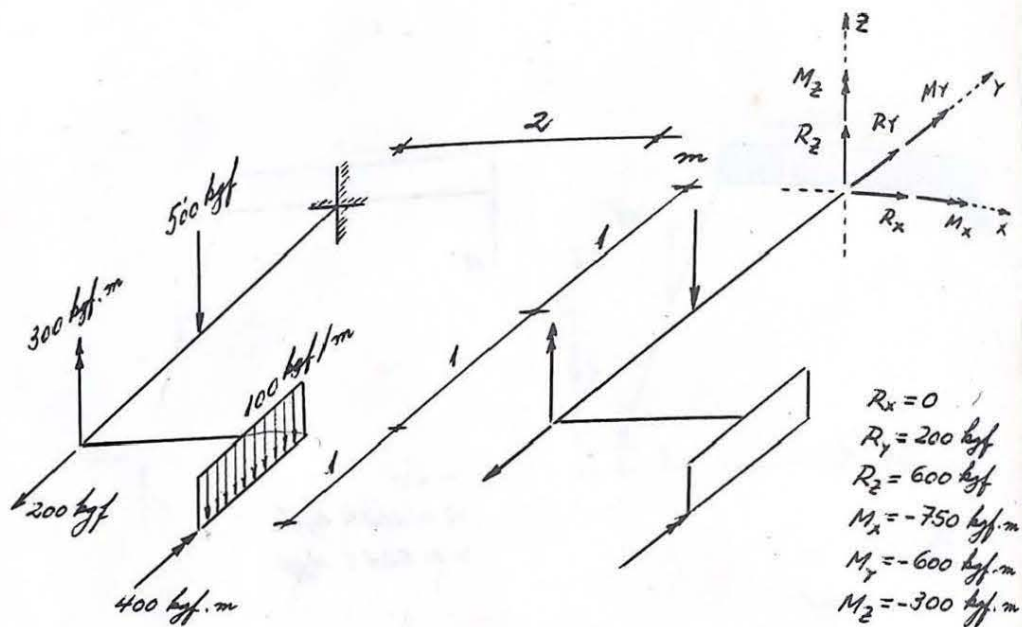


Fig. 25

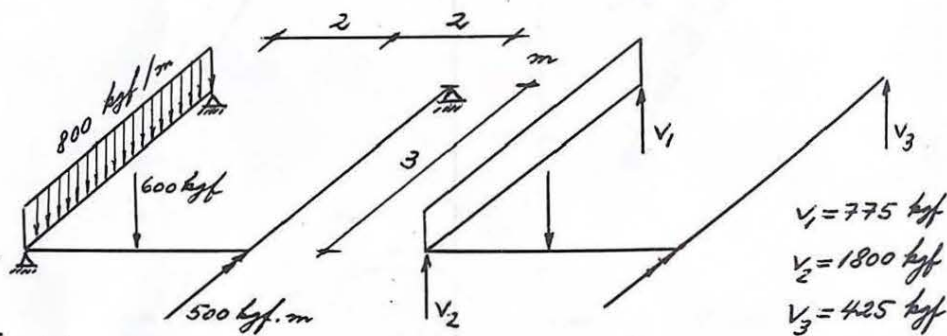


Fig. 26

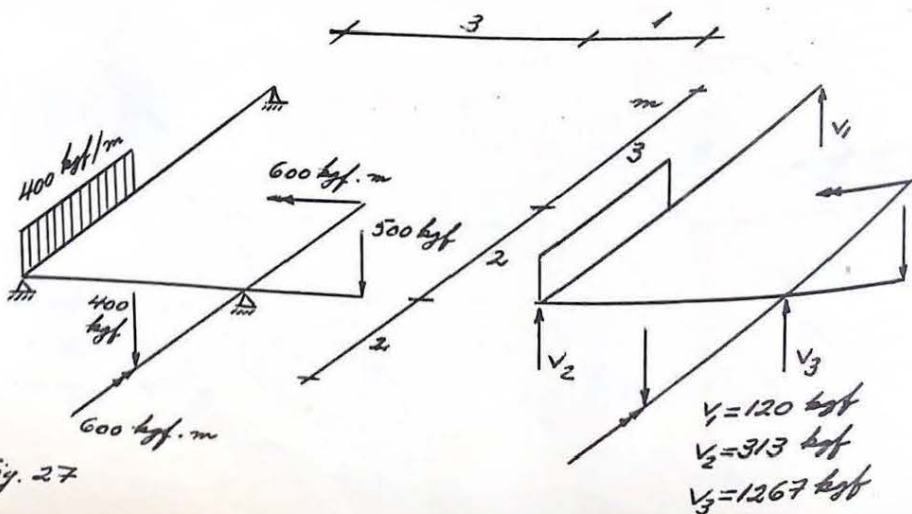


Fig. 27

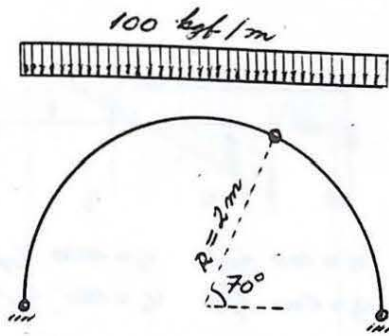


Fig. 28

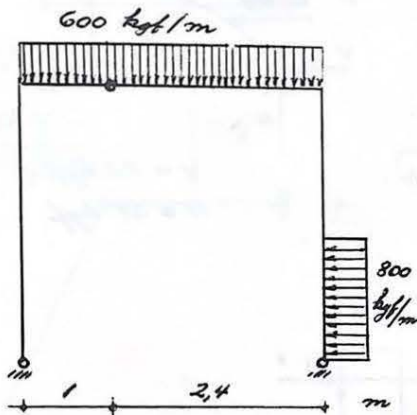
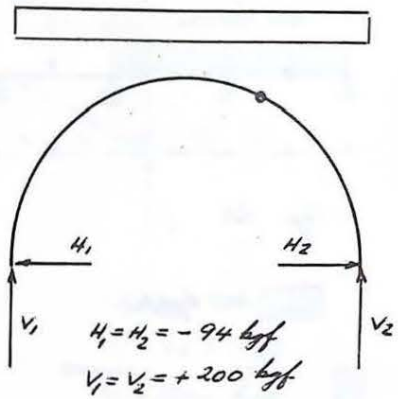


Fig. 29

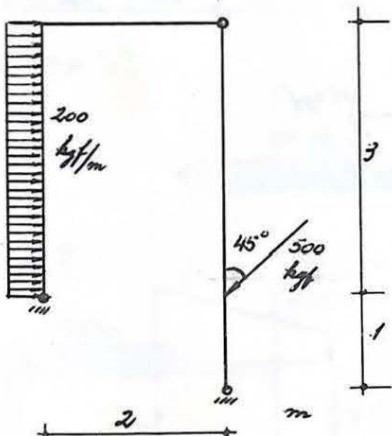
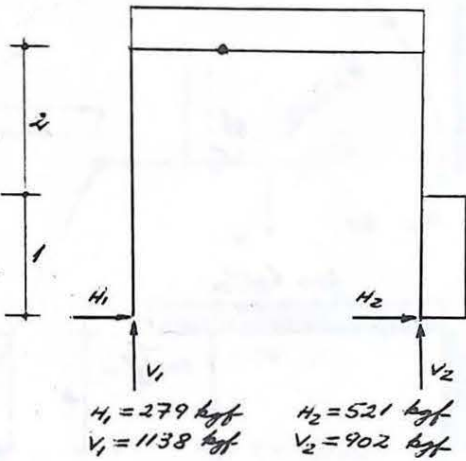


Fig. 30

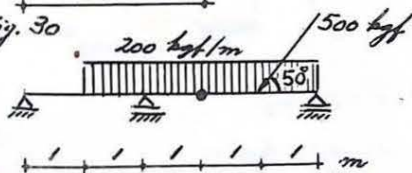
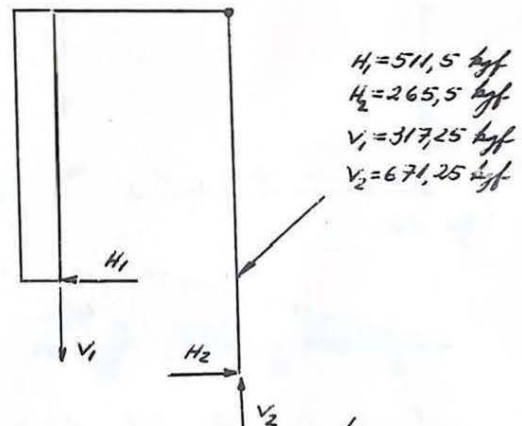
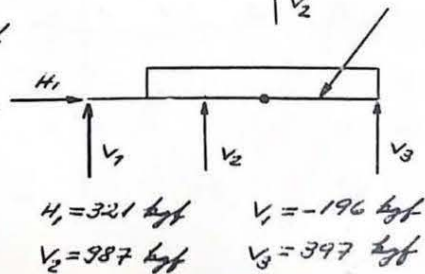


Fig. 31



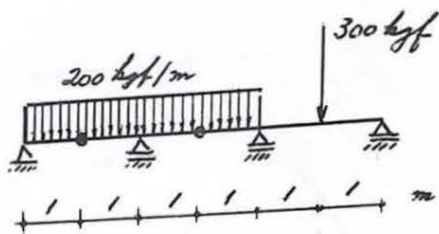


Fig. 32

200 kgf/m

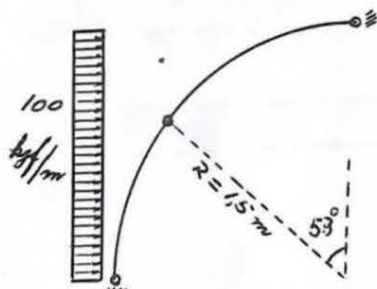
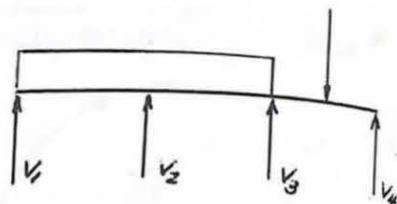
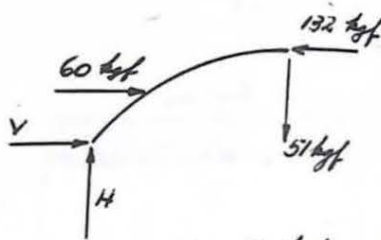


Fig. 33



$$\begin{aligned} V_1 &= 100 \text{ kgf} & V_3 &= 250 \text{ kgf} \\ V_2 &= 600 \text{ kgf} & V_4 &= 150 \text{ kgf} \end{aligned}$$



$$\begin{aligned} V &= 72 \text{ kgf} \\ H &= 51 \text{ kgf} \end{aligned}$$

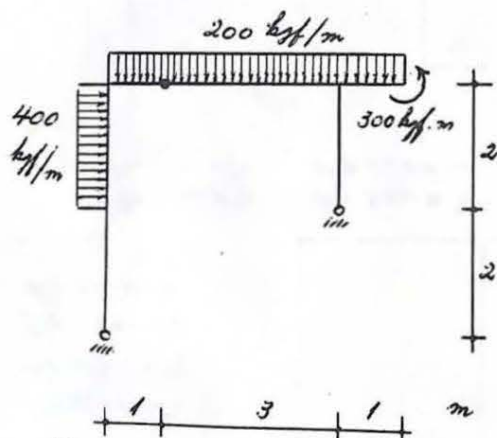
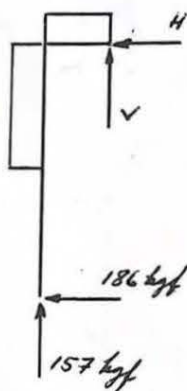


Fig. 34



$$\begin{aligned} H &= 614 \text{ kgf} \\ V &= 43 \text{ kgf} \end{aligned}$$

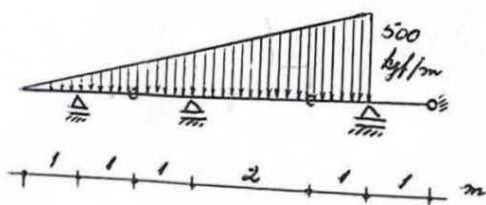
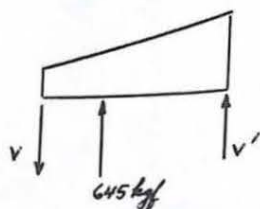
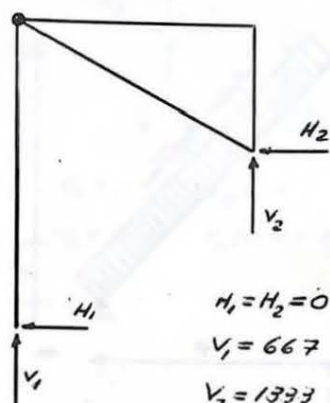
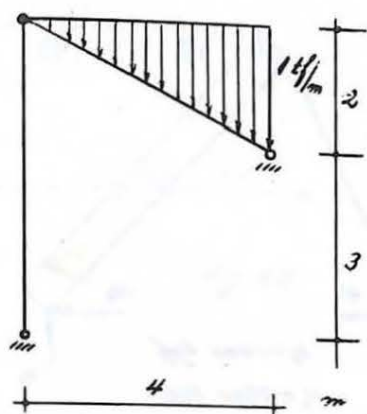


Fig. 35



$$\begin{aligned} V &= 55 \text{ kgf} \\ V' &= 285 \text{ kgf} \end{aligned}$$

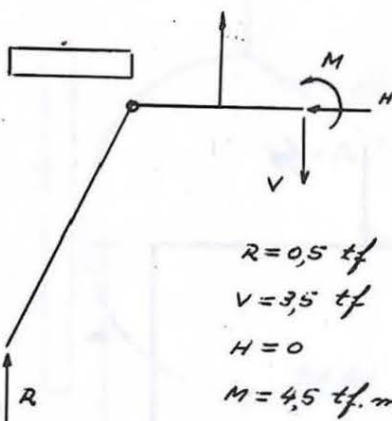
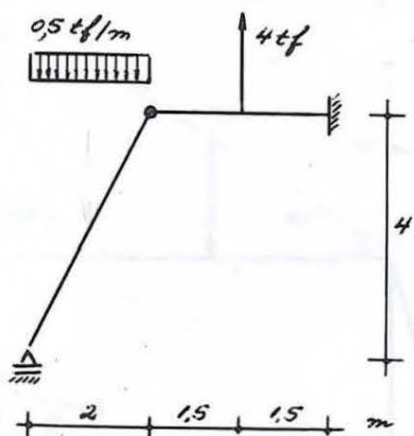


$$H_1 = H_2 = 0$$

$$V_1 = 667 \text{ kgf}$$

$$V_2 = 1333 \text{ kgf}$$

Fig. 36



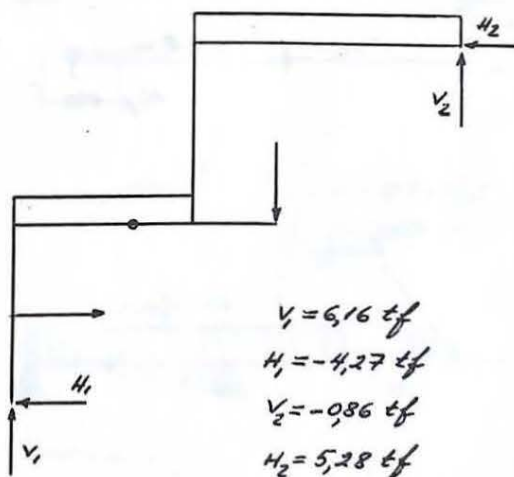
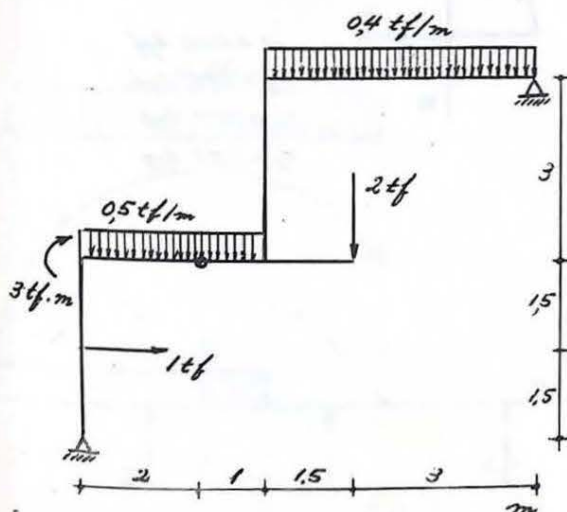
$$R = 0,5 \text{ tf}$$

$$V = 3,5 \text{ tf}$$

$$H = 0$$

$$M = 4,5 \text{ tf}\cdot\text{m}$$

Fig. 37



$$V_1 = 6,16 \text{ tf}$$

$$H_1 = -4,27 \text{ tf}$$

$$V_2 = -0,86 \text{ tf}$$

$$H_2 = 5,28 \text{ tf}$$

Fig. 38

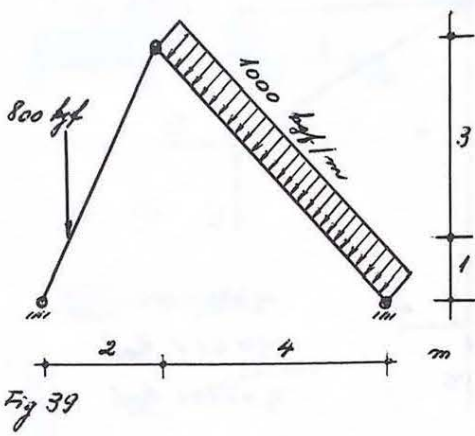
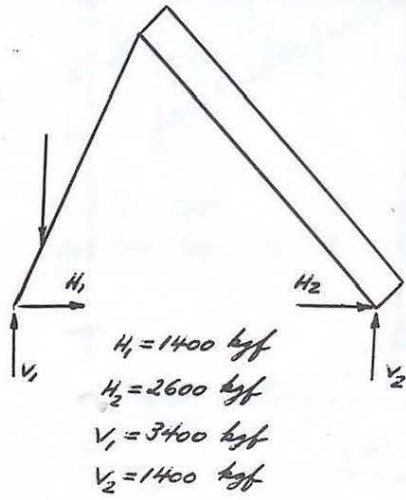


Fig 39



$H_1 = 1400 \text{ kgf}$   
 $H_2 = 2600 \text{ kgf}$   
 $V_1 = 3400 \text{ kgf}$   
 $V_2 = 1400 \text{ kgf}$

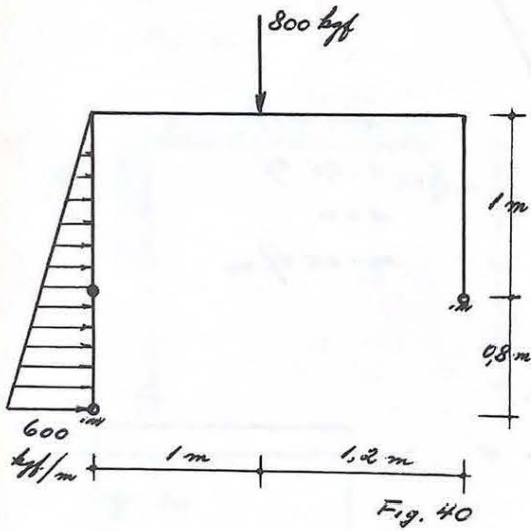
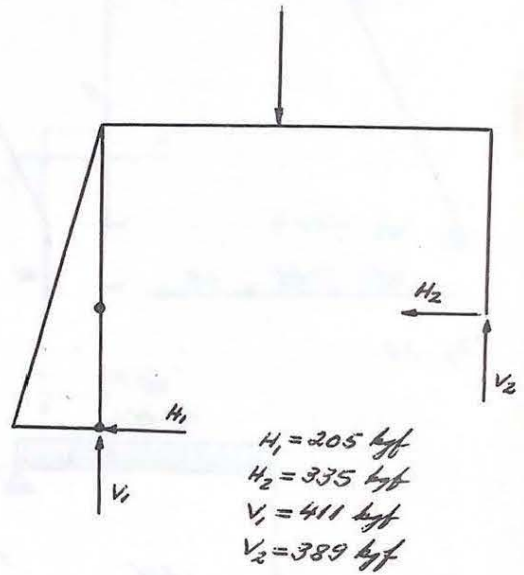


Fig. 40



$H_1 = 205 \text{ kgf}$   
 $H_2 = 335 \text{ kgf}$   
 $V_1 = 411 \text{ kgf}$   
 $V_2 = 389 \text{ kgf}$

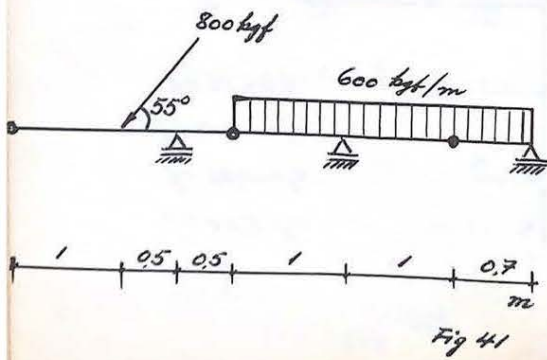
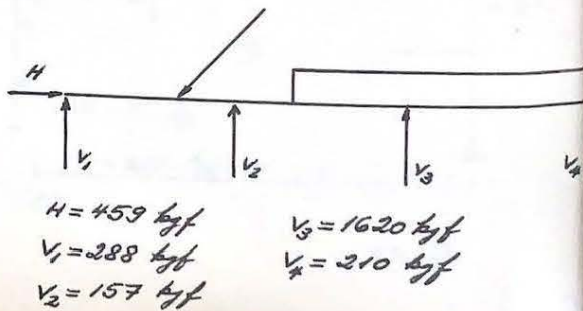


Fig 41



$H = 459 \text{ kgf}$   
 $V_1 = 288 \text{ kgf}$   
 $V_2 = 157 \text{ kgf}$   
 $V_3 = 1620 \text{ kgf}$   
 $V_4 = 210 \text{ kgf}$



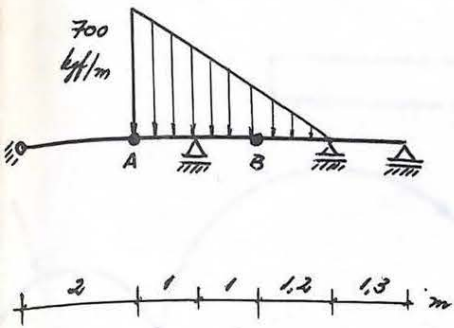
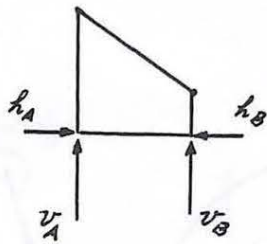


Fig 42



$$h_A = 0 \quad h_B = 0$$

$$v_A = 0 \quad v_B = 143 \text{ kN}$$

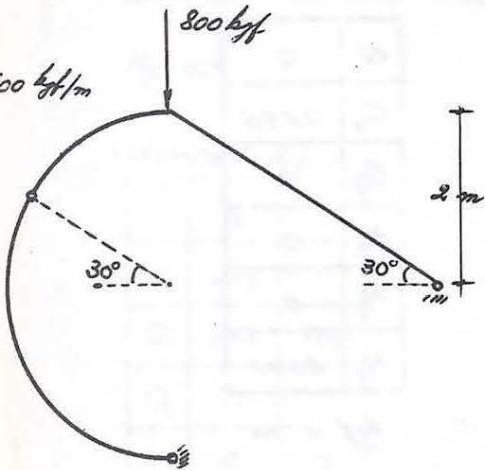


Fig 43

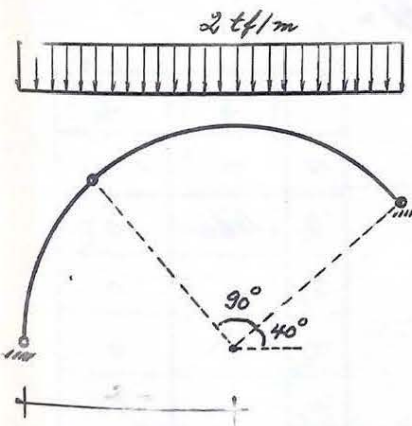
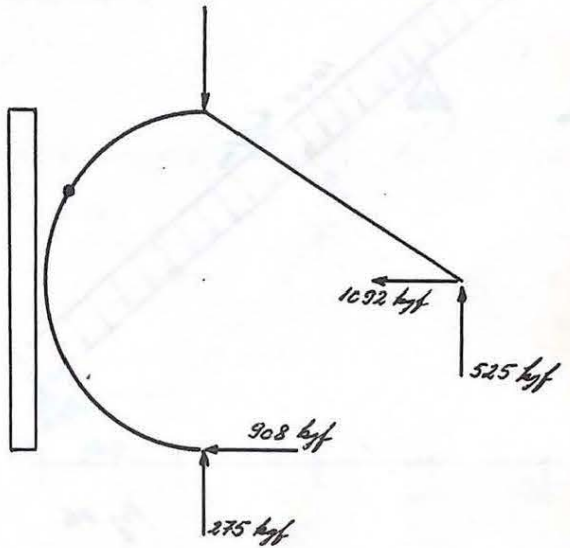
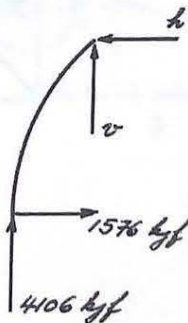


Fig 44



$$h = 1576 \text{ kN}$$

$$v = 2686 \text{ kN}$$

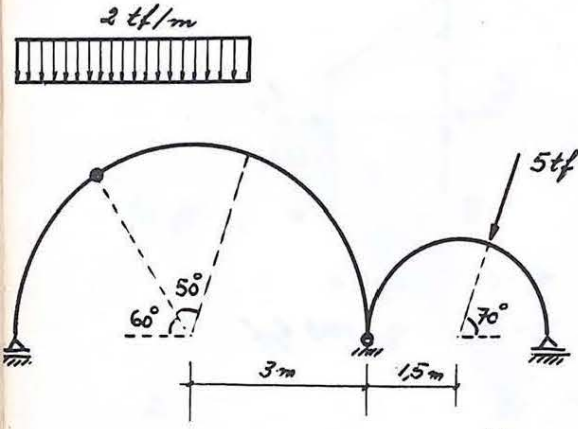


Fig 45

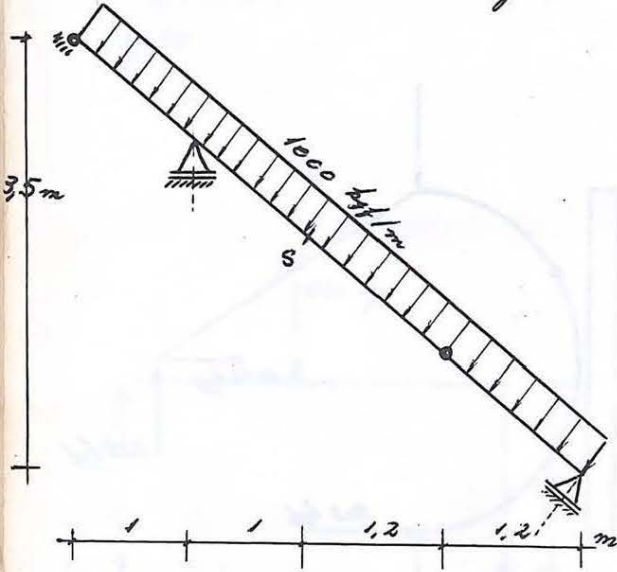
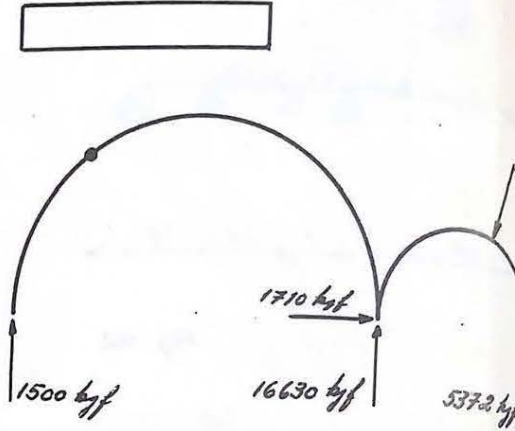


Fig 46

$N$	0
$Q_y$	2295
$Q_z$	0
$M_x$	0
$M_y$	0
$M_z$	2341

kpf = m

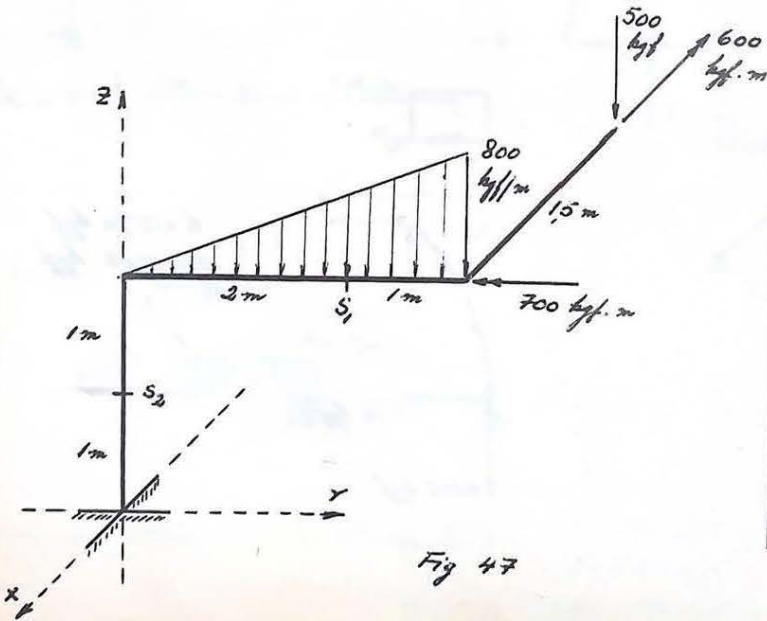


Fig 47

	$S_1$	$S_2$
$N$	0	-1700
$Q_y$	1166	0
$Q_z$	0	0
$M_x$	1450	0
$M_y$	0	1450
$M_z$	1456	4500

kpf = m

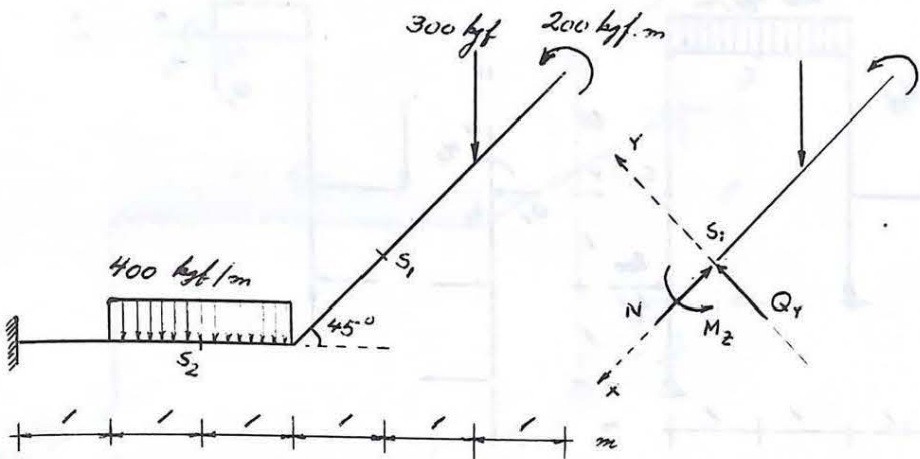


Fig. 48

RESPOSTAS : kgf e m

	$S_1$	$S_2$
N	213	0
$Q_Y$	213	700
$Q_2$	0	0
$M_t$	0	0
$M_Y$	0	0
$M_2$	100	900

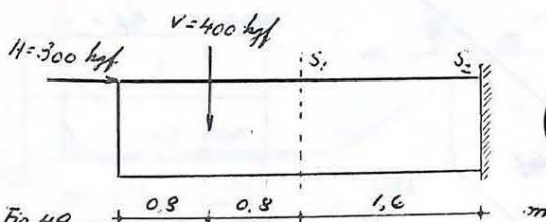
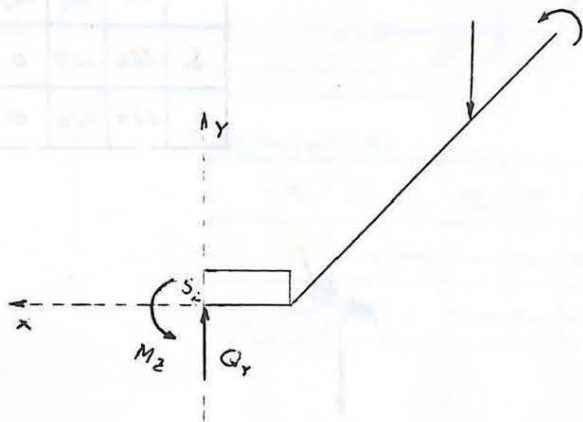
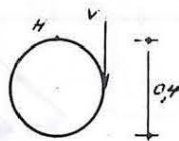
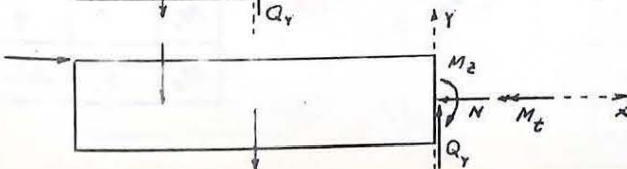
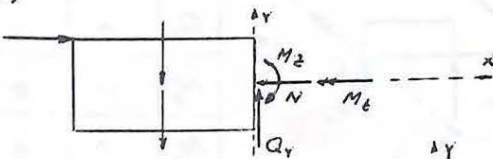


Fig. 49



RESPOSTAS: kgf e m

	$S_1$	$S_2$
N	300	300
$Q_Y$	560	720
$Q_2$	0	0
$M_t$	80	80
$M_Y$	0	0
$M_2$	388	1412



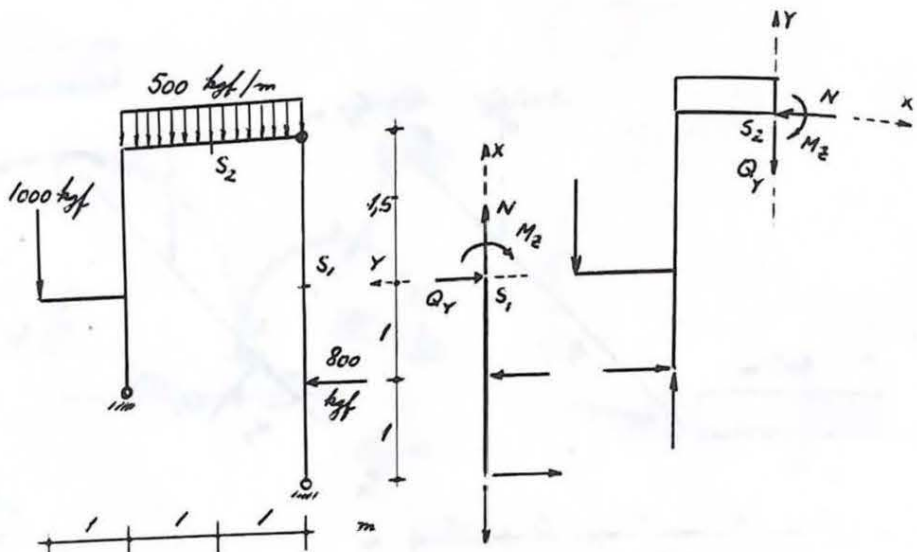


Fig 50

RESPOSTAS: kgf e m

	N	Q <sub>Y</sub>	Q <sub>Z</sub>	M <sub>E</sub>	M <sub>Y</sub>	M <sub>Z</sub>
S <sub>1</sub>	286	229	0	0	0	342
S <sub>2</sub>	224	786	0	0	0	536,5

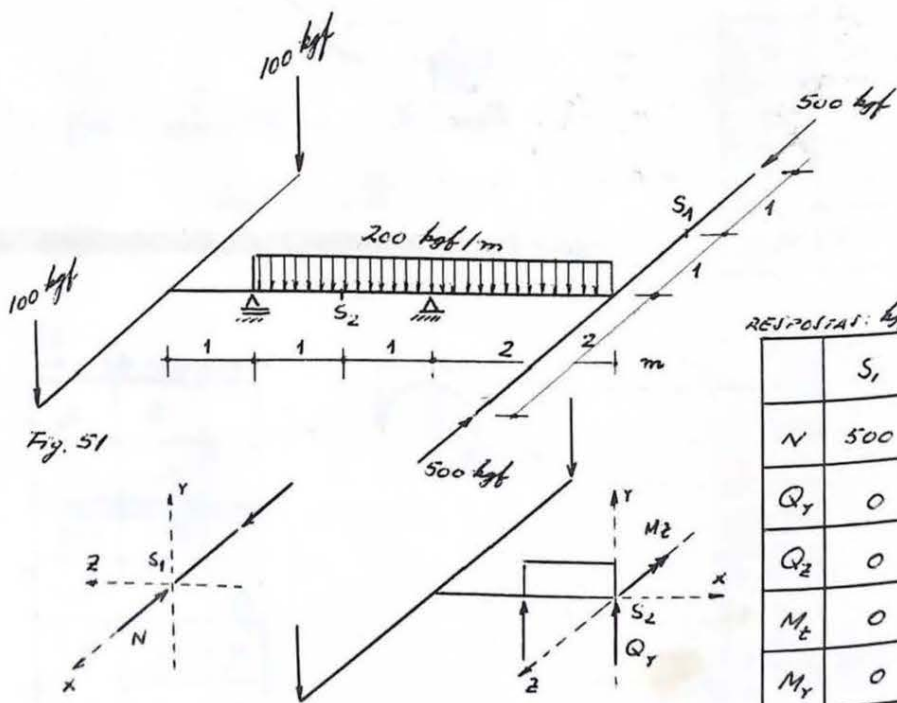


Fig. 51

RESPOSTAS: kgf e m

	S <sub>1</sub>	S <sub>2</sub>
N	500	0
Q <sub>Y</sub>	0	100
Q <sub>Z</sub>	0	0
M <sub>E</sub>	0	0
M <sub>Y</sub>	0	0
M <sub>Z</sub>	0	200

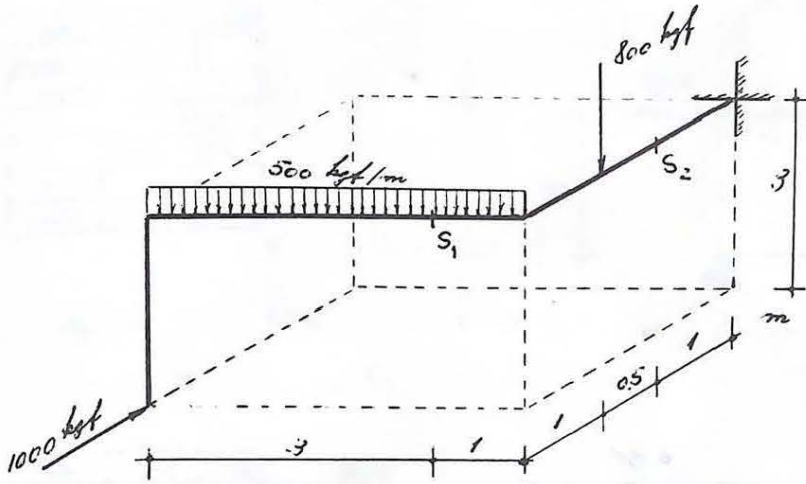
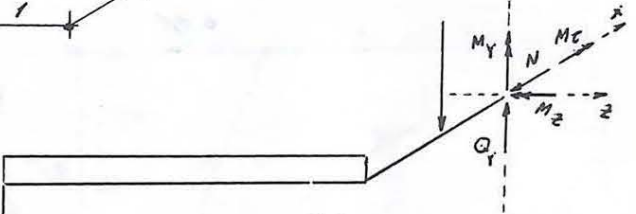
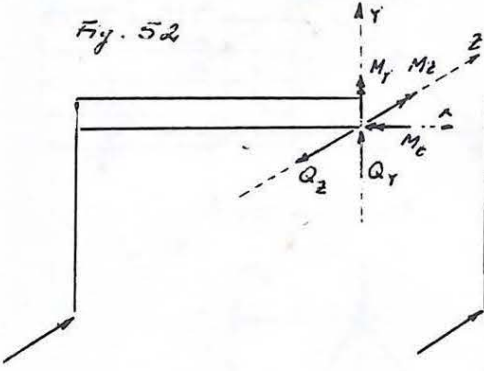


Fig. 52



RESPOSTAS: kgf e m

	N	Q <sub>y</sub>	Q <sub>z</sub>	M <sub>c</sub>	M <sub>y</sub>	M <sub>z</sub>
S <sub>1</sub>	0	1500	1000	3000	1000	2250
S <sub>2</sub>	1000	2800	0	4000	4000	6400

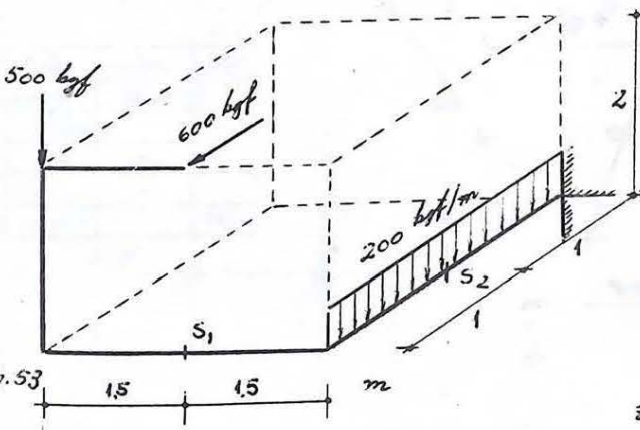
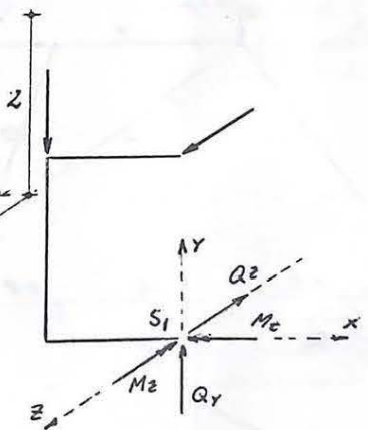


Fig. 53



RESPOSTAS: kgf e m

	N	Q <sub>y</sub>	Q <sub>z</sub>	M <sub>c</sub>	M <sub>y</sub>	M <sub>z</sub>
S <sub>1</sub>	0	500	600	1200	0	750
S <sub>2</sub>	600	700	0	1500	900	1800



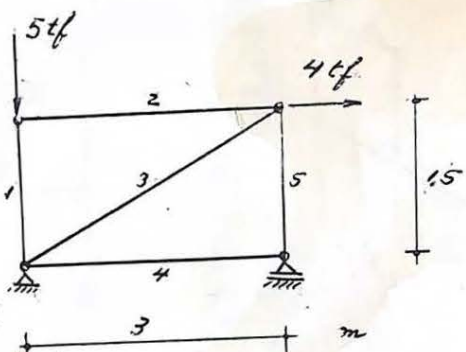


Fig. 54

Haste	Esforço kgf	
	Tensão	Compressão
1		5000
2	-	-
3	4472	
4	-	-
5		2000

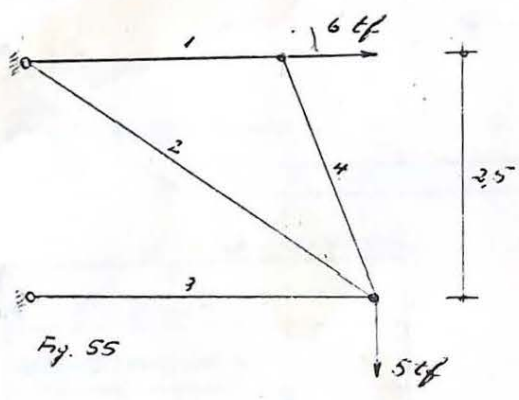


Fig. 55

Haste	Esforço kgf	
	Tensão	Compressão
1	6000	
2	9430	
3		8000
4	-	-

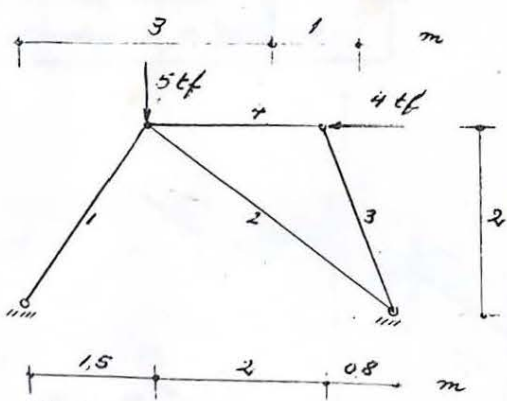


Fig. 56

Haste	Esforço kgf	
	Tensão	Compressão
1		6395
2	200	
3	-	-
4		4000

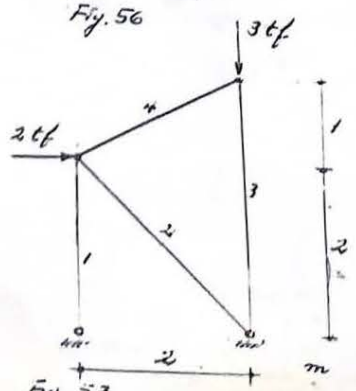


Fig. 57

Haste	Esforço kgf	
	Tensão	Compressão
1	2000	2828
2		3000
3		
4	-	-

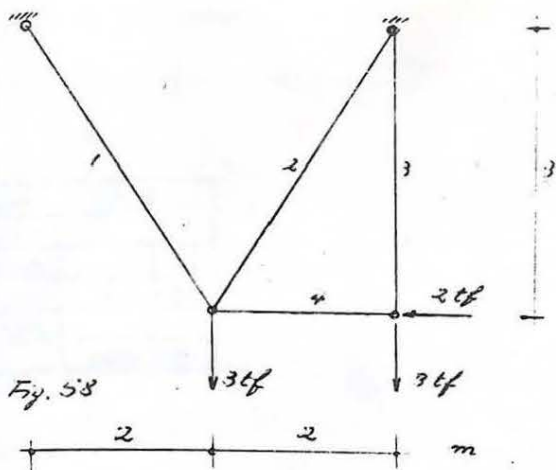


Fig. 58

Haste	Esfuerzo kgf	
	T	C
1	-	-
2	3606	
3	3000	
4		2000

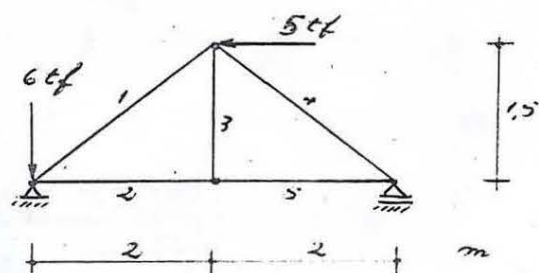


Fig. 59

Haste	Esfuerzo kgf	
	T	C
1		3125
2		2500
3	-	-
4	3125	
5		2500

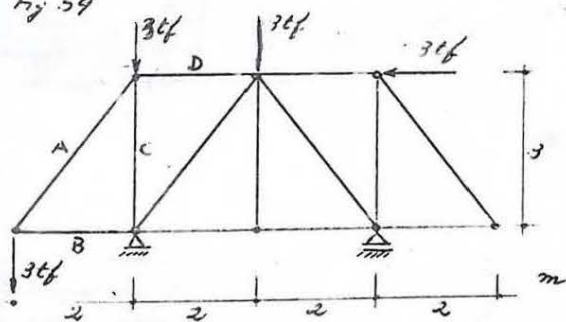


Fig. 60

Haste	Esfuerzo kgf	
	T	C
A	3606	
B		2000
C		6000
D	2009	

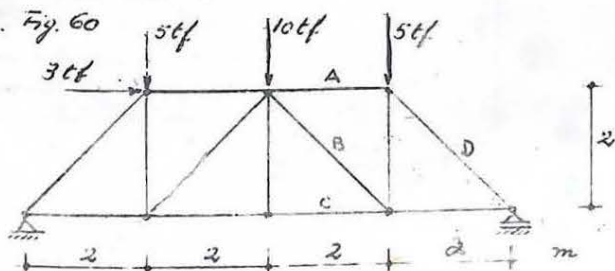
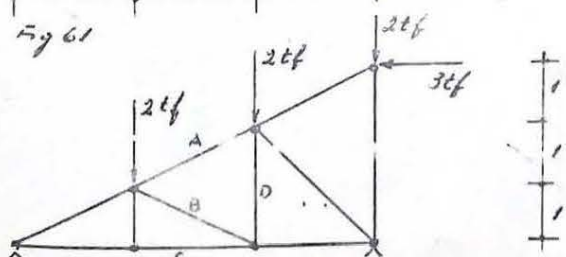
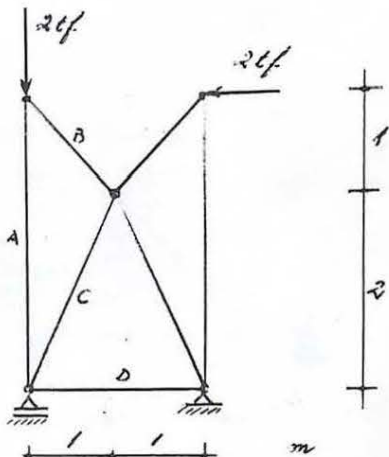


Fig. 61

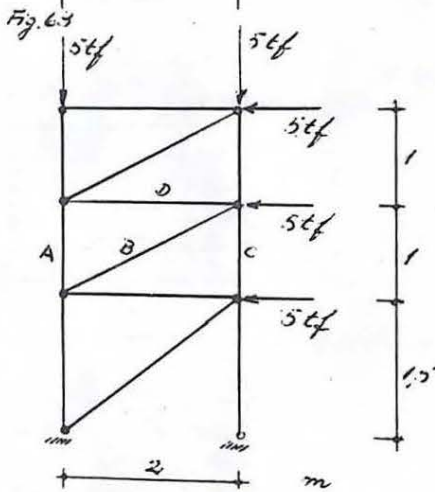
Haste	Esfuerzo kgf	
	T	C
A		10750
B		3132
C	16500	
D		15203



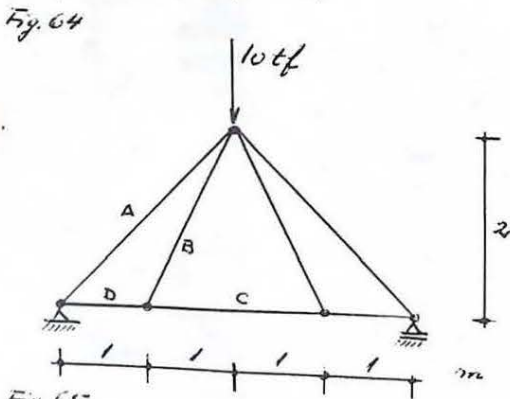
Haste	Esfuerzo kgf	
	T	C
A		5530
B		2236
C	7000	
D	1000	



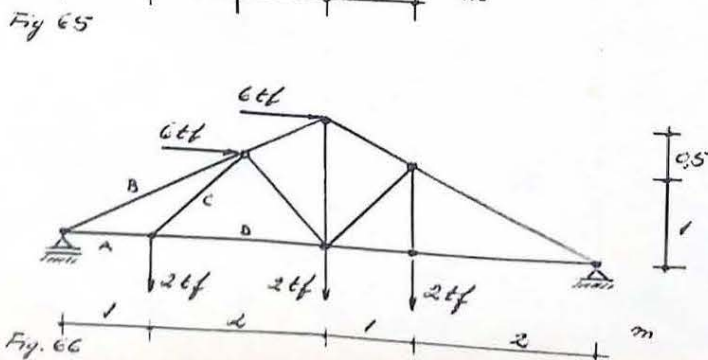
H	ESF.	
	T	C
A		2000
B	-	-
C		3354
D	1500	



H	ESF.	
	T	C
A		7500
B		11180
C	2500	
D	5000	



H	ESF.	
	T	C
A		7071
B	-	-
C	5000	
D	5000	



H	ESF.	
	T	C
A	1666	
B		1863
C	2828	
D		334

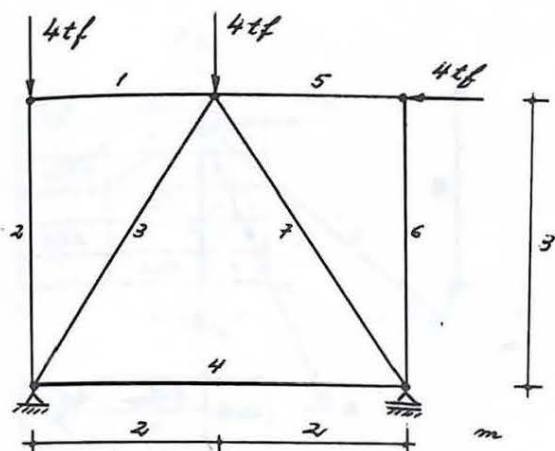


Fig. 67

H	ESF.		kgf
	T	C	
1	-	-	
2			4000
3			6000
4			667
5			4000
6	-	-	
7	1800		

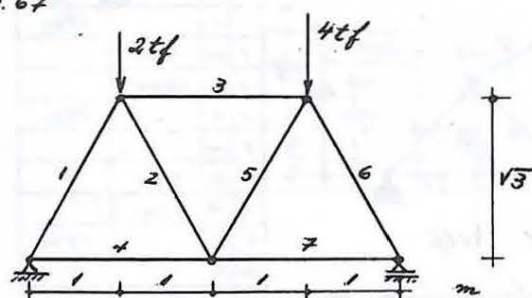


Fig. 68

H	ESF.		kgf
	T	C	
1			2887
2	577		
3			1732
4	1443		
5			577
6			4041
7	2021		

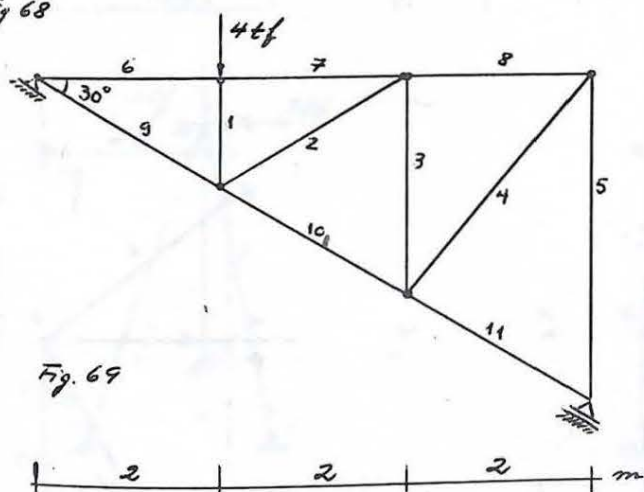


Fig. 69

H	ESF.		kgf
	T	C	
1			4000
2	4000		
3			2000
4	1764		
5			1333
6			4619
7			4619
8			1155
9	6000		
10	2000		
11	667		

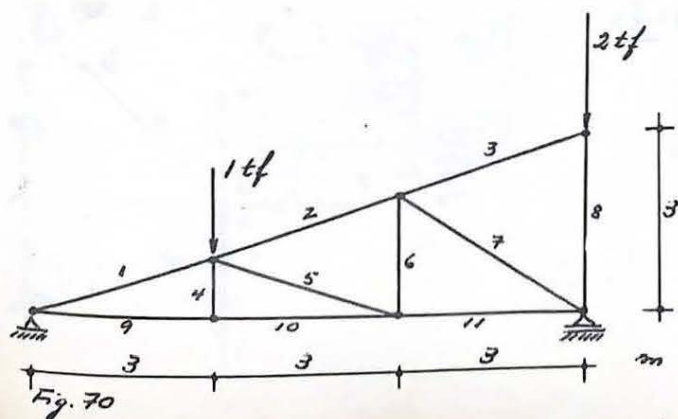


Fig. 70

H	ESF.		kgf
	T	C	
1			2100
2			520
3	-	-	
4	-	-	
5			1580
6	500		
7			600
8			2000
9	2000		
10	2000		
11	500		



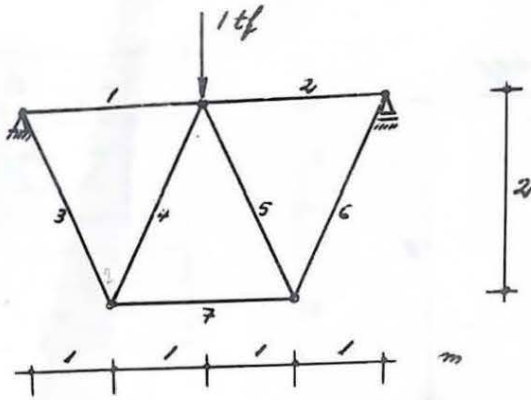


Fig. 71

Harta	Eforosa kgf	
	T	C
1 2		250
3 6	560	
4 5		560
7	500	

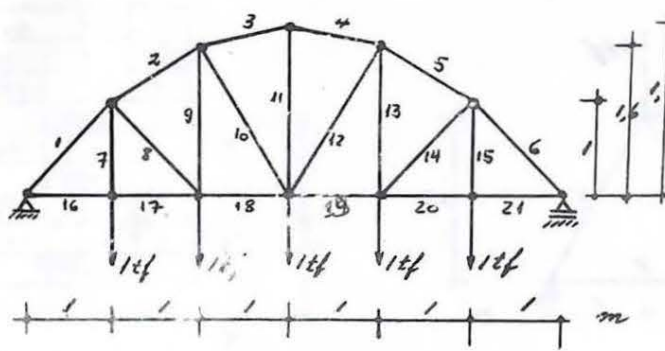


Fig. 72

Harta	Eforosa kgf	
	T	C
1 11	2500	
1 6		3540
7 15	1000	
17 20	2500	
2 5		2960
8 14	-	-
9 13	1000	
18 19	2500	
3 4		2570
10 12	-	-
11	1000	

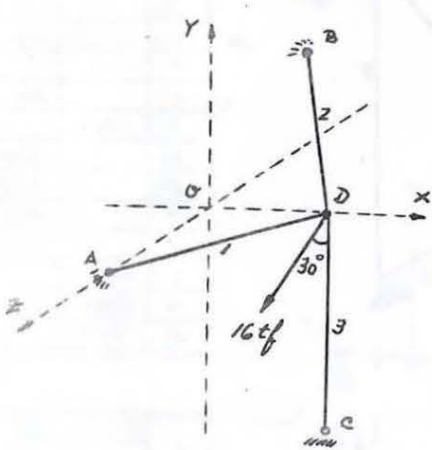
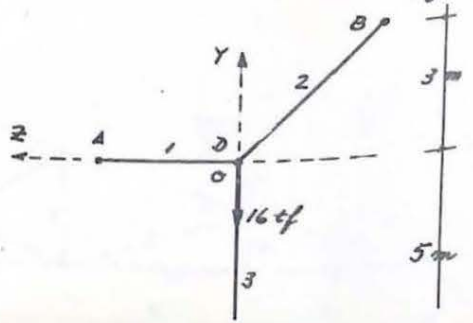
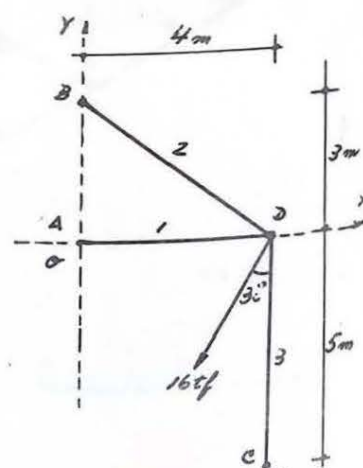


Fig. 73

Harta	Eforosa kgf	
	T	C
1		5000
2		5830
3		16340





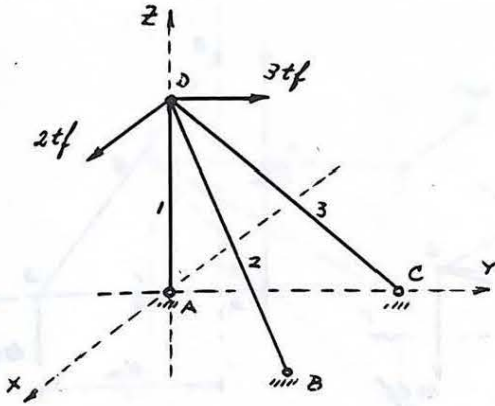


Fig. 74

Haste	Esforço $kgf$	
	T	C
1	2400	
2		4730
3	427	

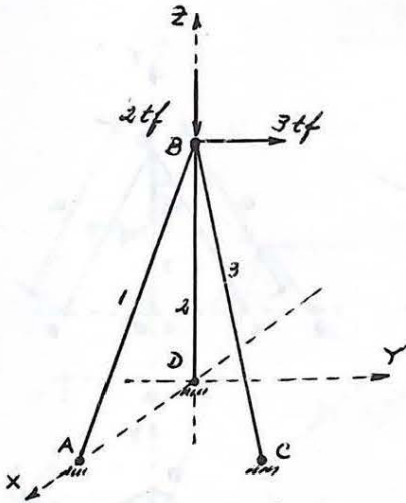
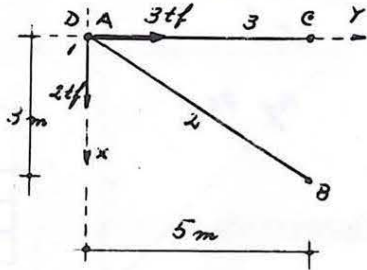
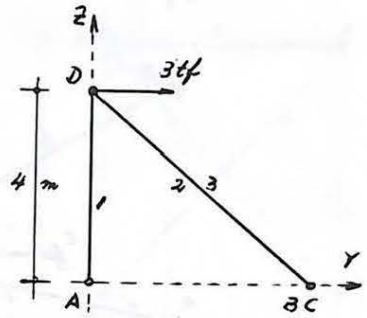
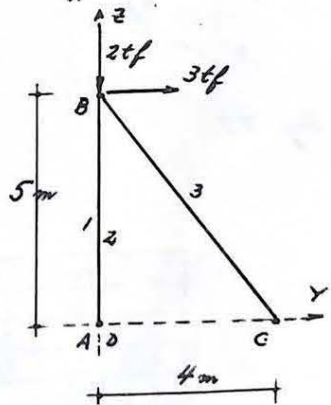
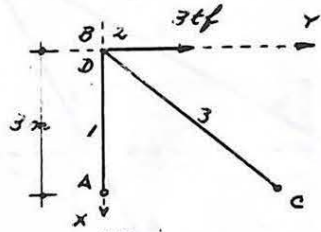


Fig. 75

Haste	Esforço $kgf$	
	T	C
1	4373	
2		2000
3		5303



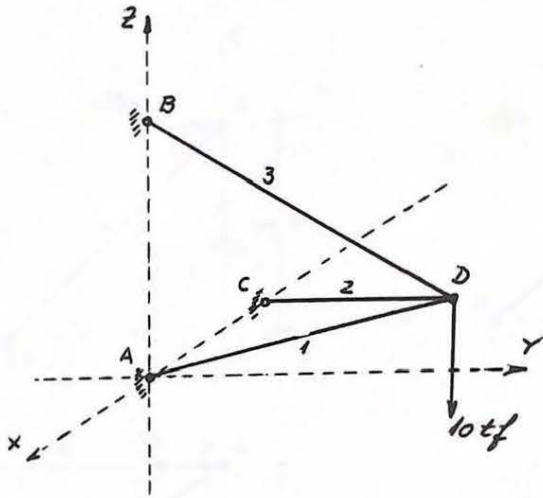


Fig. 76

H	ESF. $\Sigma yf$	
	T	C
1		10000
2	-	-
3	14140	

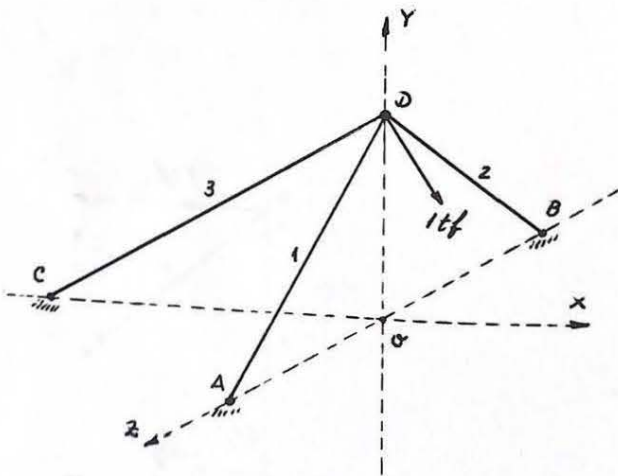
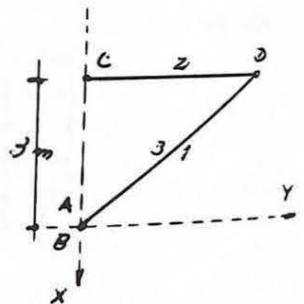
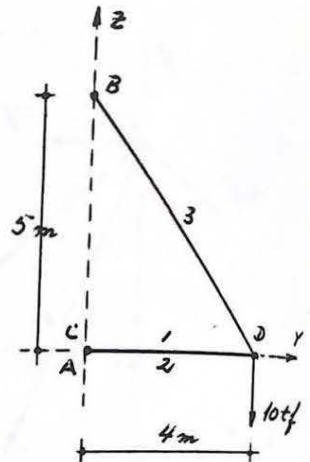
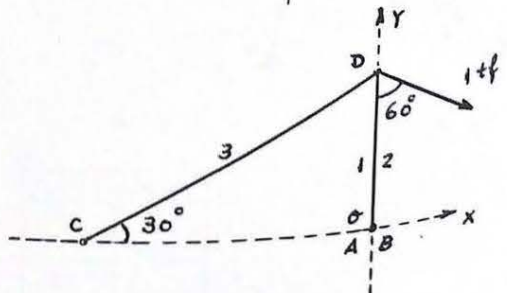
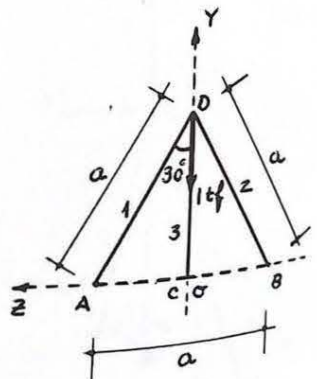


Fig. 77

H	ESF. $\Sigma yf$	
	T	C
1		580
2		580
3	1000	



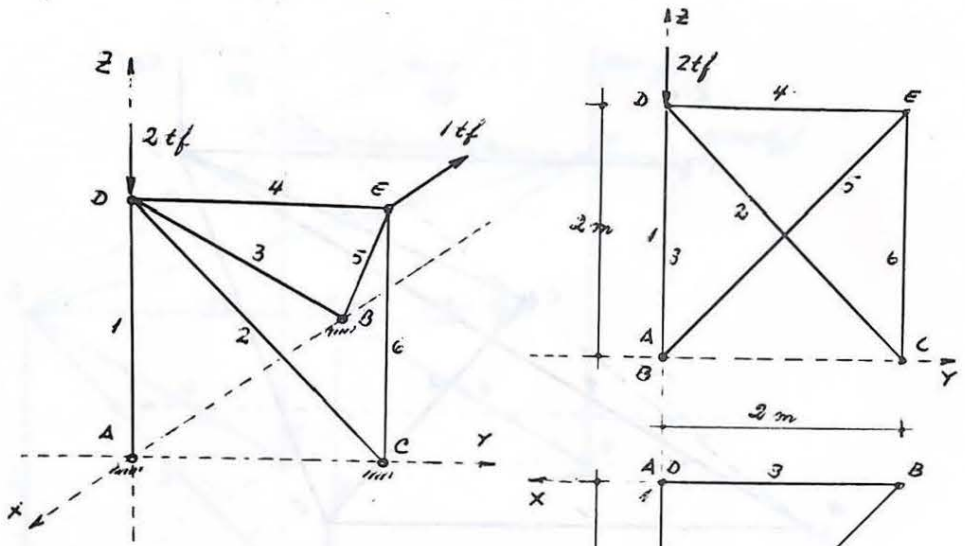


Fig. 78

H	ESF. $kgf$	
	T	C
1		1000
2		1414
3	-	-
4	1000	
5		1732
6	1000	

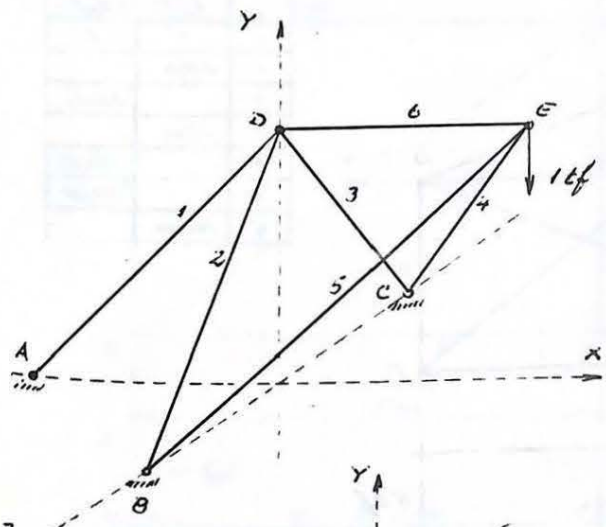
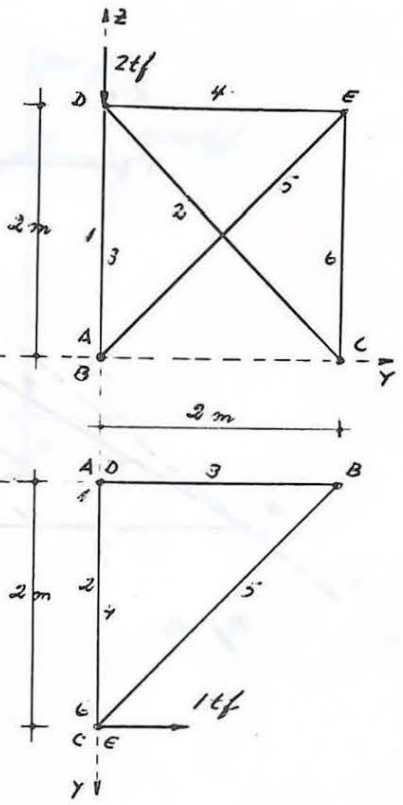
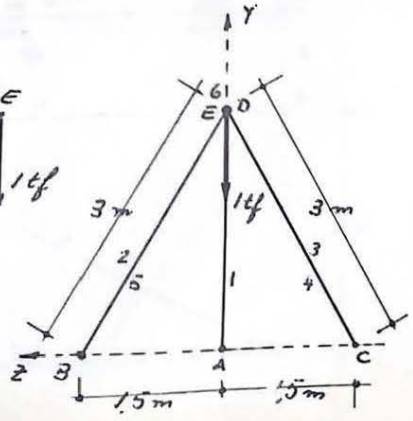
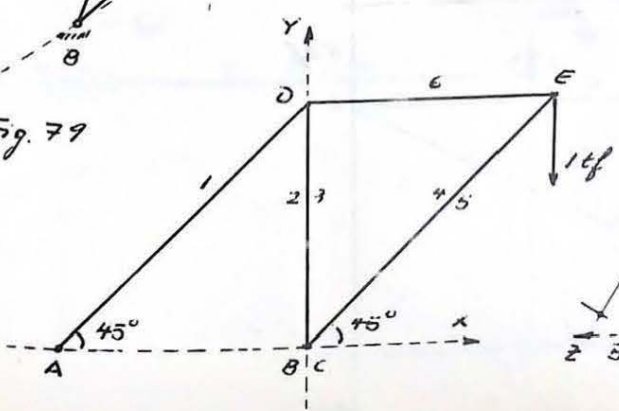
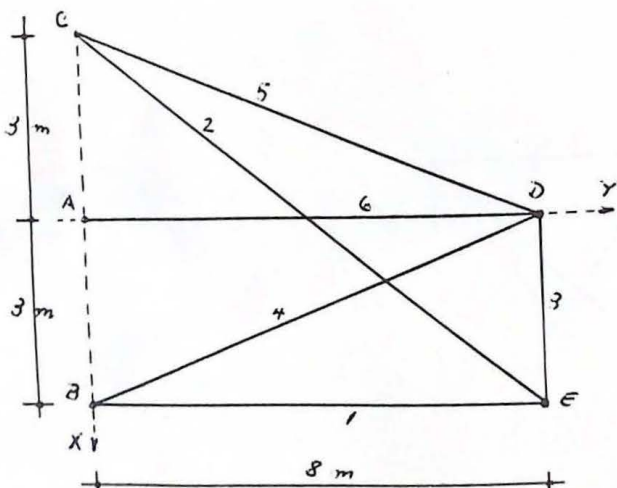
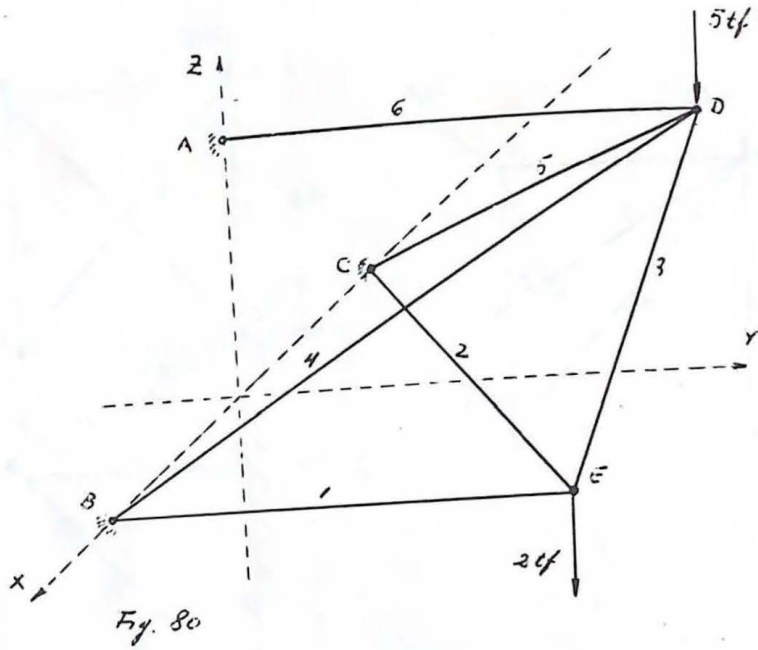


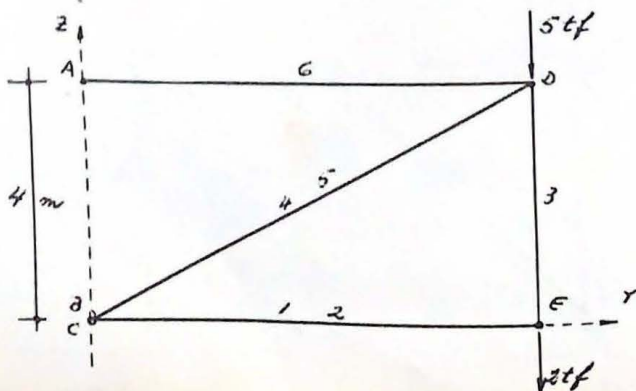
Fig. 79

H	ESF. $kgf$	
	T	C
1	1400	
2		600
3		600
4		760
5		760
6	1000	





H	E.J.F.	
	T	C
1	2000	
2		2500
3	2500	
4		10608
5		5300
6	14000	



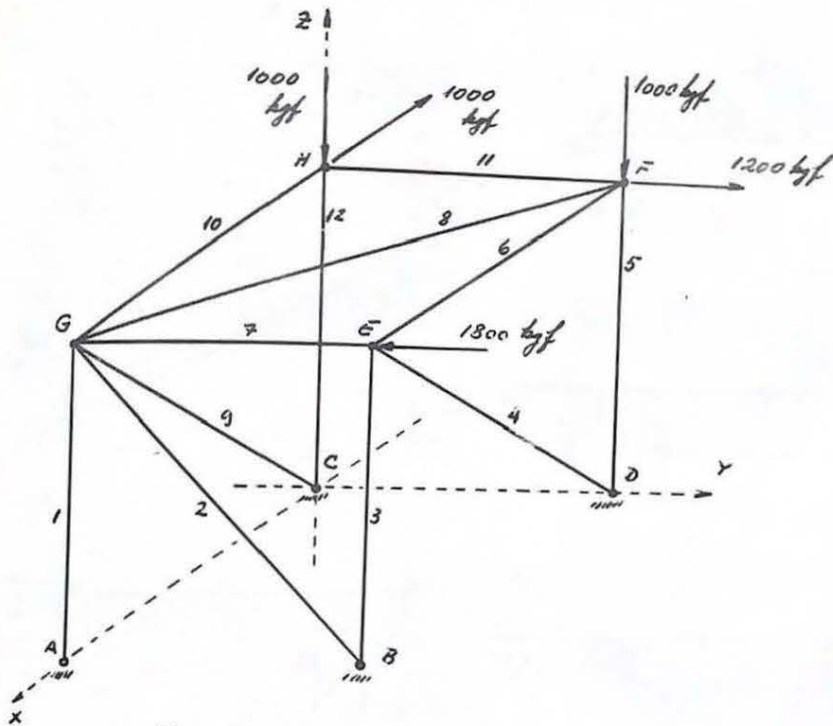
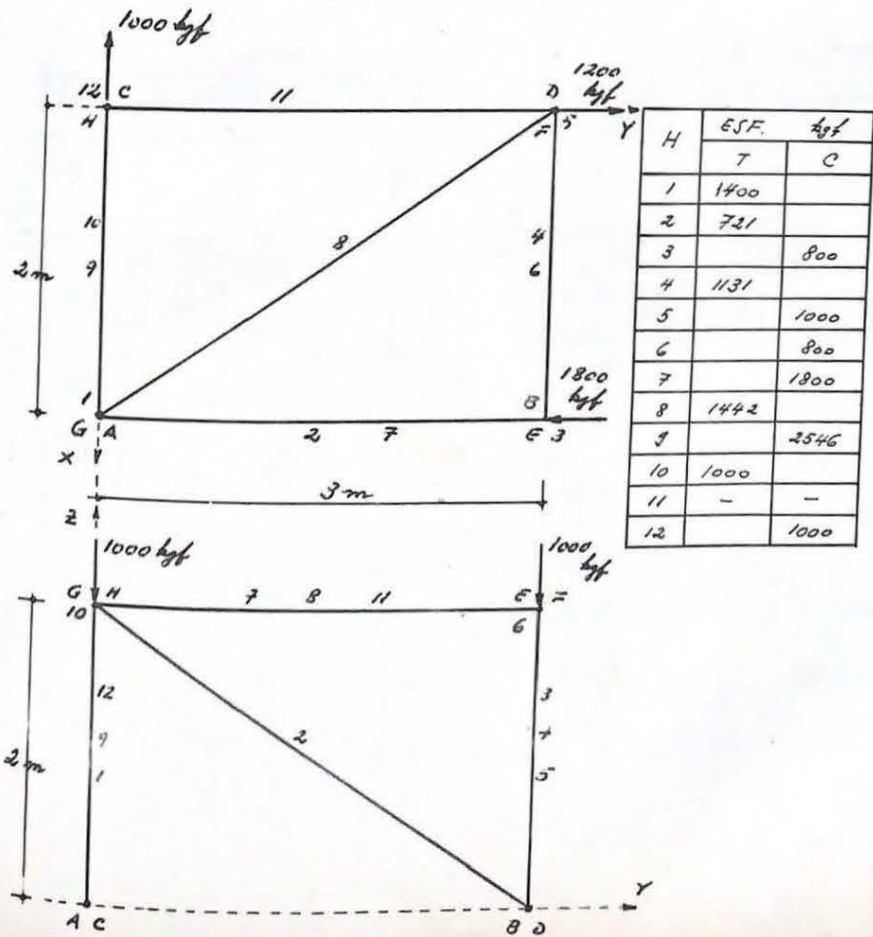
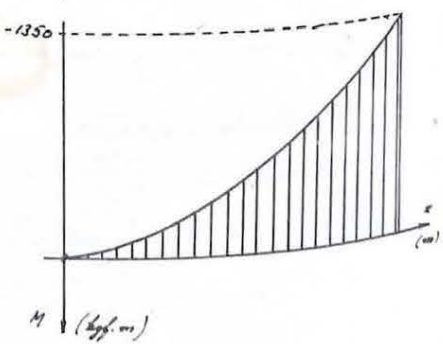
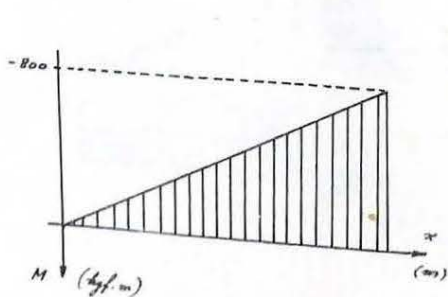
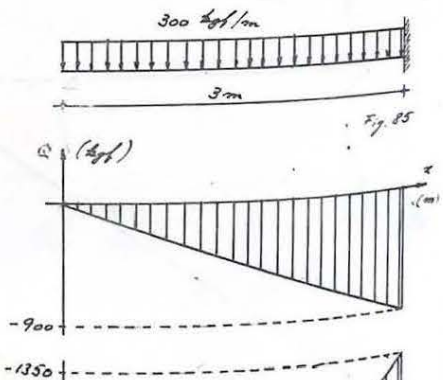
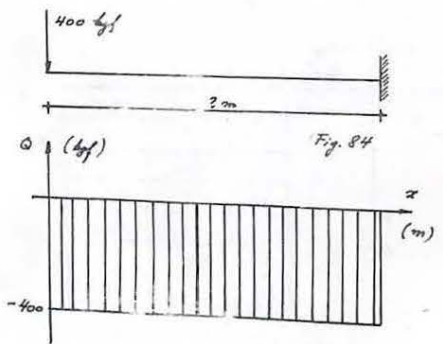
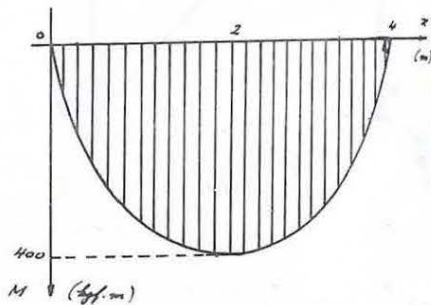
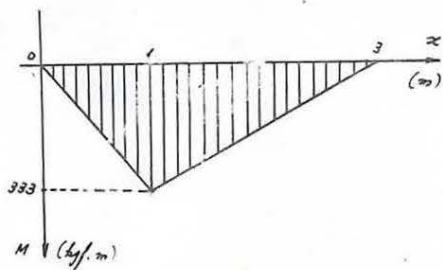
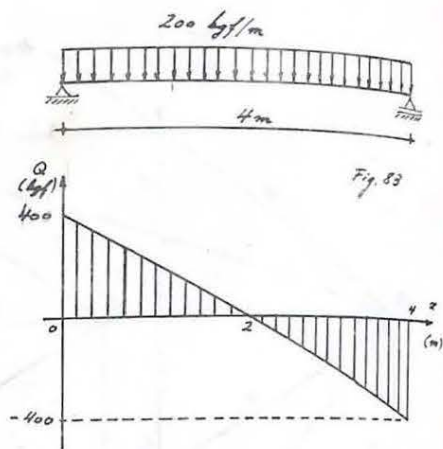
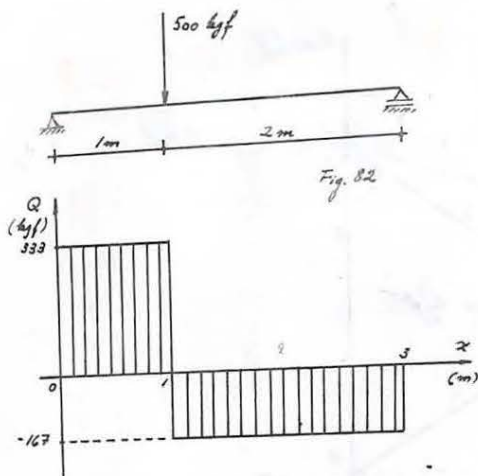
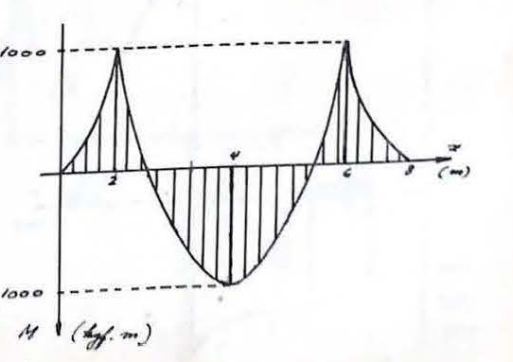
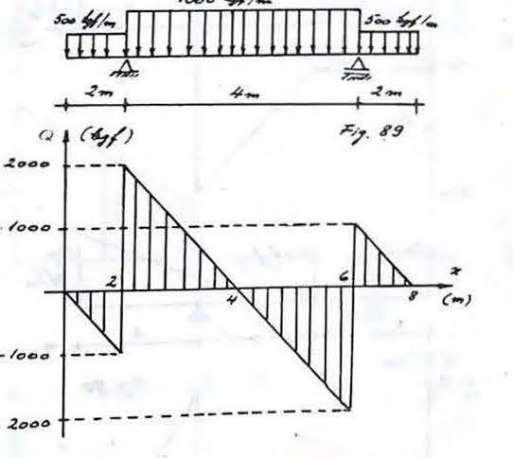
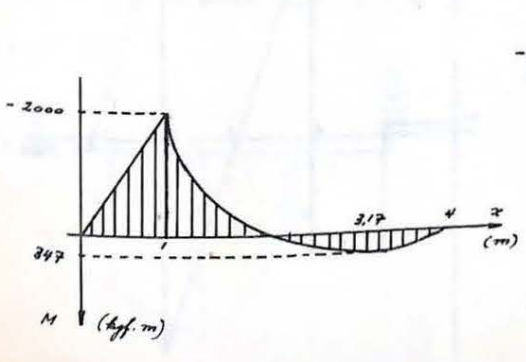
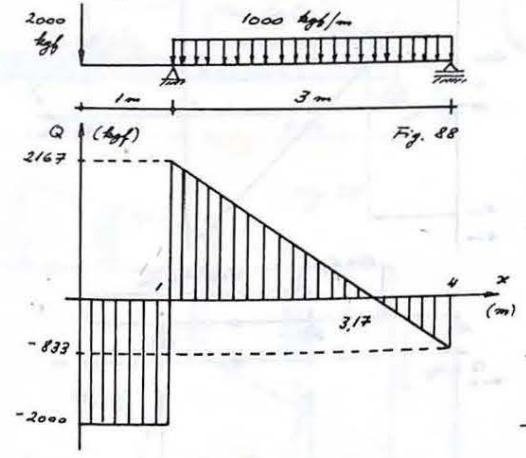
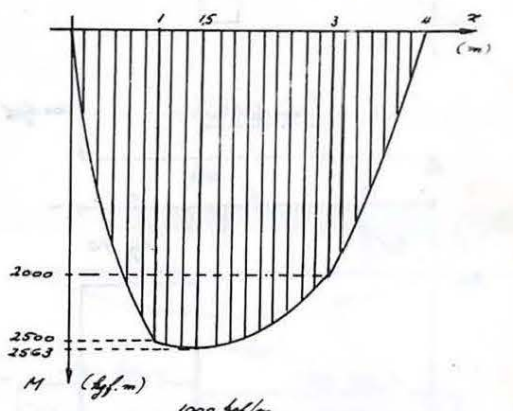
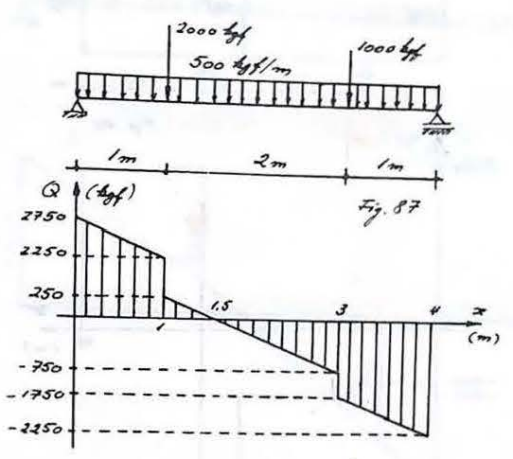
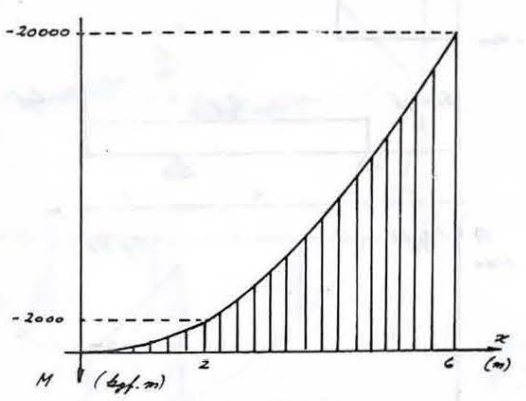
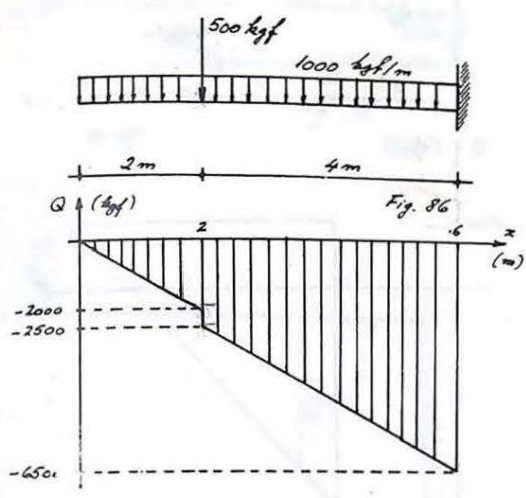


Fig. 81









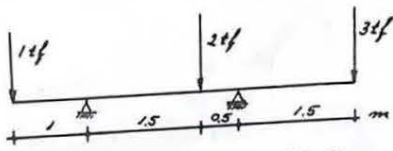


Fig. 90

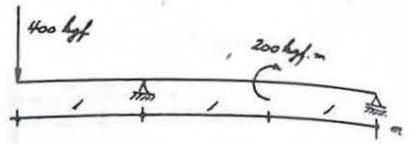
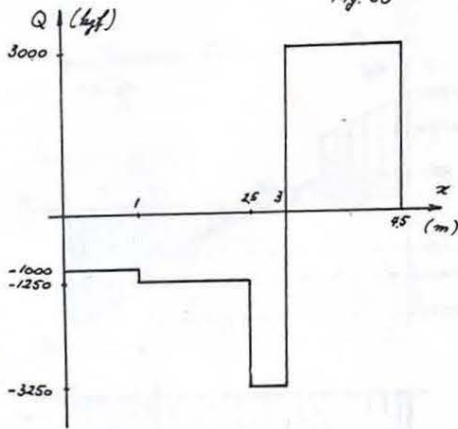


Fig. 91

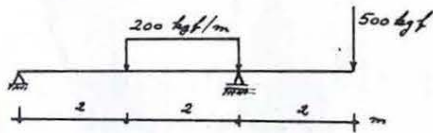
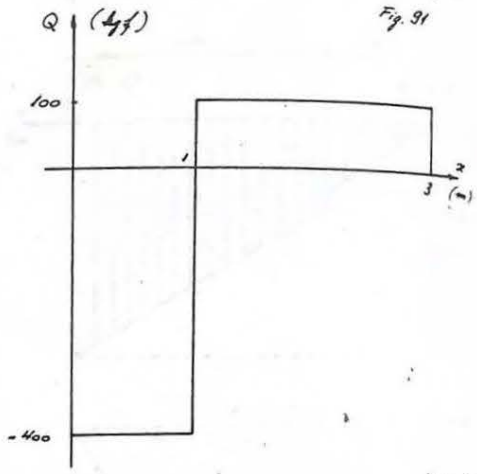


Fig. 92

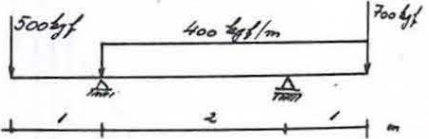
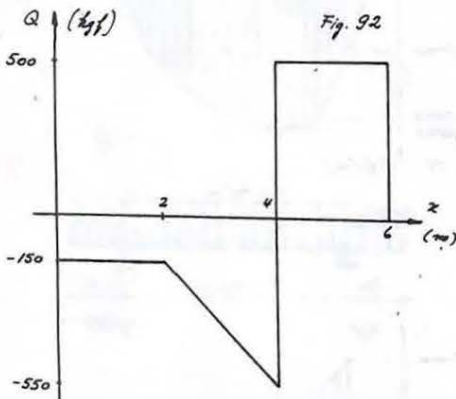


Fig. 93

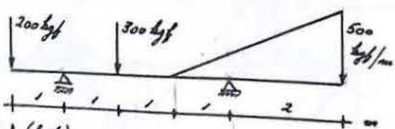
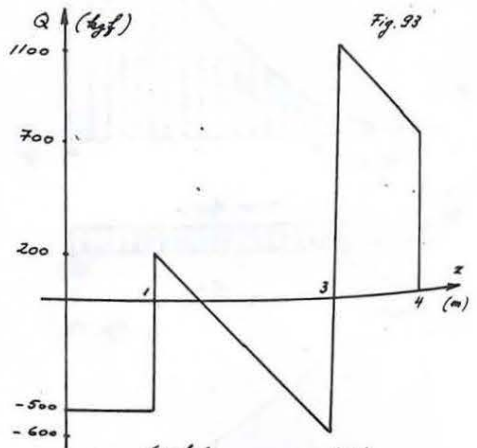


Fig. 94

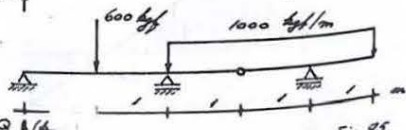
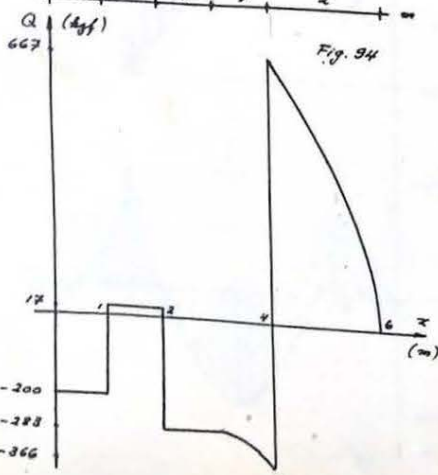
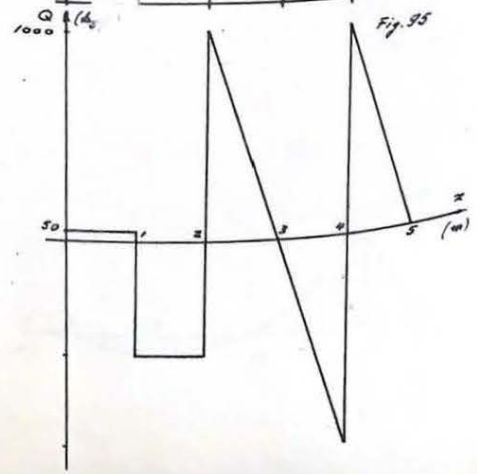


Fig. 95



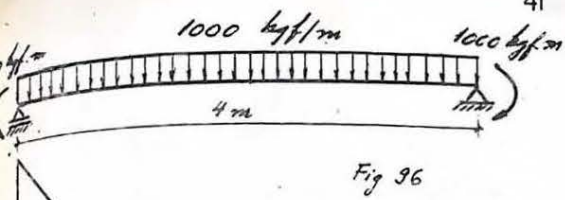


Fig 96

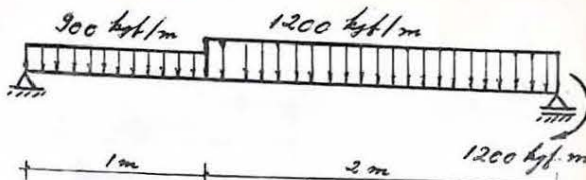
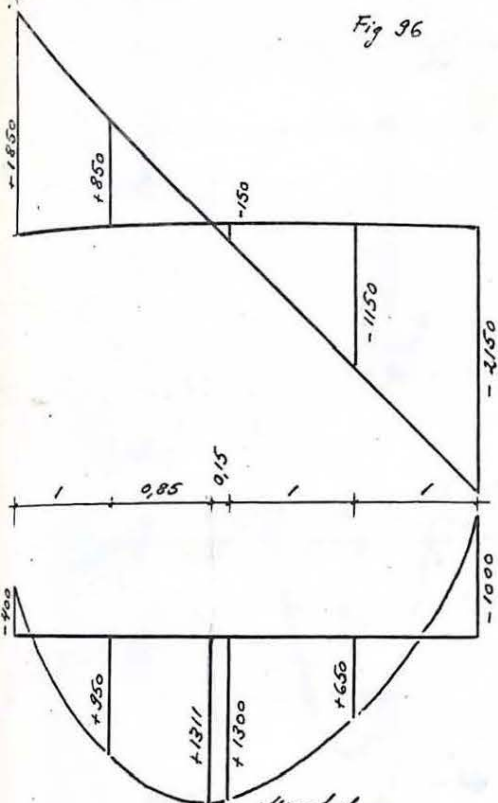


Fig 97

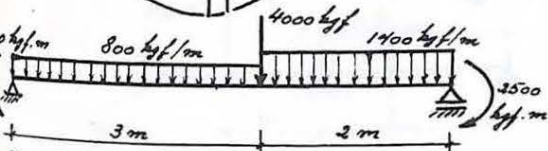
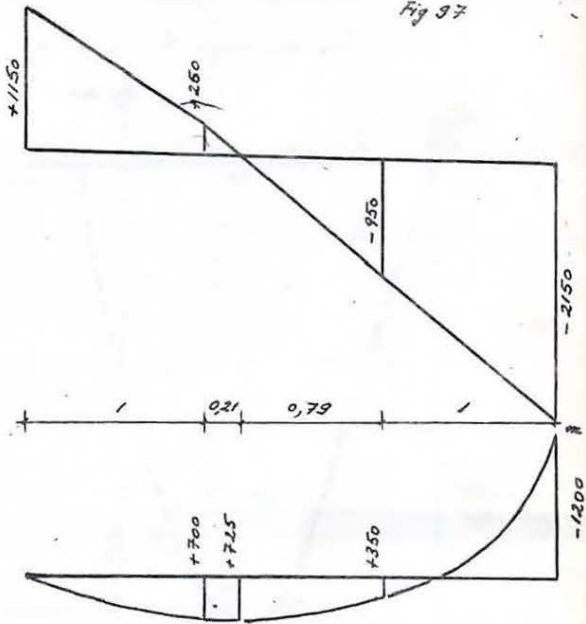


Fig 98

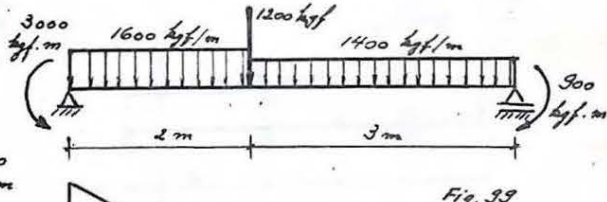
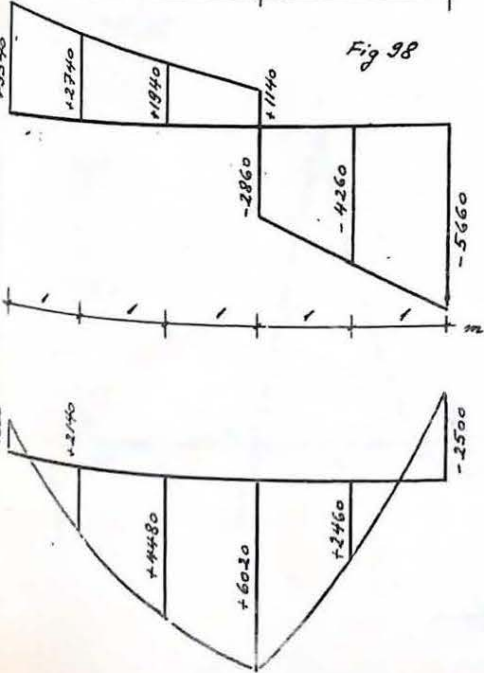
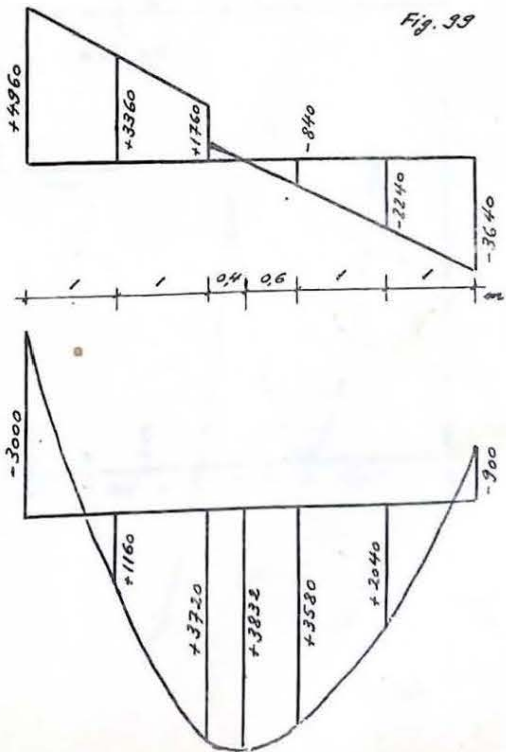


Fig 99





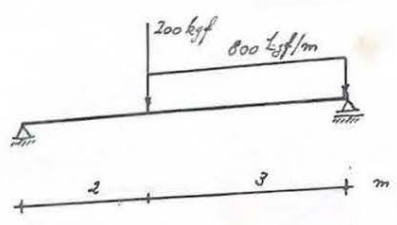


Fig. 100

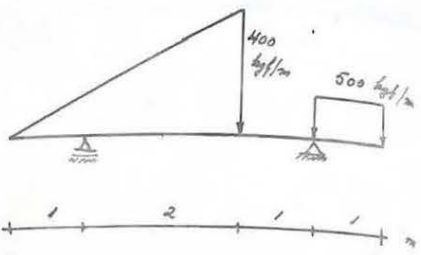
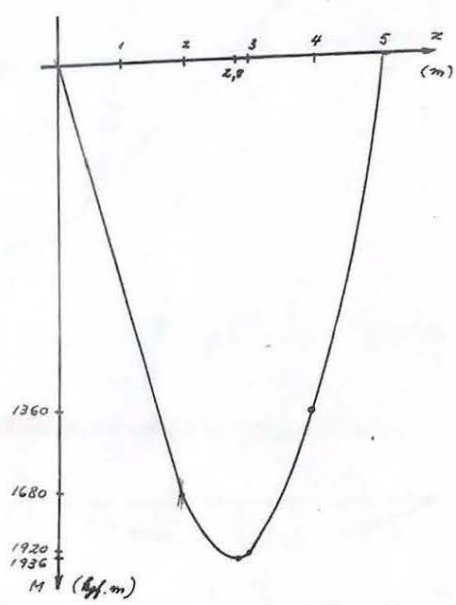


Fig. 101

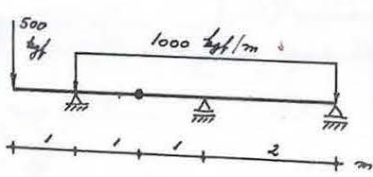
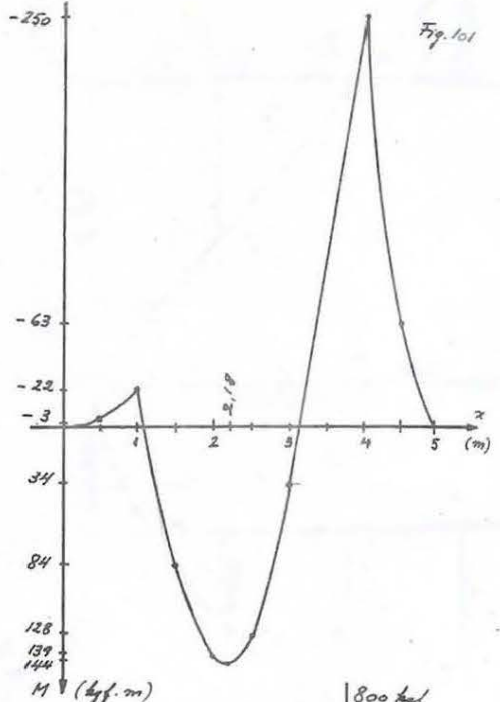


Fig. 102

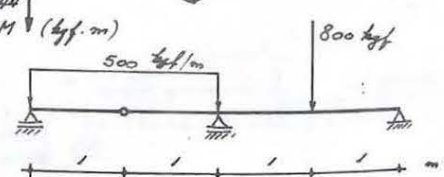
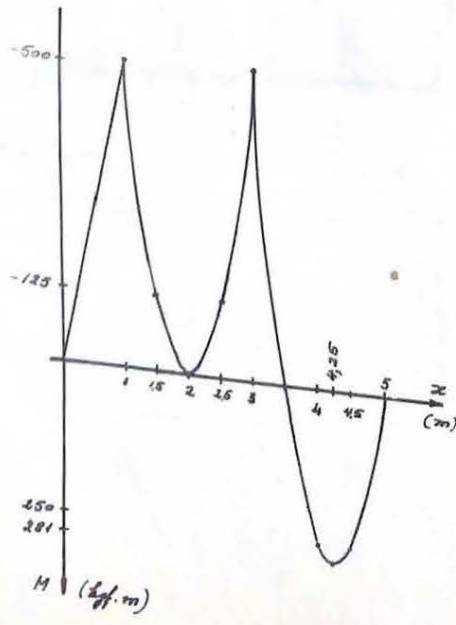
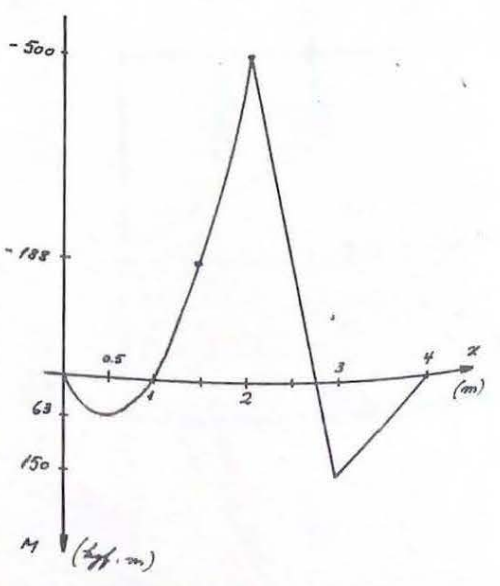


Fig. 103





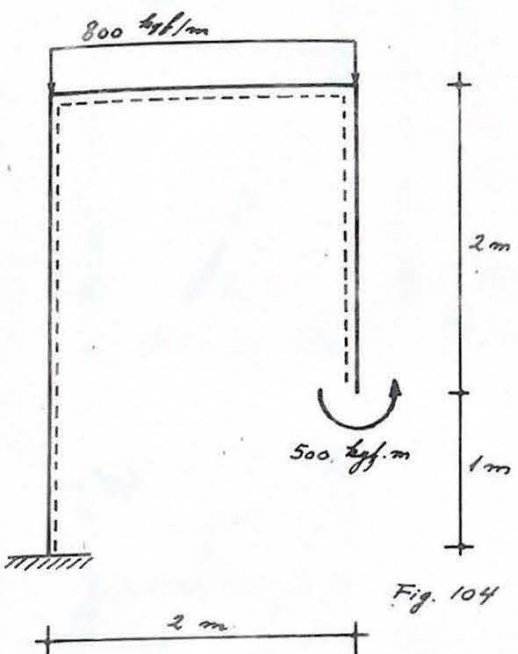
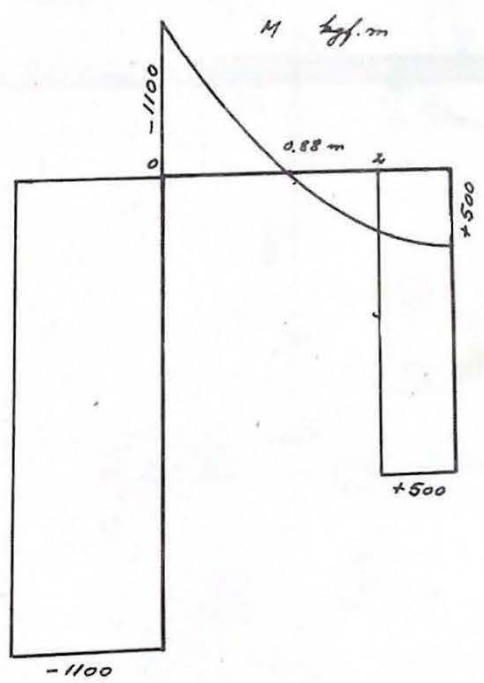
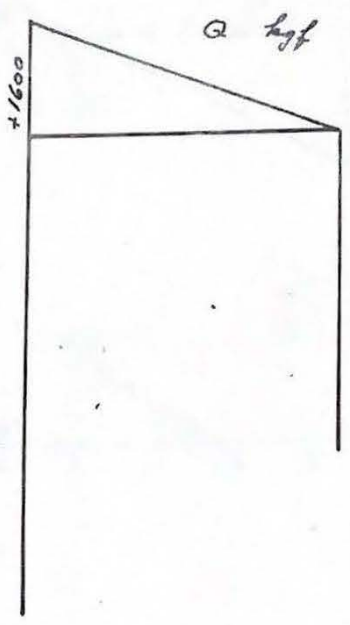
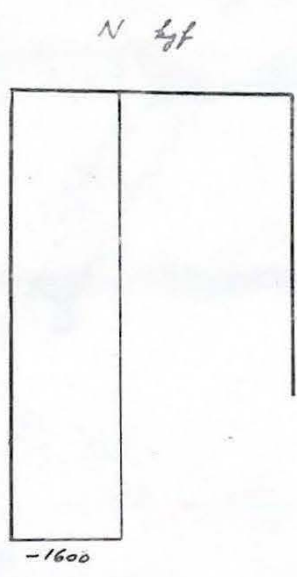


Fig. 104



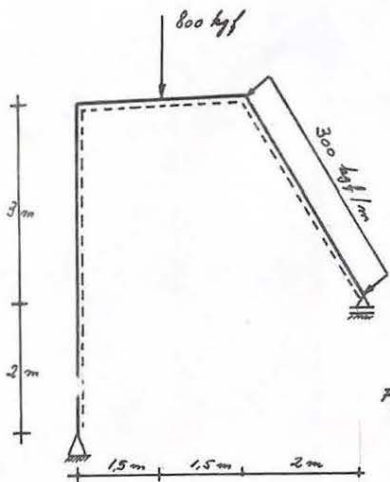


Fig. 105

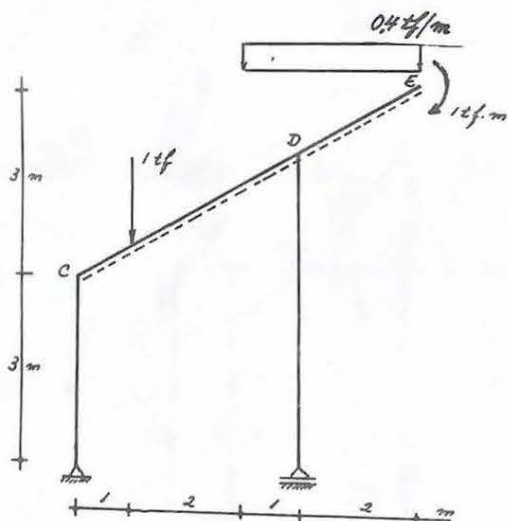
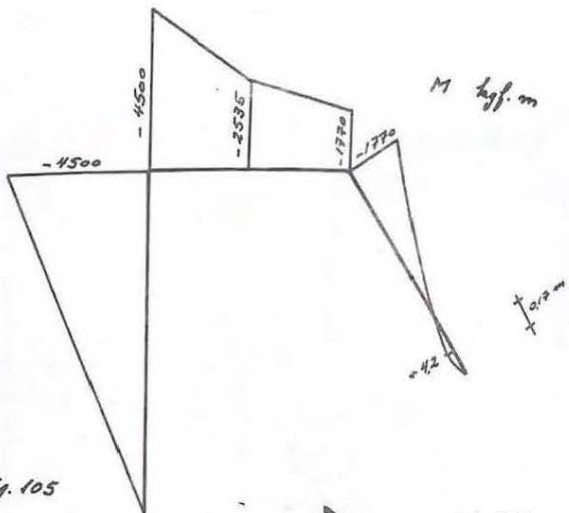


Fig. 106

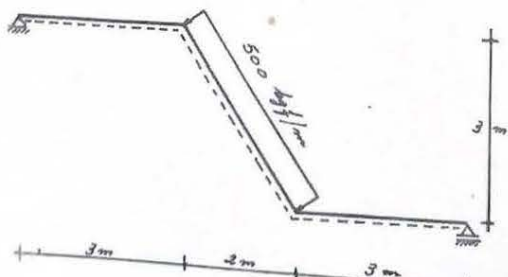
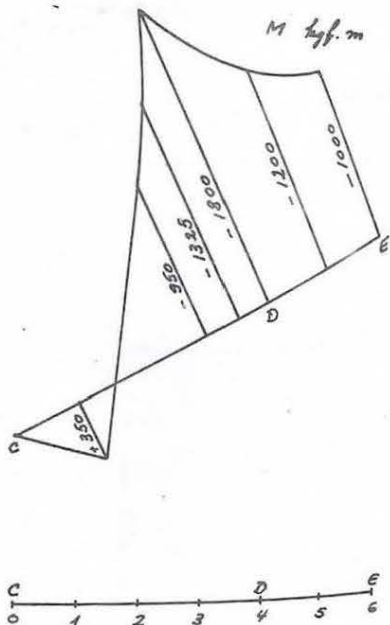
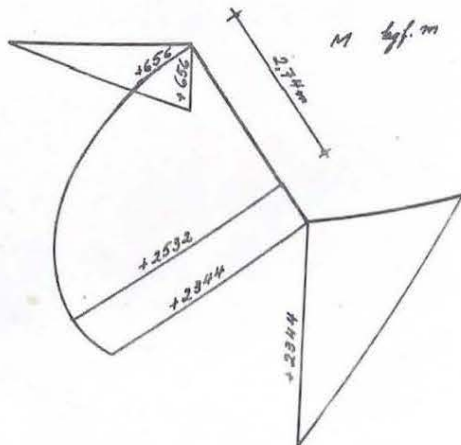


Fig. 107



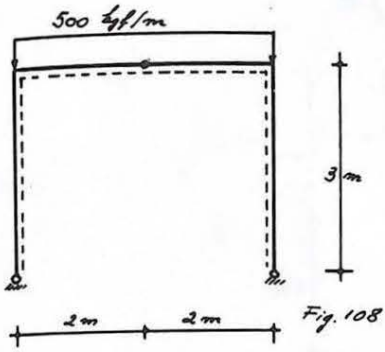


Fig. 108

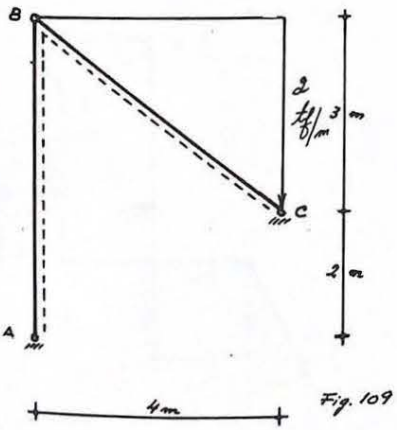
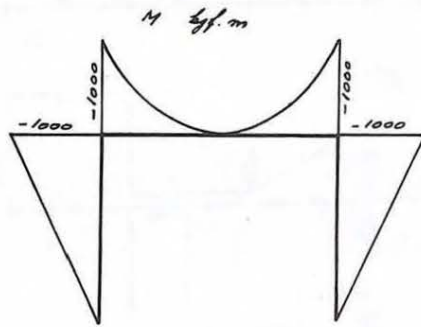
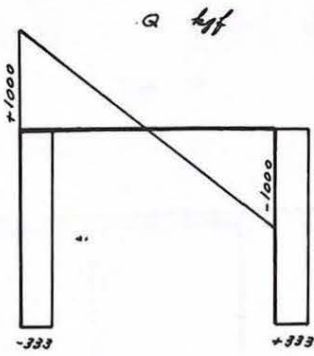
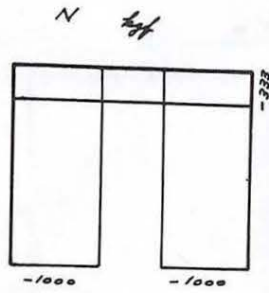
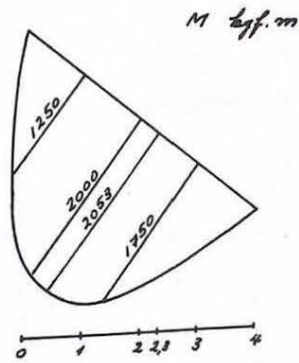


Fig. 109



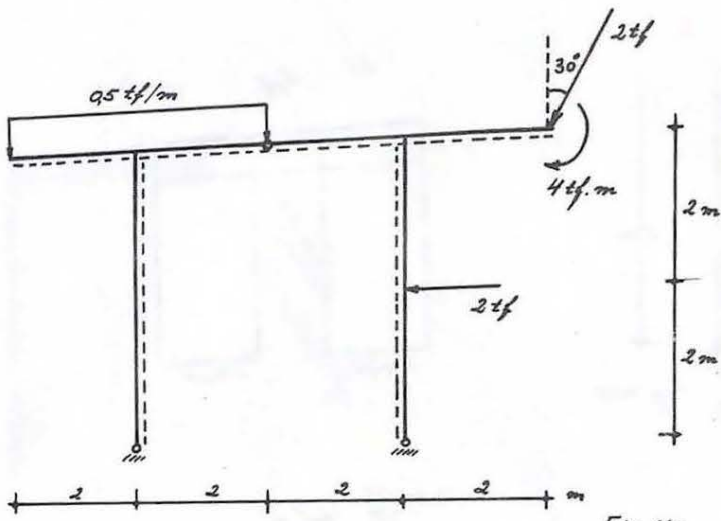
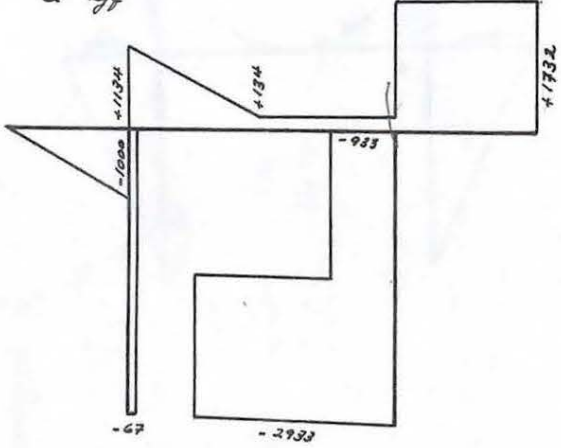


Fig 110

Q *kyf*



N *kyf*

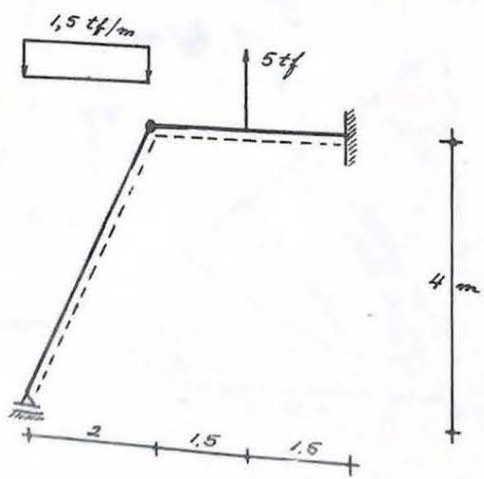
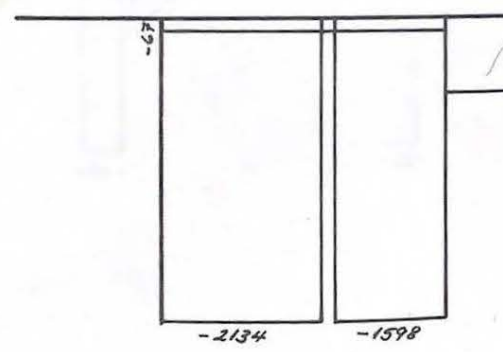
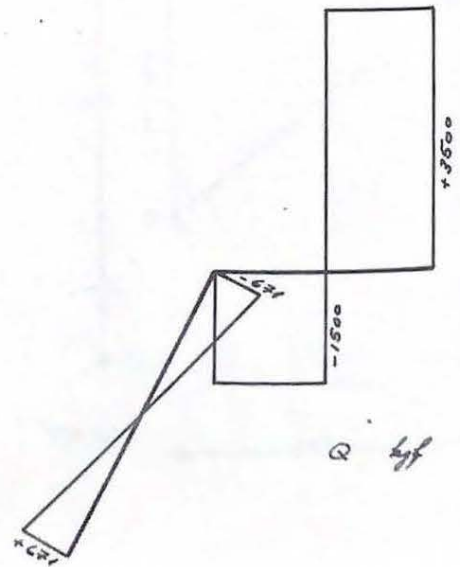


Fig. 111



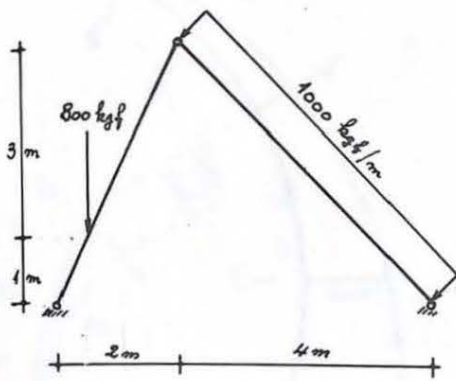


Fig 112

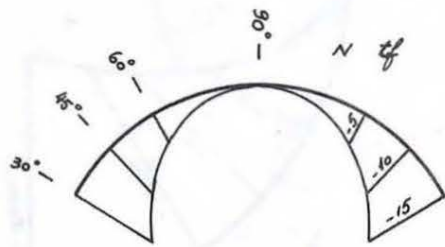
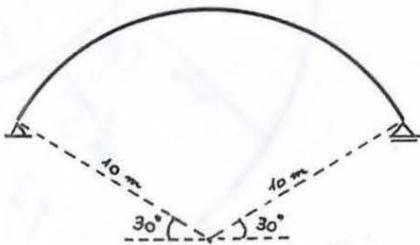
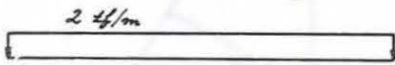
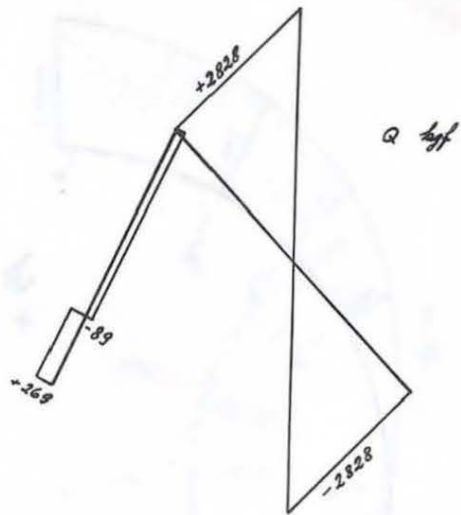


Fig 113

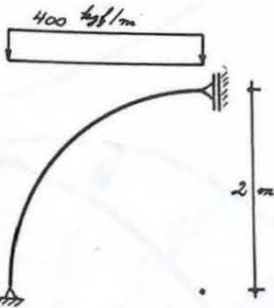


Fig 114

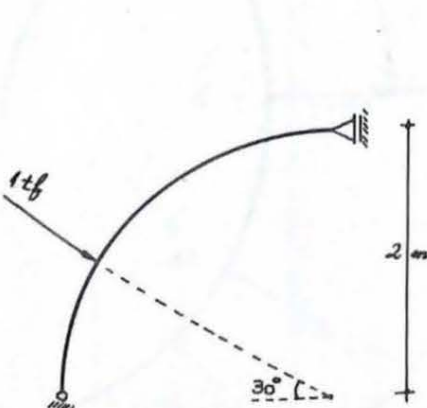
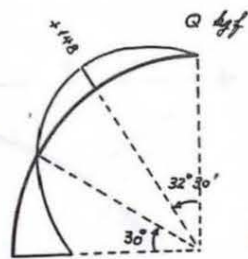
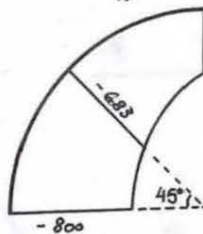
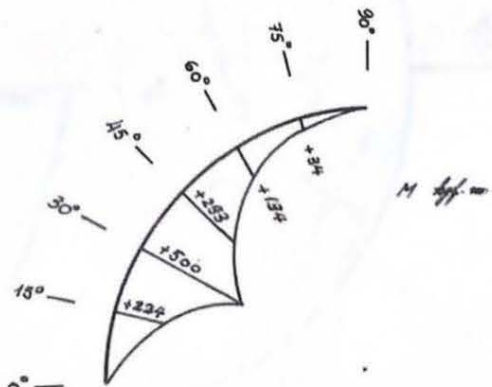
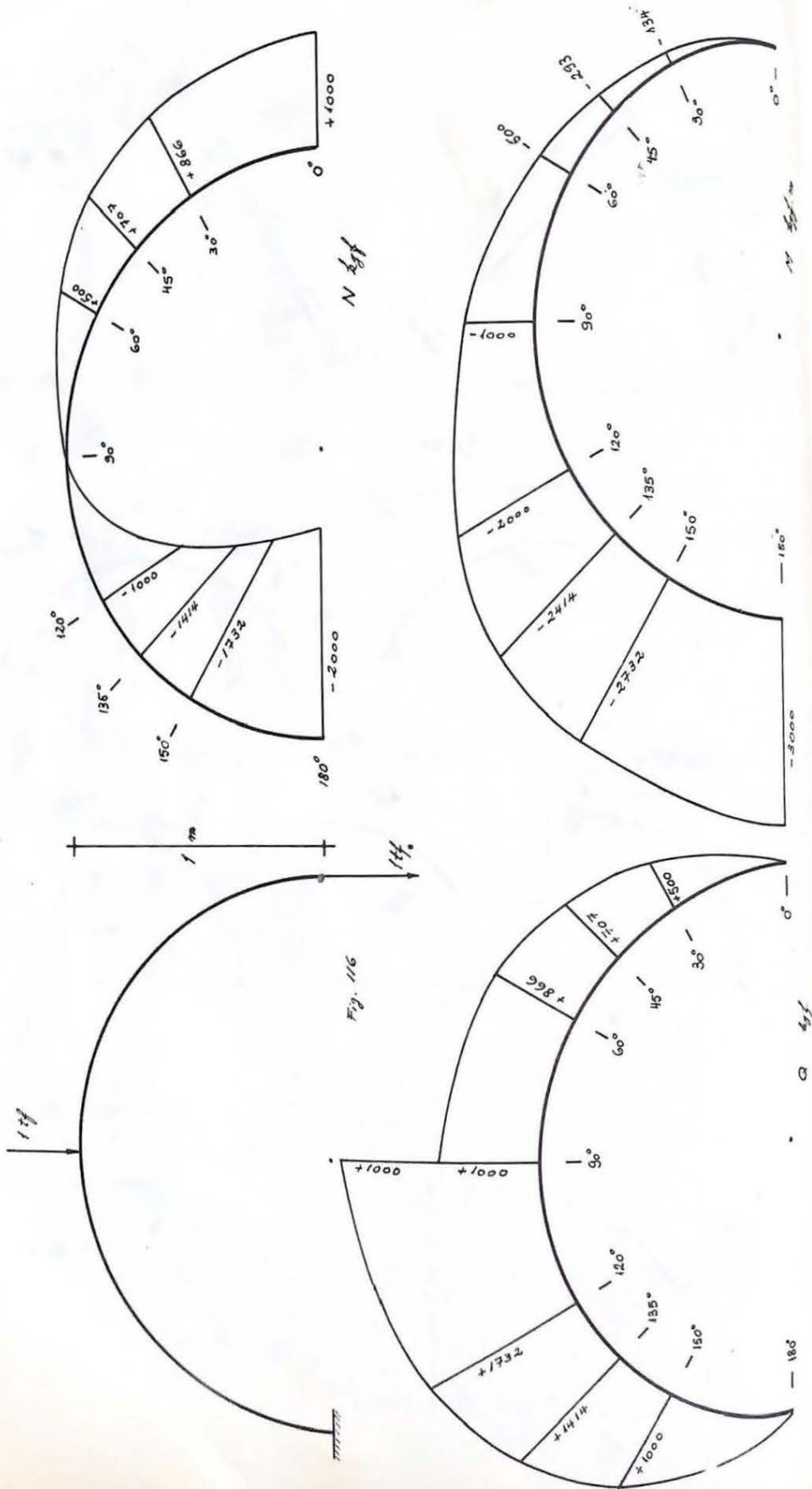


Fig 115







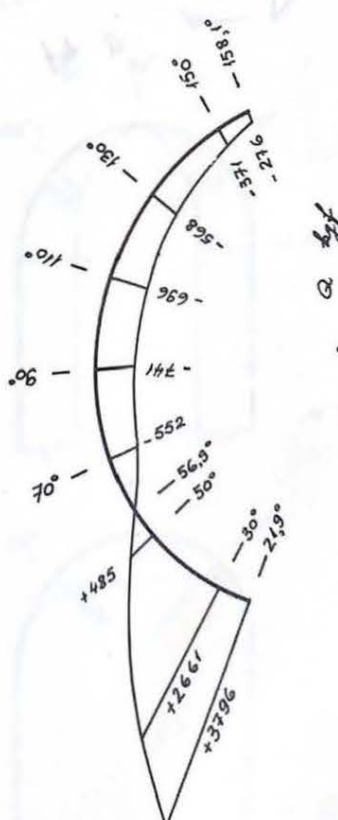
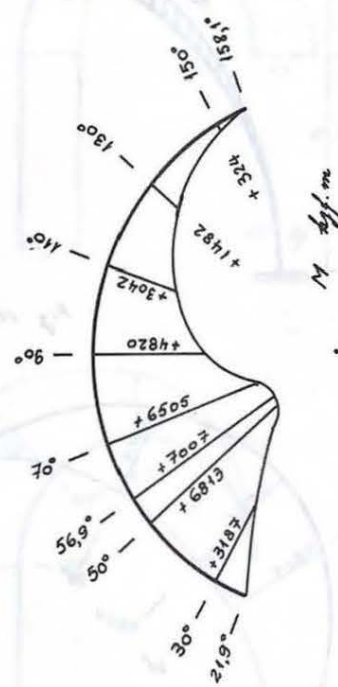
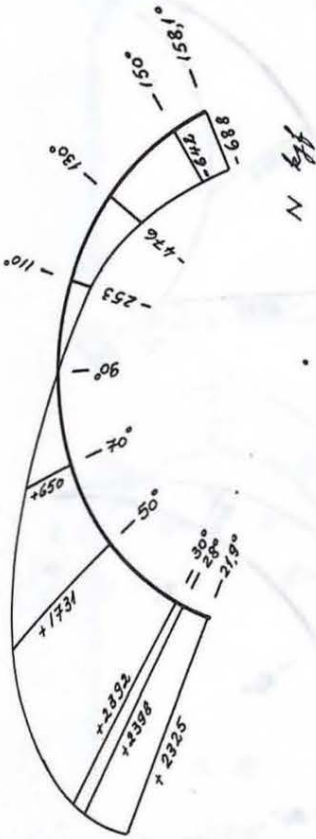
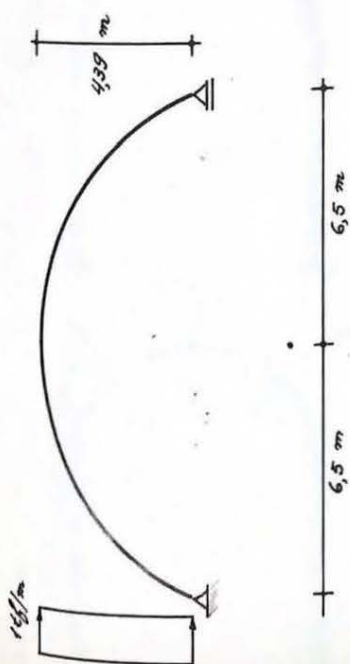


Fig 117



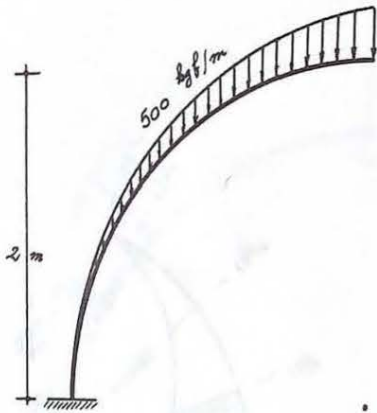
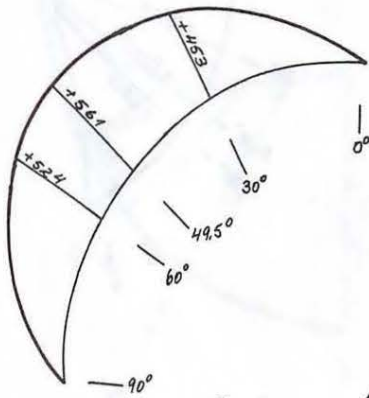
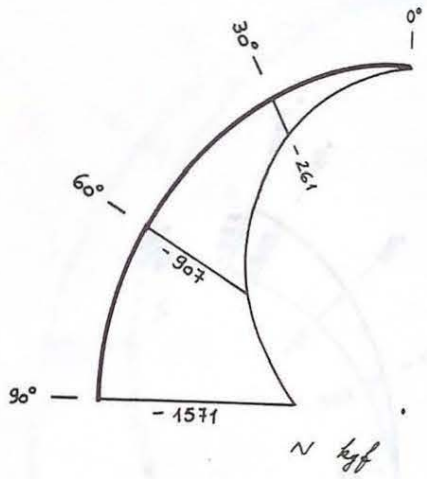
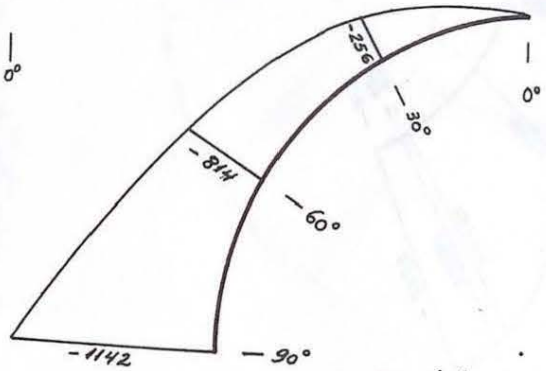


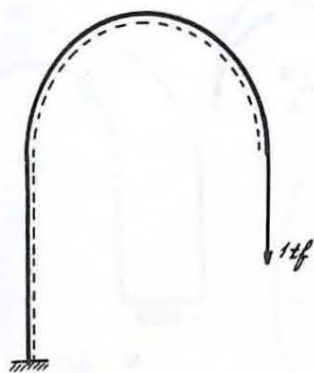
Fig 118



Q kgf



M kgf.m



1m 1m Fig. 119

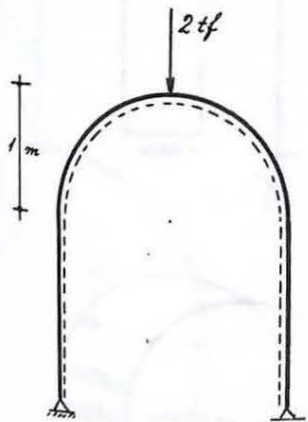
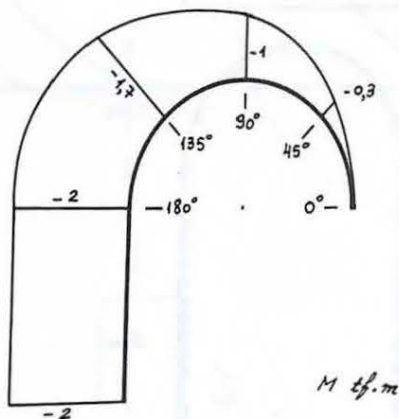
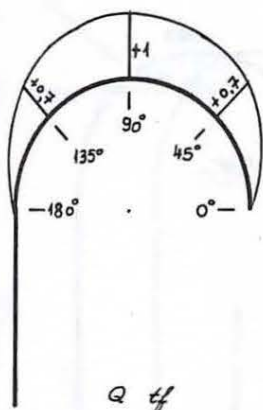
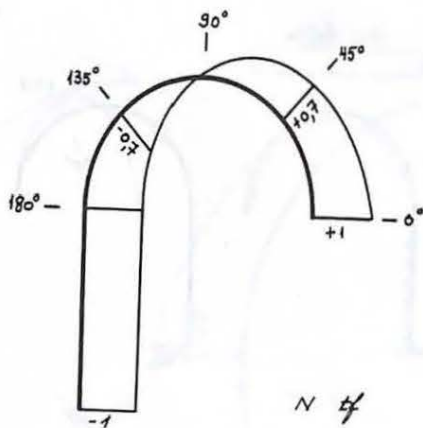
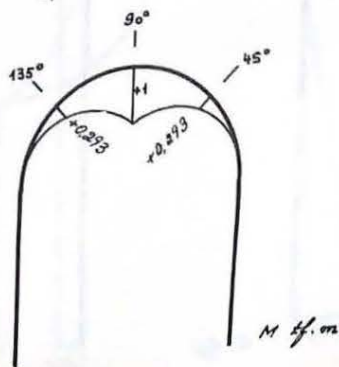
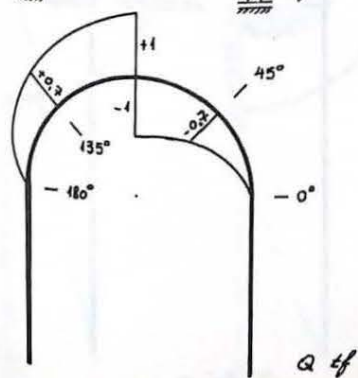
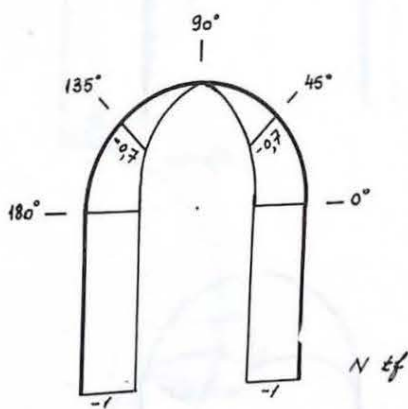
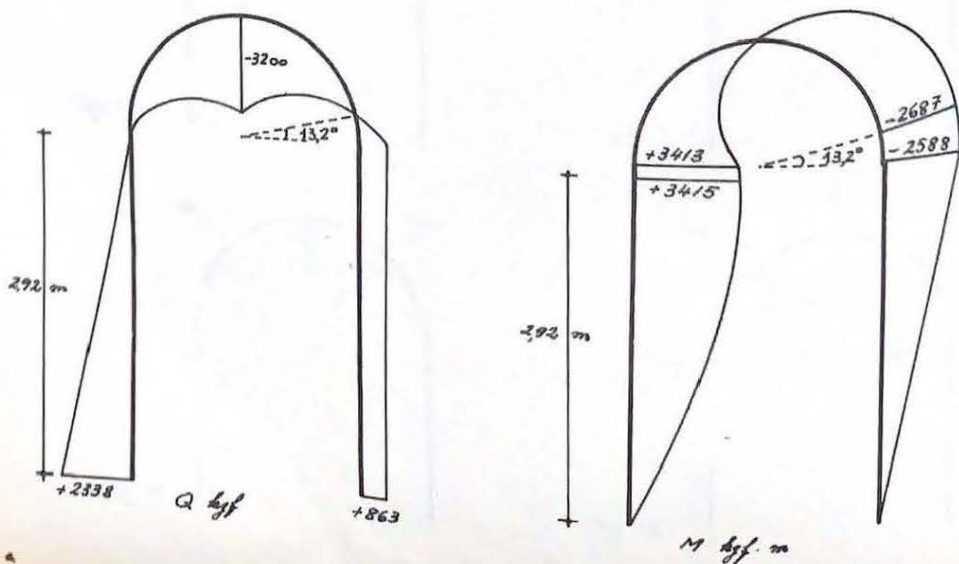
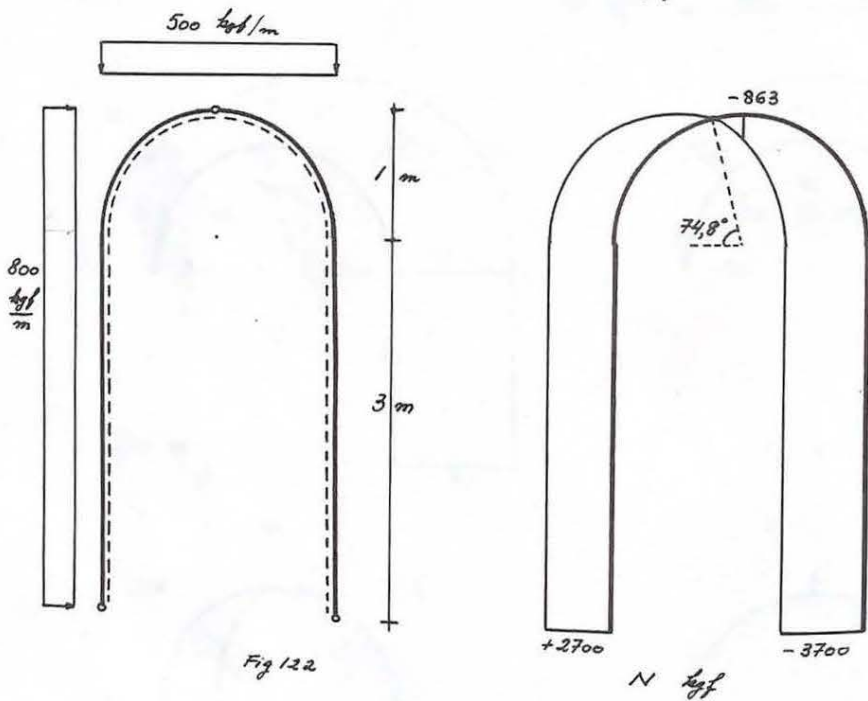
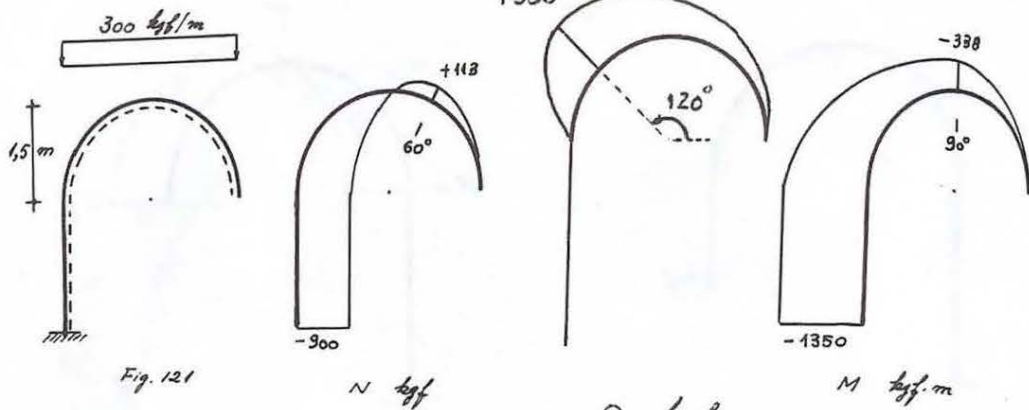


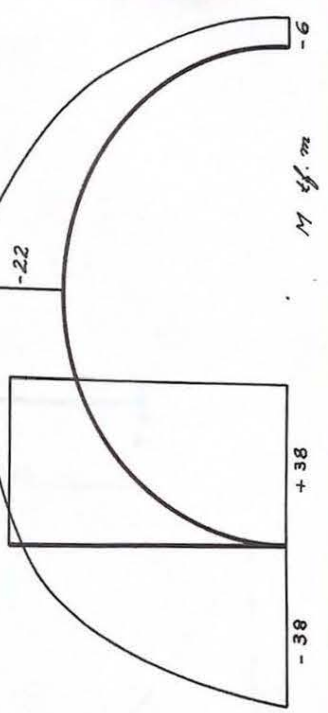
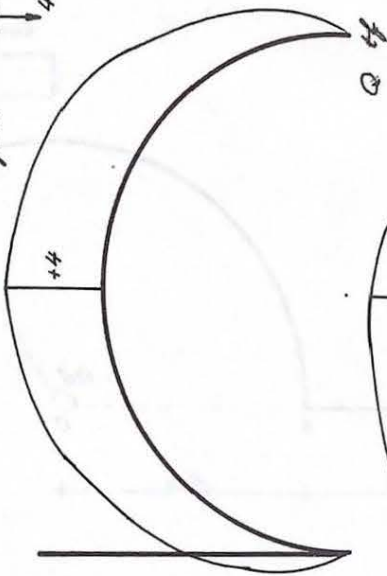
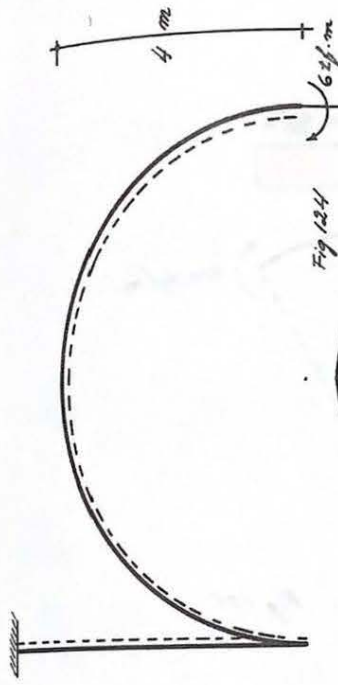
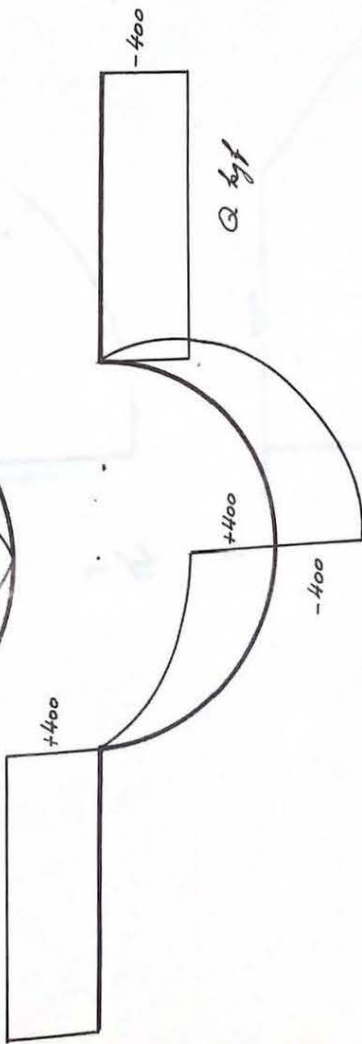
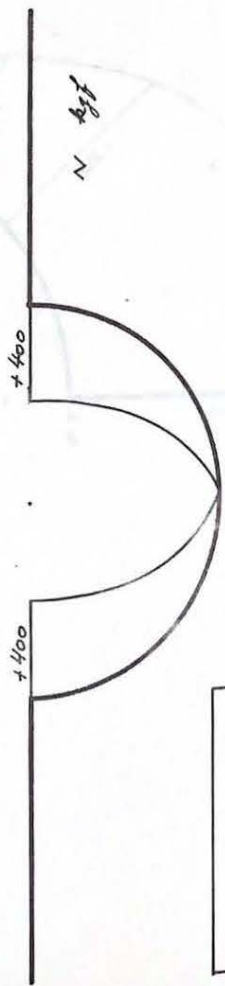
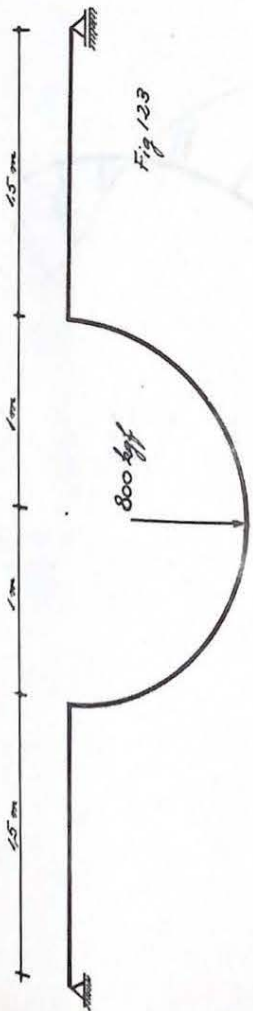
Fig. 120



M tf.m







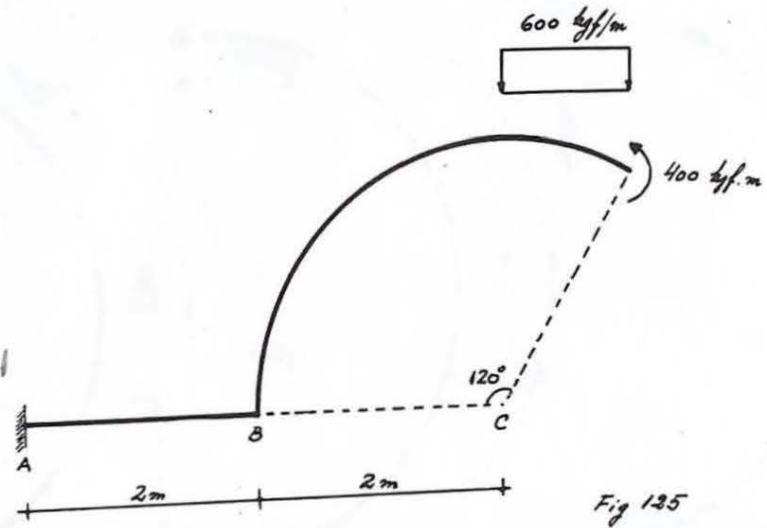
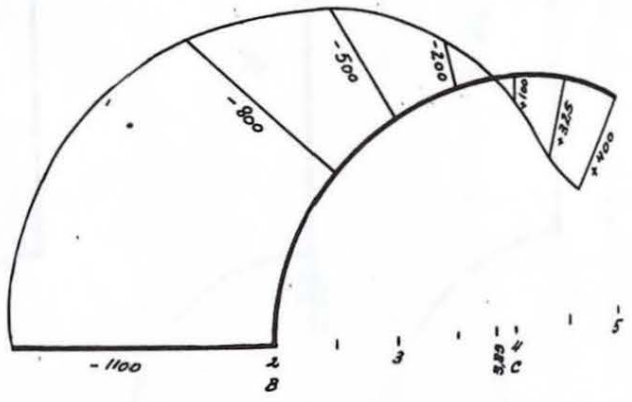
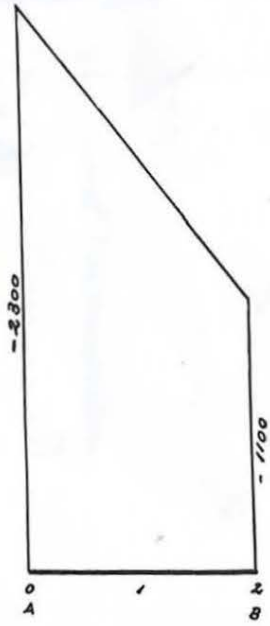


Fig 125



M kgf.m

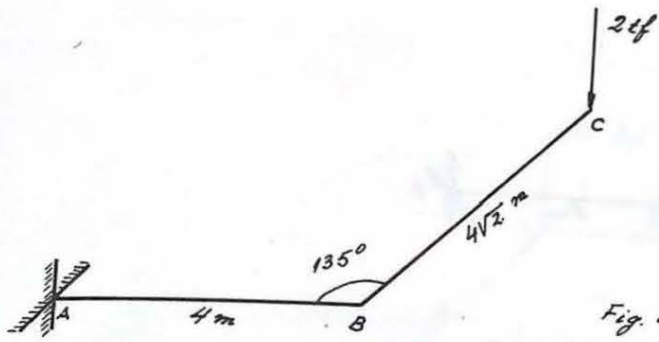
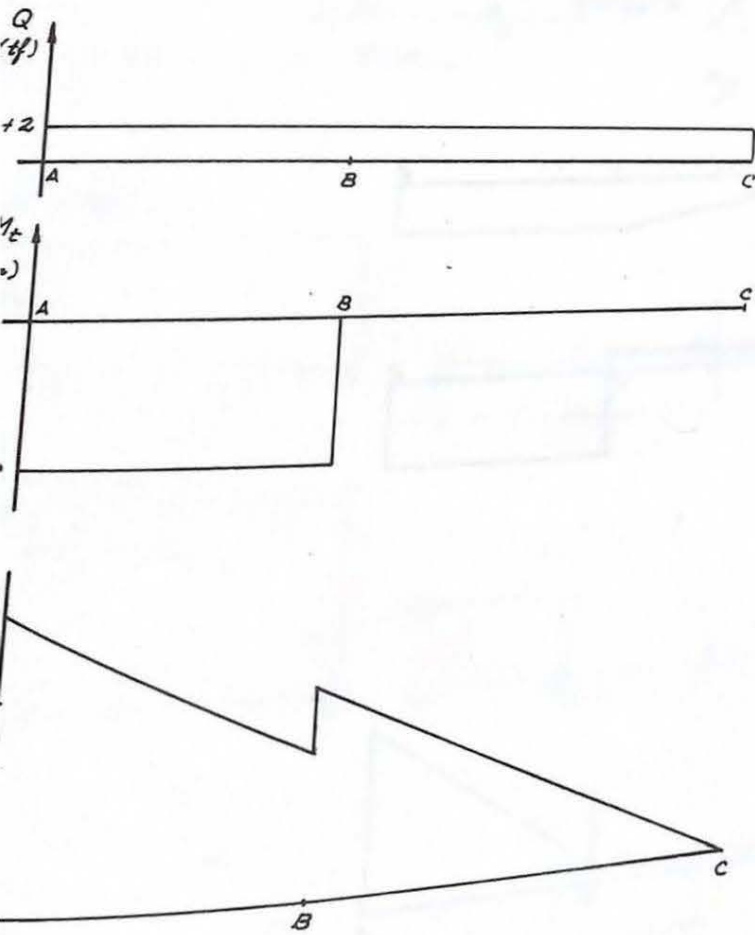


Fig. 126



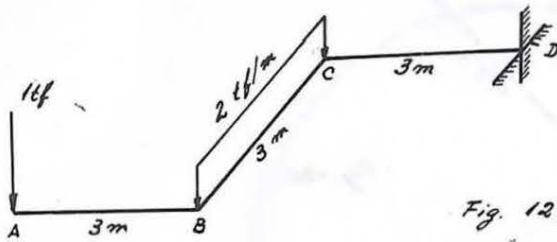
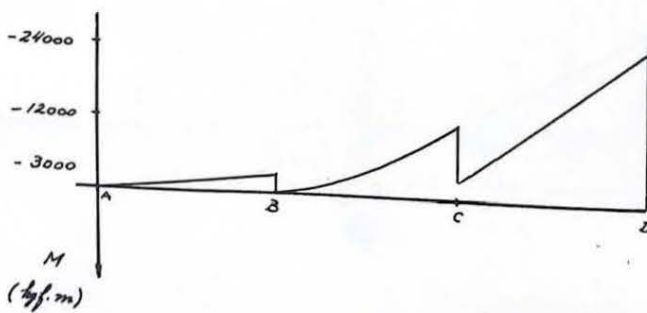
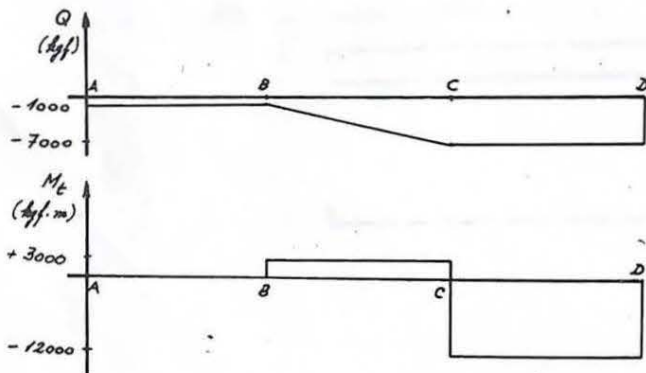


Fig. 127



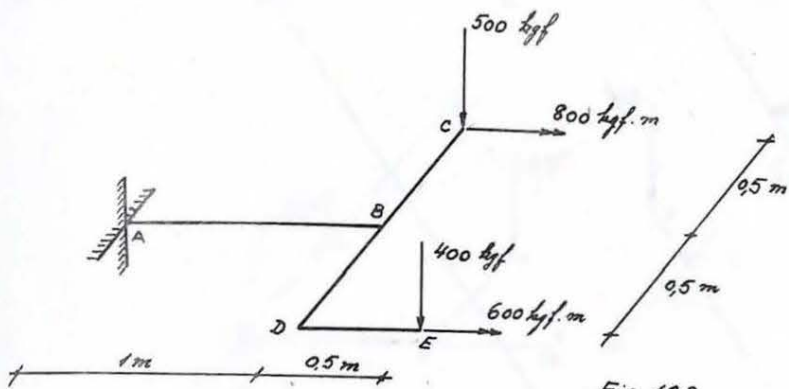
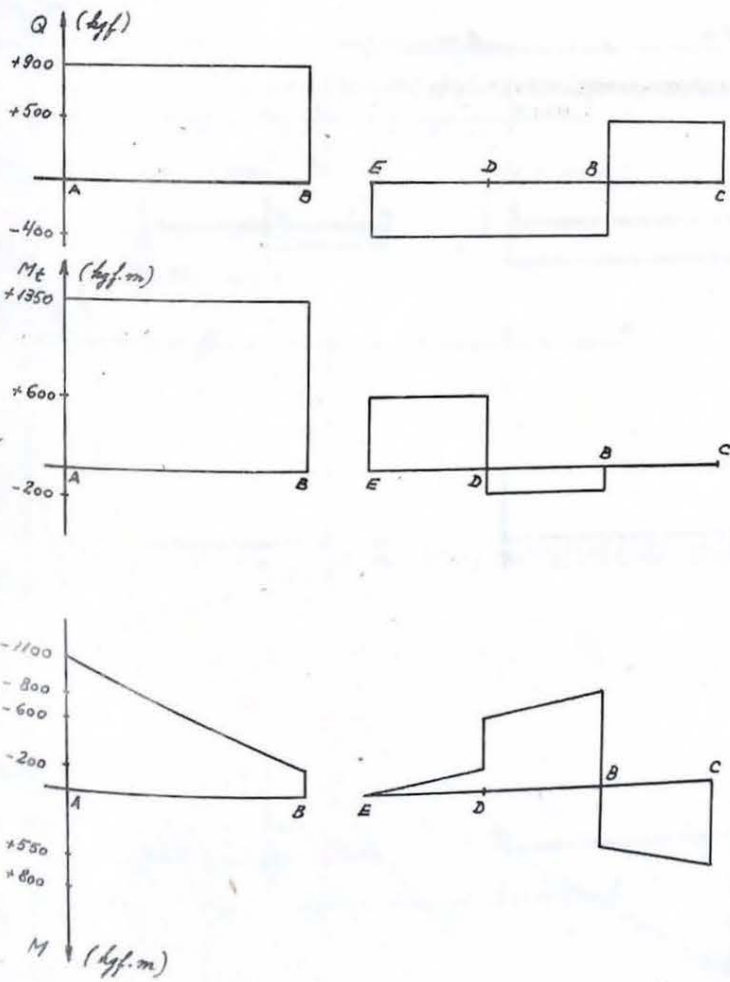


Fig. 128





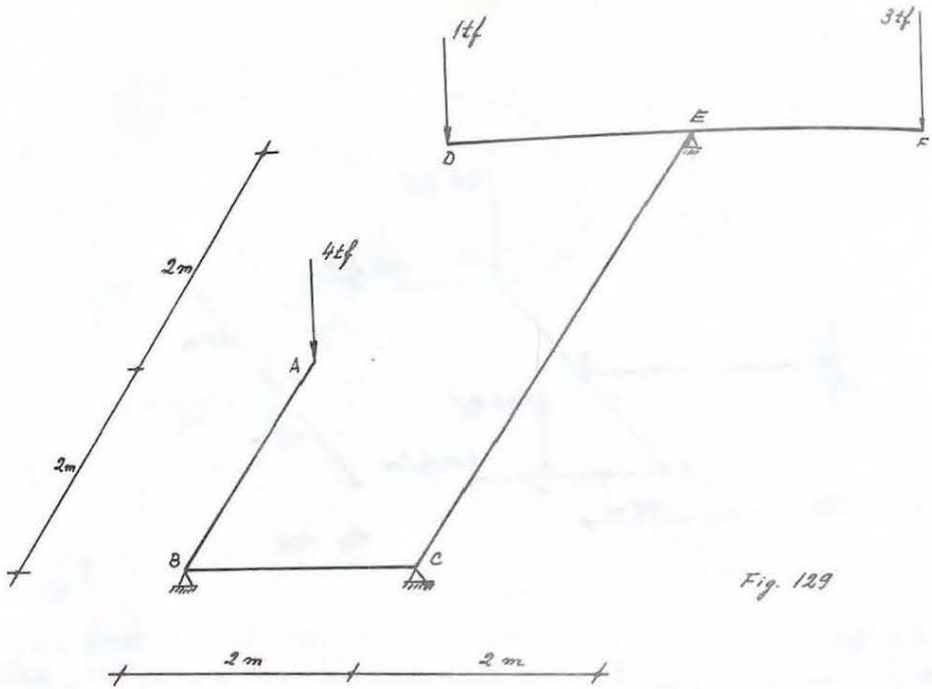
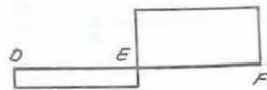
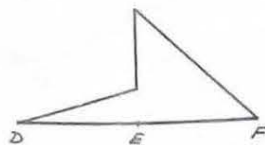
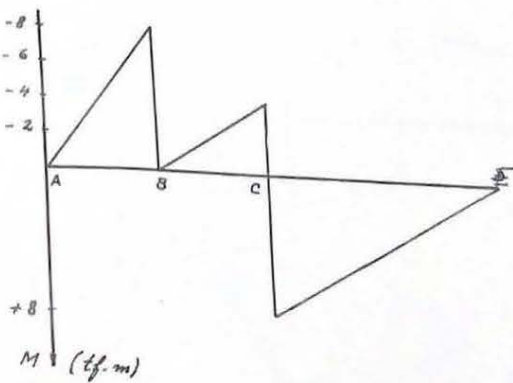
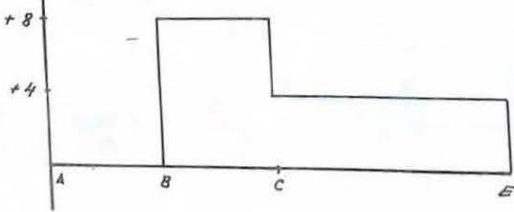


Fig. 129

Q (tf)

 $M_x$  (tf.m)

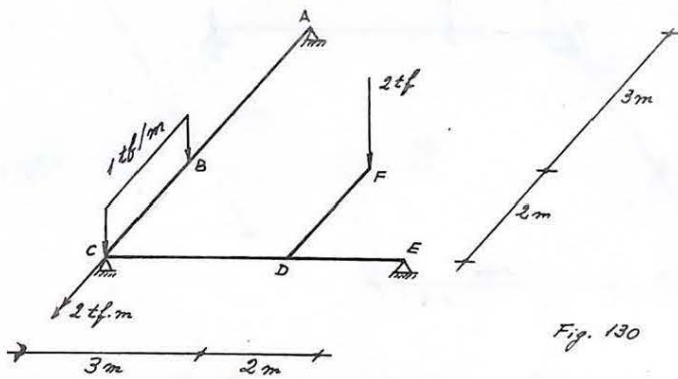
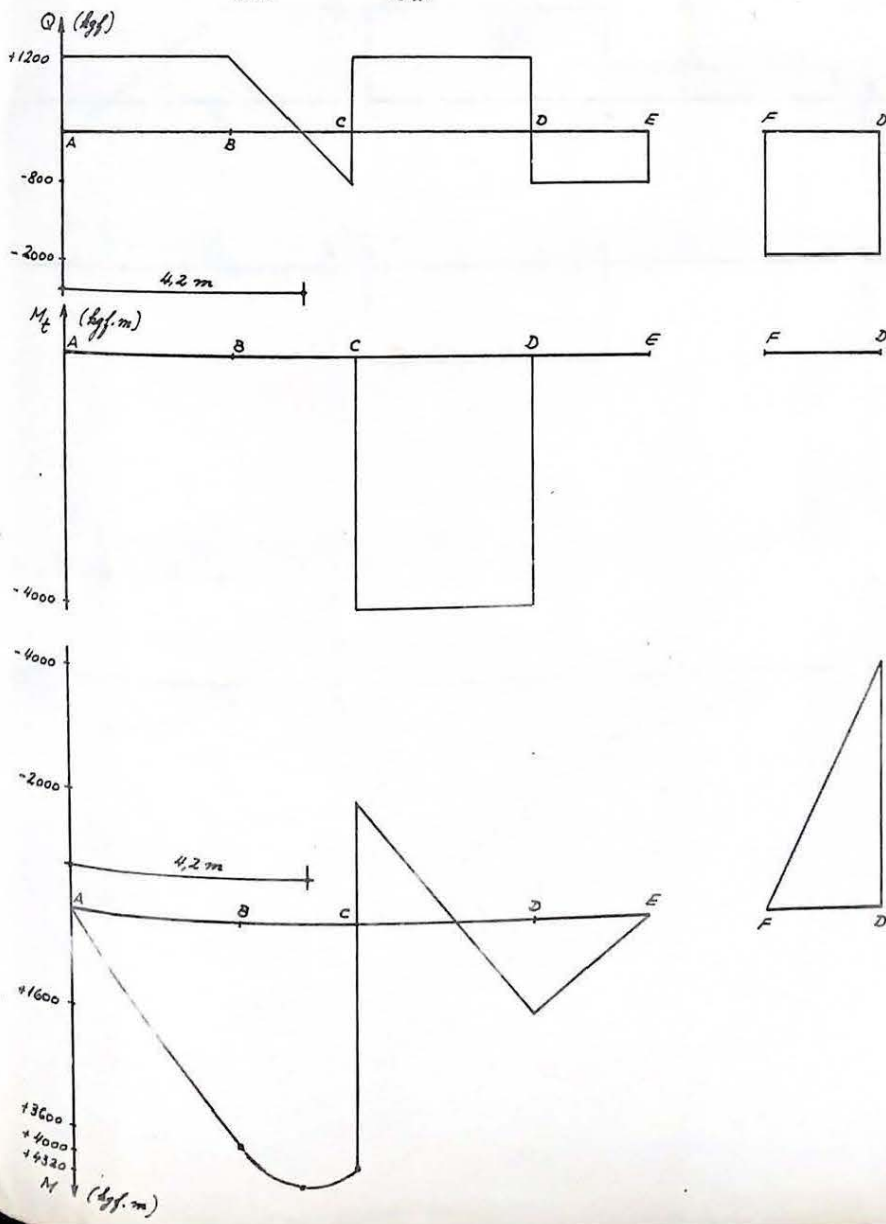


Fig. 130



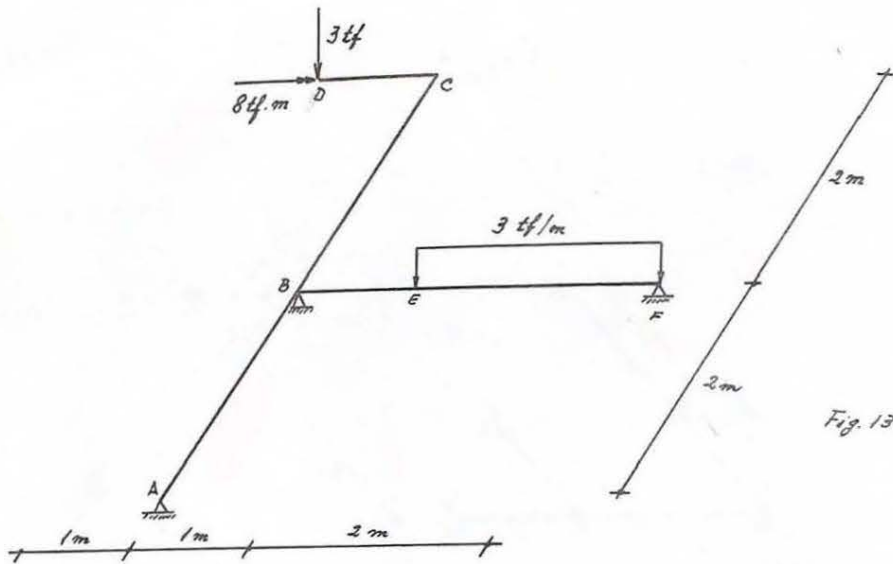
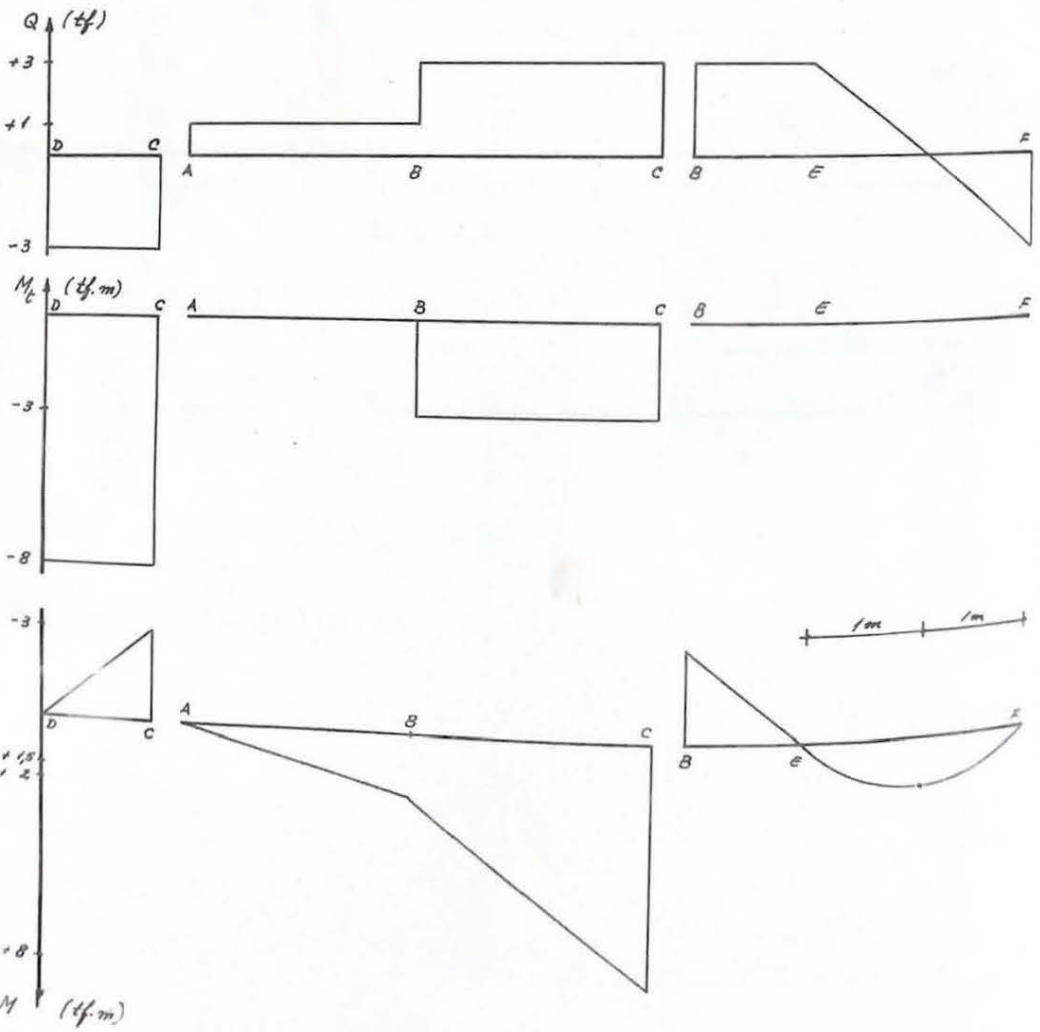


Fig. 131



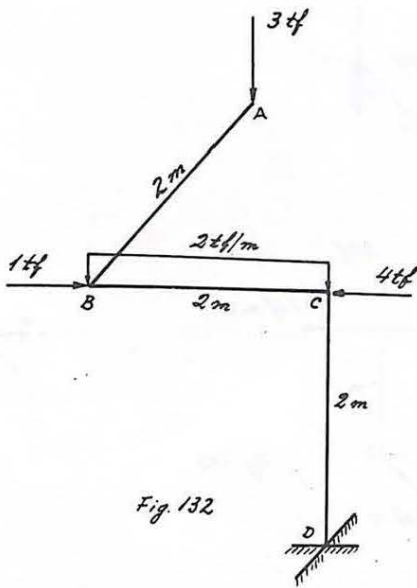
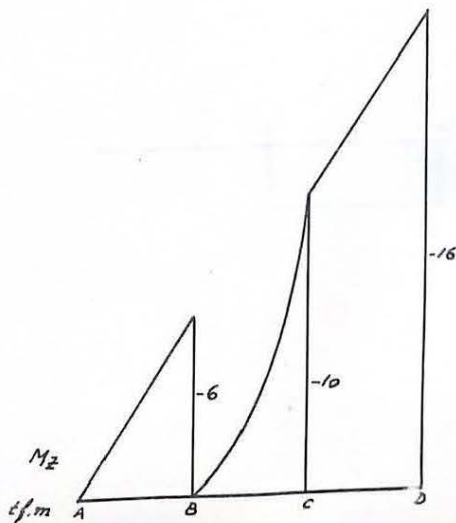
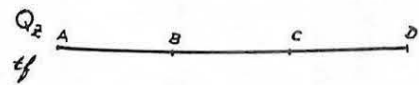
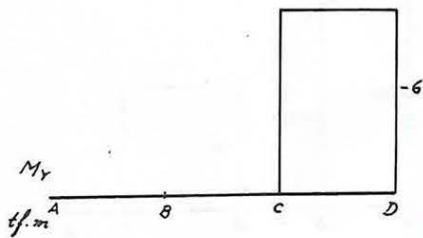
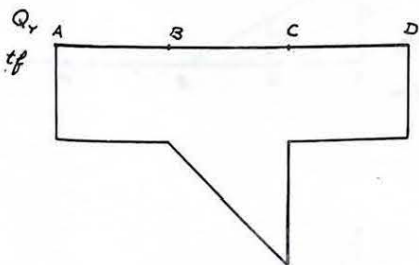
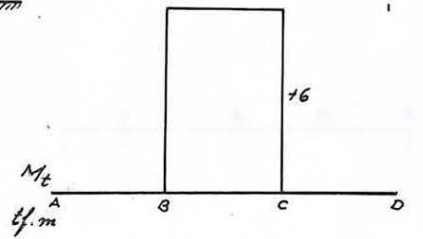
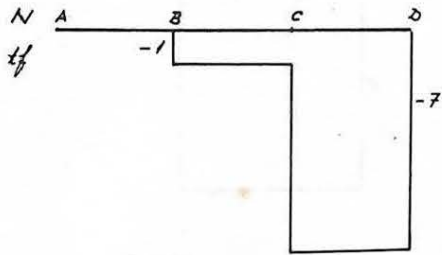


Fig. 132



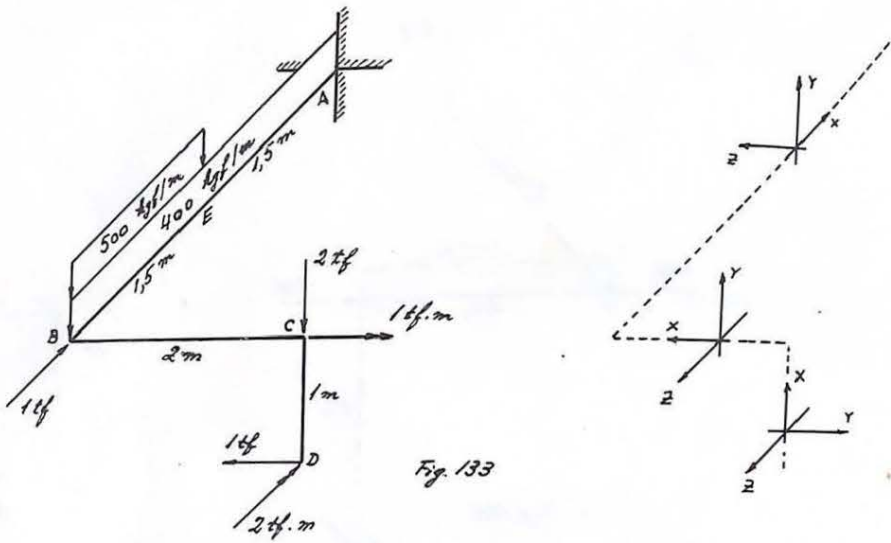
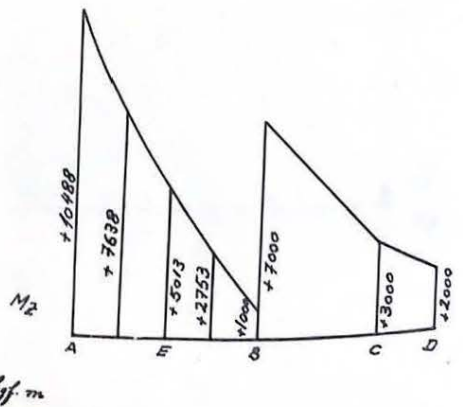
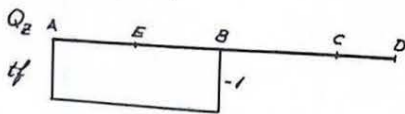
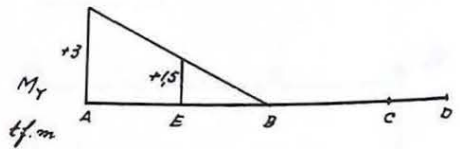
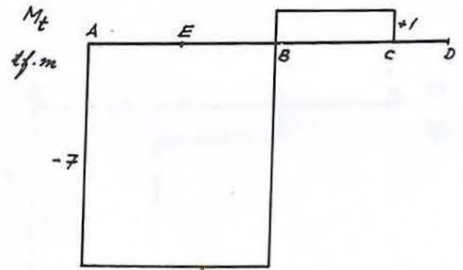
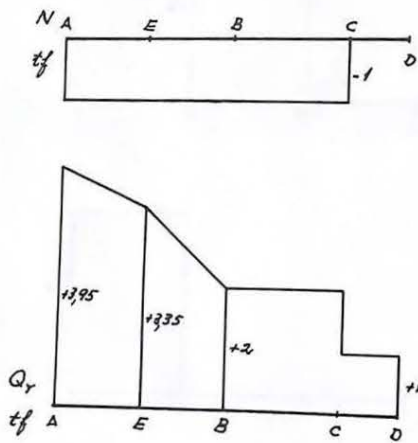


Fig. 133



kgf.m



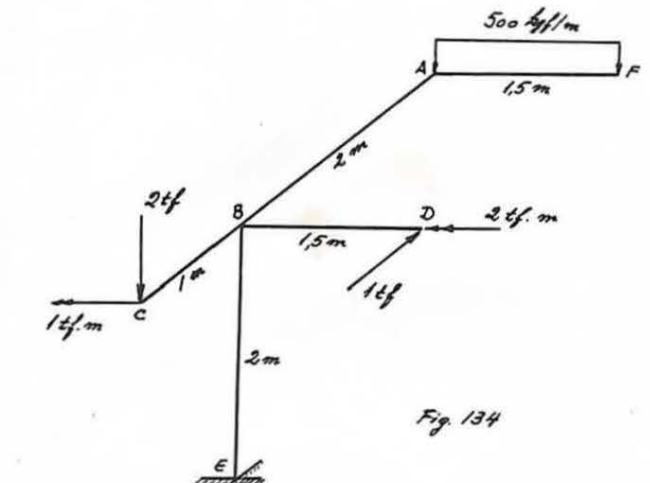
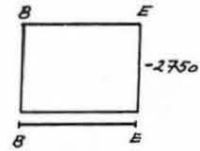
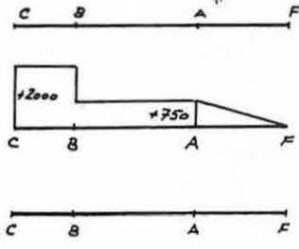
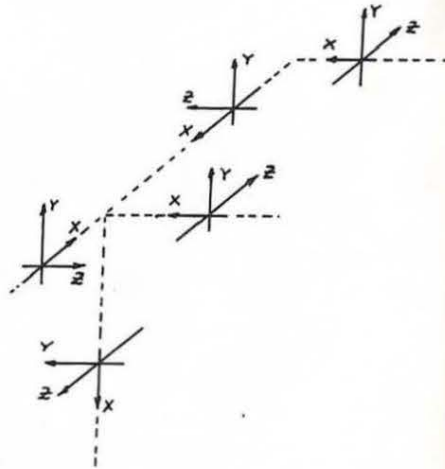
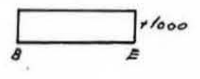
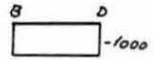


Fig. 134

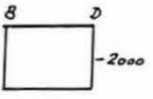
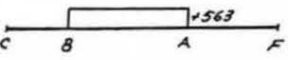


$N$   $2\text{tf}$

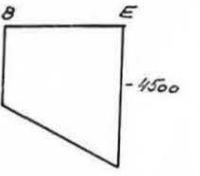
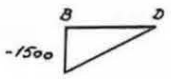
$Q_y$   $2\text{tf}$



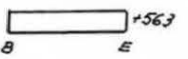
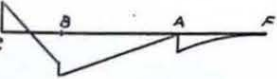
$Q_z$   $1\text{tf}$



$M_x$   $563\text{kgf.m}$



$M_y$   $1500\text{kgf.m}$



$M_z$   $563\text{kgf.m}$

- $+1000$
- $-1000$
- $-1500$
- $-563$