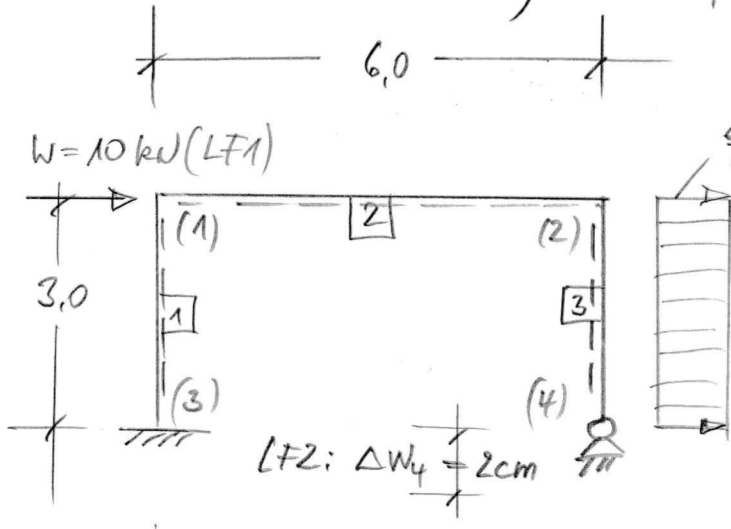


Übungsaufgabe

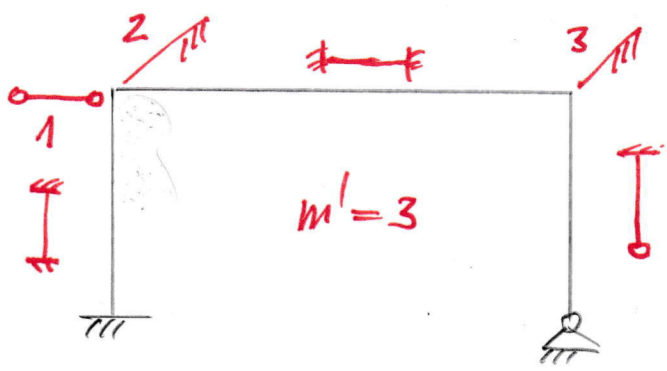
- 1) mit Hilfe des DWV ($EA = \infty$)
- 2) mit Hilfe des WGV ($EA = 12/m^2 \cdot EJ$)
- 3) mit Hilfe des NAV in Matrixdarst.

- System :

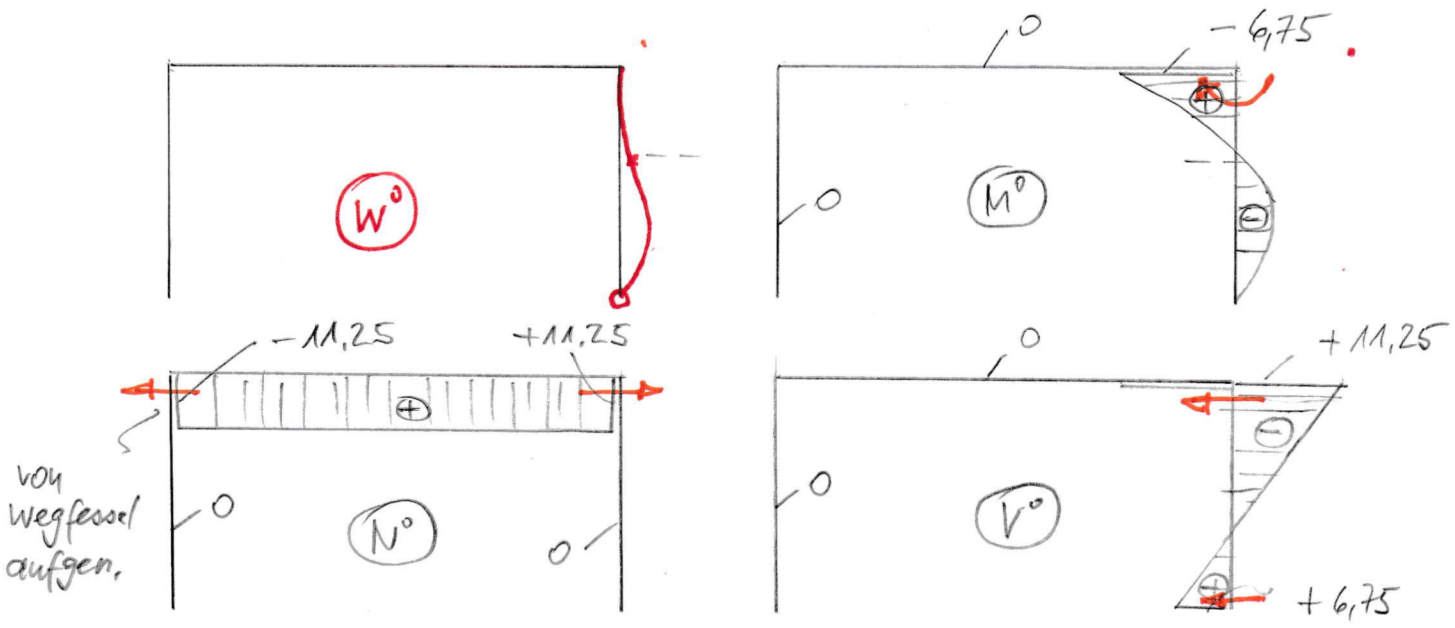


i	a	e	l	EJ	β°
1	3	1	3.0	7200	+90
2	1	2	6.0	9000	0
3	2	4	3.0	6000	-90

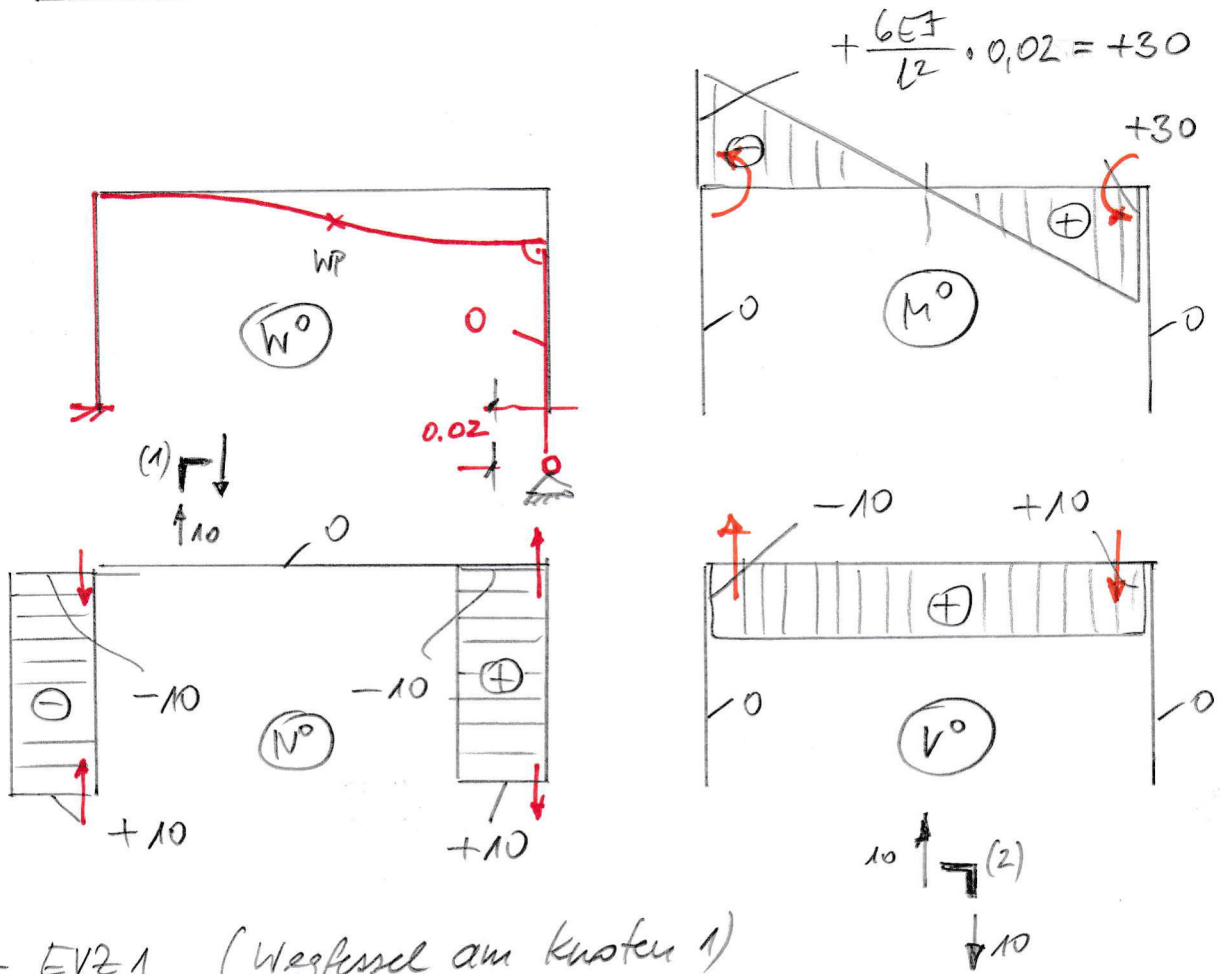
- kinem. best. Hauptsystem : (DWV)



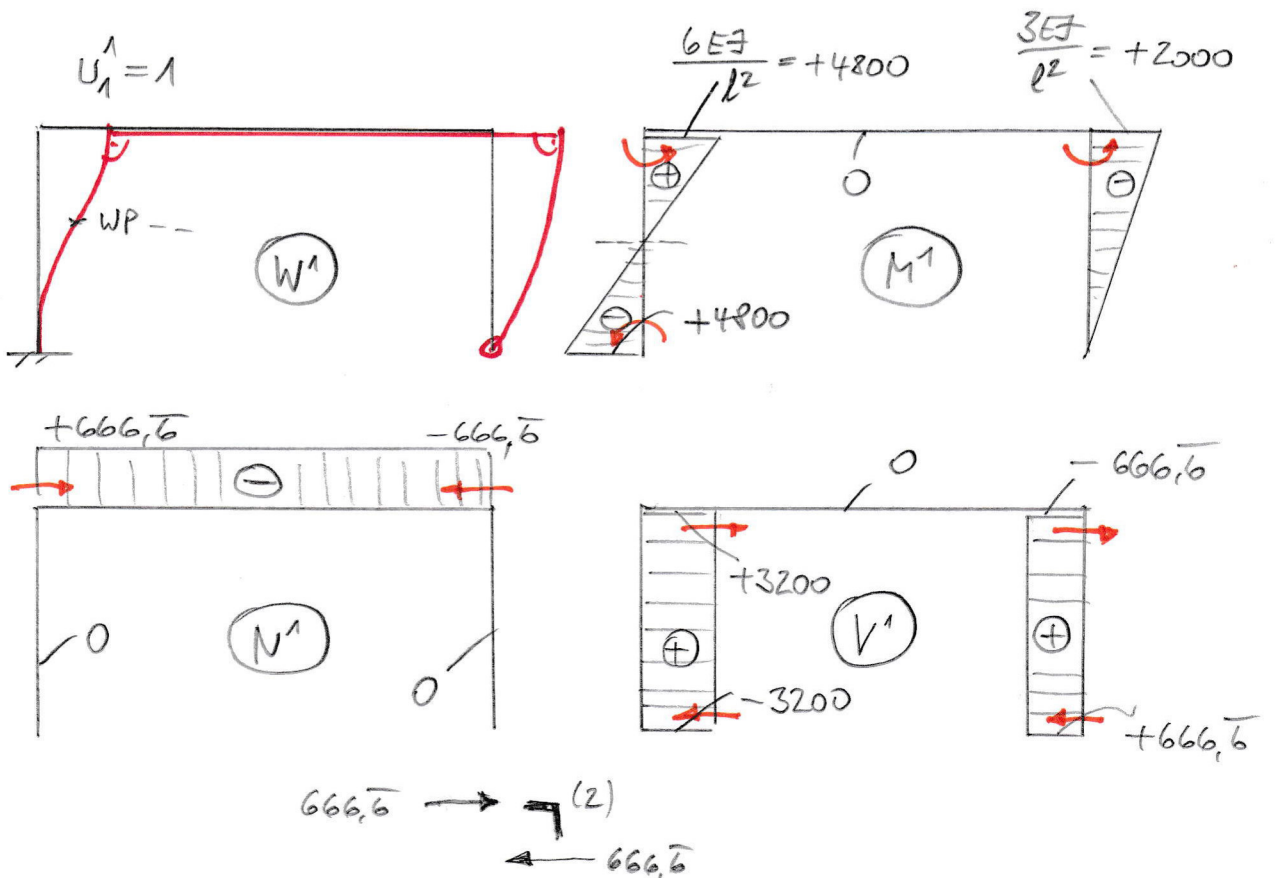
- LVZ 1 : (Lastfall 1)



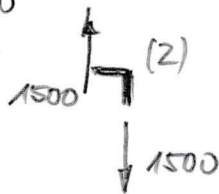
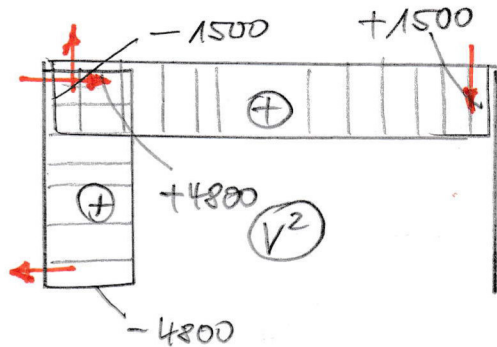
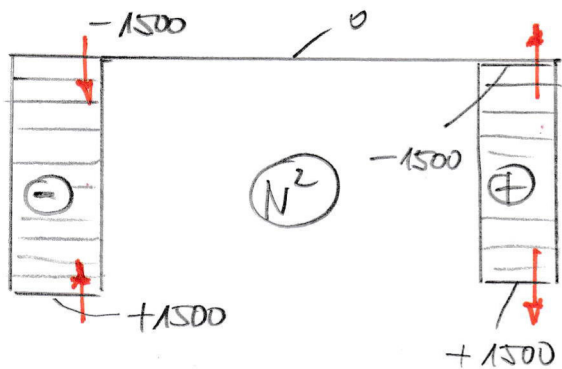
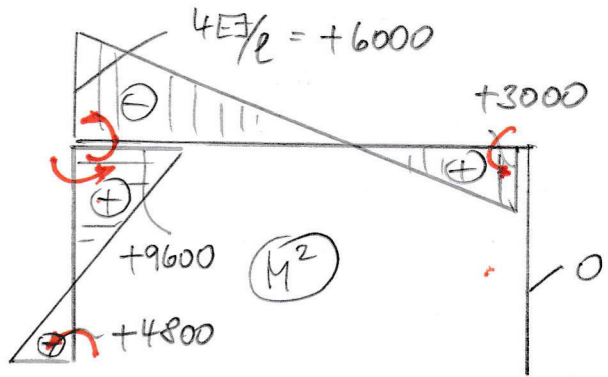
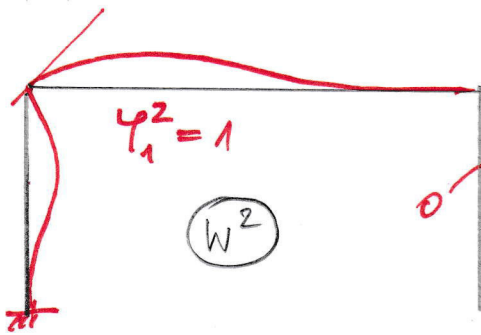
- LVZ 2 (Lastfall 2)



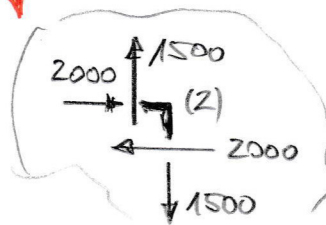
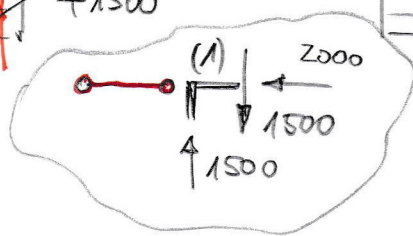
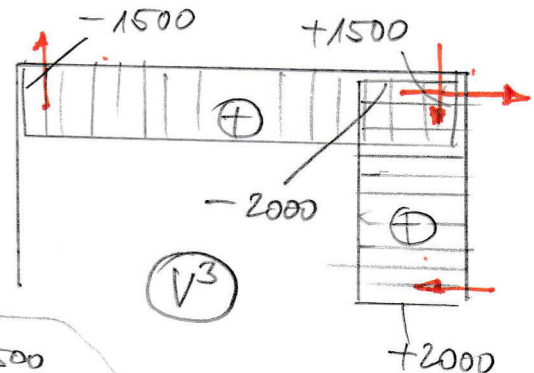
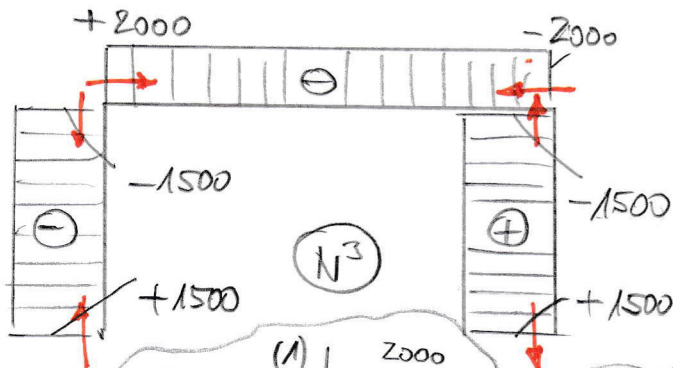
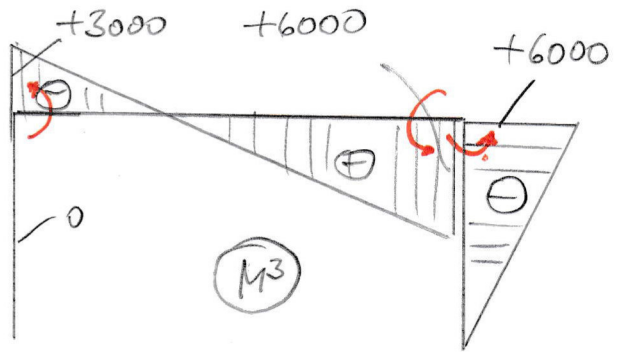
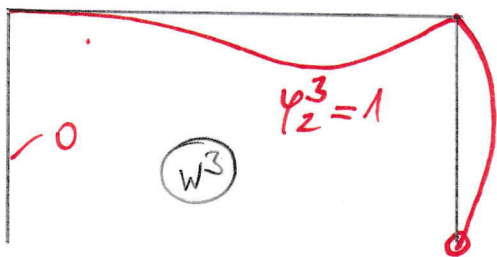
- EVZ 1 (Wegfessel am Knoten 1)



- EVZ2 (Drehfeld am Kn. 1)



- EVZ3 (Drehfeld am Kn. 2)



- Aufstellen der Gleichgewichtsbedingungen: LF1

$\sum \bar{K}_x = 0$: $(-11,25 - 10,0) + y_1 (\cdot 666,6 + 3200) + y_1 (+4800) + y_3 (2000) = 0$

! Knotenlast
"global"?

$$3866,6 \cdot y_1 + 4800 y_2 + 2000 y_3 = +21,25$$

$\sum M_1 = 0$: $0 + y_1 (4800) + y_2 (6000 + 9600) + y_3 (3000) = 0$

$$4800 \cdot y_1 + 15600 y_2 + 3000 y_3 = 0$$

$\sum M_2 = 0$: $(-6,75) + y_1 (2000) + y_2 (3000) + y_3 (6000 + 6000) = 0$

$$2000 y_1 + 3000 y_2 + 12000 y_3 = 6,75$$

- Aufstellen der Gleichgew.-bedingungen: LF2

$$3866,6 \cdot y_1 + 4800 y_2 + 2000 y_3 = 0$$

$$4800 \cdot y_1 + \dots = -30$$

$$2000 \cdot y_1 + \dots = -30$$

Lösung:

Kontrollen
✓✓

3866,6	4800	2000
4800	15600	3000
2000	3000	12000

LF1	LF2	LF1	LF2
y_1	y_1	21,25	0
y_2	y_2	0	-30
y_3	y_3	6,75	-30

1. Übungsbeispiel zum DWV bzw. WGV

08.05.2020

Lösung des Gleichungssystems $[K] \cdot [y] = [r]$

[K] = Steifigkeitsmatrix (pos. Definit + symmetrisch)

3866,667	4800,000	2000,000
4800,000	15600,000	3000,000
2000,000	3000,000	12000,000

LF1 LF2

[r] = Lastvektor (recht Seite)

21,250	0,000
0,000	-30,000
6,750	-30,000

[K]⁻¹ = Inverse Steifigkeitsmatrix

4,370E-04	-1,265E-04	-4,120E-05
-1,265E-04	1,040E-04	-4,905E-06
-4,120E-05	-4,905E-06	9,143E-05

[y] = Lösungsvektor

0,009009	0,005032
-0,002722	-0,002972
-0,000258	-0,002596

entspricht:

u ₁
phi ₁
phi ₂

Nachlaufrechnung (Superposition)

mit Hilfe einer einfachen Matrizenmultiplikation

Stabend- (Vorzeichen nach WGV)
schnittgrößen

	am LVZ1	am EVZ1	am EVZ2	am EVZ3
M _{3,oben}	0,000	4800,000	4800,000	0,000
M _{1,unten}	0,000	4800,000	9600,000	0,000
M _{1,rechts}	0,000	0,000	6000,000	3000,000
M _{2,links}	0,000	0,000	3000,000	6000,000
M _{2,unten}	-6,750	2000,000	0,000	6000,000
M _{4,oben}	0,000	0,000	0,000	0,000
V _{3,oben}	0,000	-3200,000	-4800,000	0,000
V _{1,unten}	0,000	3200,000	4800,000	0,000
V _{1,rechts}	0,000	0,000	-1500,000	-1500,000
V _{2,links}	0,000	0,000	1500,000	1500,000
V _{2,unten}	11,250	-666,667	0,000	-2000,000
V _{4,oben}	6,750	666,667	0,000	2000,000
N _{3,oben}	0,000	0,000	1500,000	1500,000
N _{1,unten}	0,000	0,000	-1500,000	-1500,000
N _{1,rechts}	-11,250	666,667	0,000	2000,000
N _{2,links}	11,250	-666,667	0,000	-2000,000
N _{2,unten}	0,000	0,000	-1500,000	-1500,000
N _{4,oben}	0,000	0,000	1500,000	1500,000

LF1

1,000000
0,009009
-0,002722
-0,000258

LF1 nach Baustatik

-1	-30,175
1	17,108
-1	17,108
1	-9,717
-1	-9,717
1	0,000
-1	15,761
1	15,761
-1	-4,471
1	-4,471
-1	-5,761
1	12,239
-1	4,471
1	4,471
-1	5,761
1	5,761
-1	-4,471
1	-4,471

Gleichgewicht an den Orten der Fesseln = OK

Nachlaufrechnung (Superposition)

mit Hilfe einer einfachen Matrizenmultiplikation

Stabend- (Vorzeichen nach WGV)
schnittgrößen

	am LVZ2	am EVZ1	am EVZ2	am EVZ3
M _{3,oben}	0,000	4800,000	4800,000	0,000
M _{1,unten}	0,000	4800,000	9600,000	0,000
M _{1,rechts}	30,000	0,000	6000,000	3000,000
M _{2,links}	30,000	0,000	3000,000	6000,000
M _{2,unten}	0,000	2000,000	0,000	6000,000
M _{4,oben}	0,000	0,000	0,000	0,000
V _{3,oben}	0,000	-3200,000	-4800,000	0,000
V _{1,unten}	0,000	3200,000	4800,000	0,000
V _{1,rechts}	-10,000	0,000	-1500,000	-1500,000
V _{2,links}	10,000	0,000	1500,000	1500,000
V _{2,unten}	0,000	-666,667	0,000	-2000,000
V _{4,oben}	0,000	666,667	0,000	2000,000
N _{3,oben}	10,000	0,000	1500,000	1500,000
N _{1,unten}	-10,000	0,000	-1500,000	-1500,000
N _{1,rechts}	0,000	666,667	0,000	2000,000
N _{2,links}	0,000	-666,667	0,000	-2000,000
N _{2,unten}	-10,000	0,000	-1500,000	-1500,000
N _{4,oben}	10,000	0,000	1500,000	1500,000

LF2

1,000000
0,005032
-0,002972
-0,002596

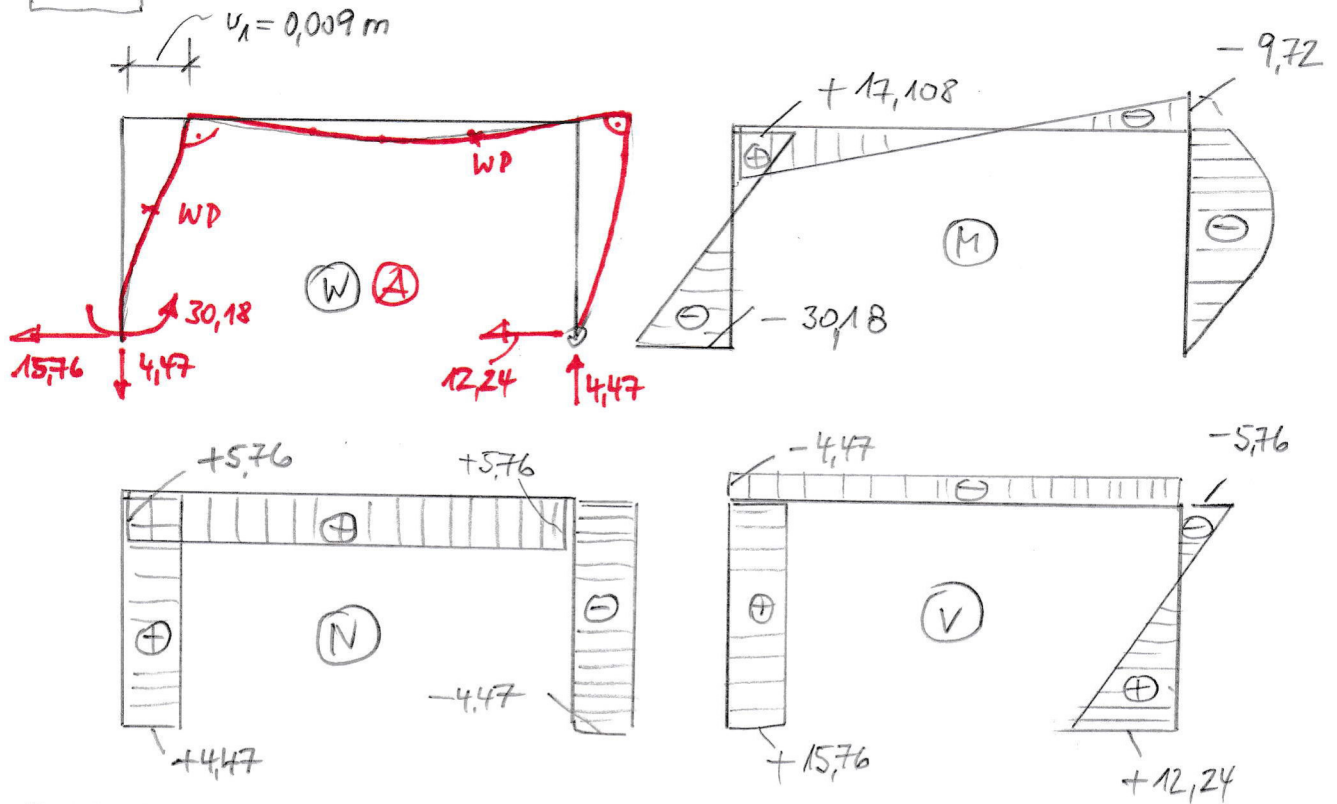
LF2 nach Baustatik

-1	-9,888
1	-4,379
-1	-4,379
1	5,509
-1	5,509
1	0,000
-1	1,836
1	1,836
-1	1,648
1	1,648
-1	-1,836
1	-1,836
-1	-1,648
1	-1,648
-1	1,836
1	1,836
-1	1,648
1	1,648

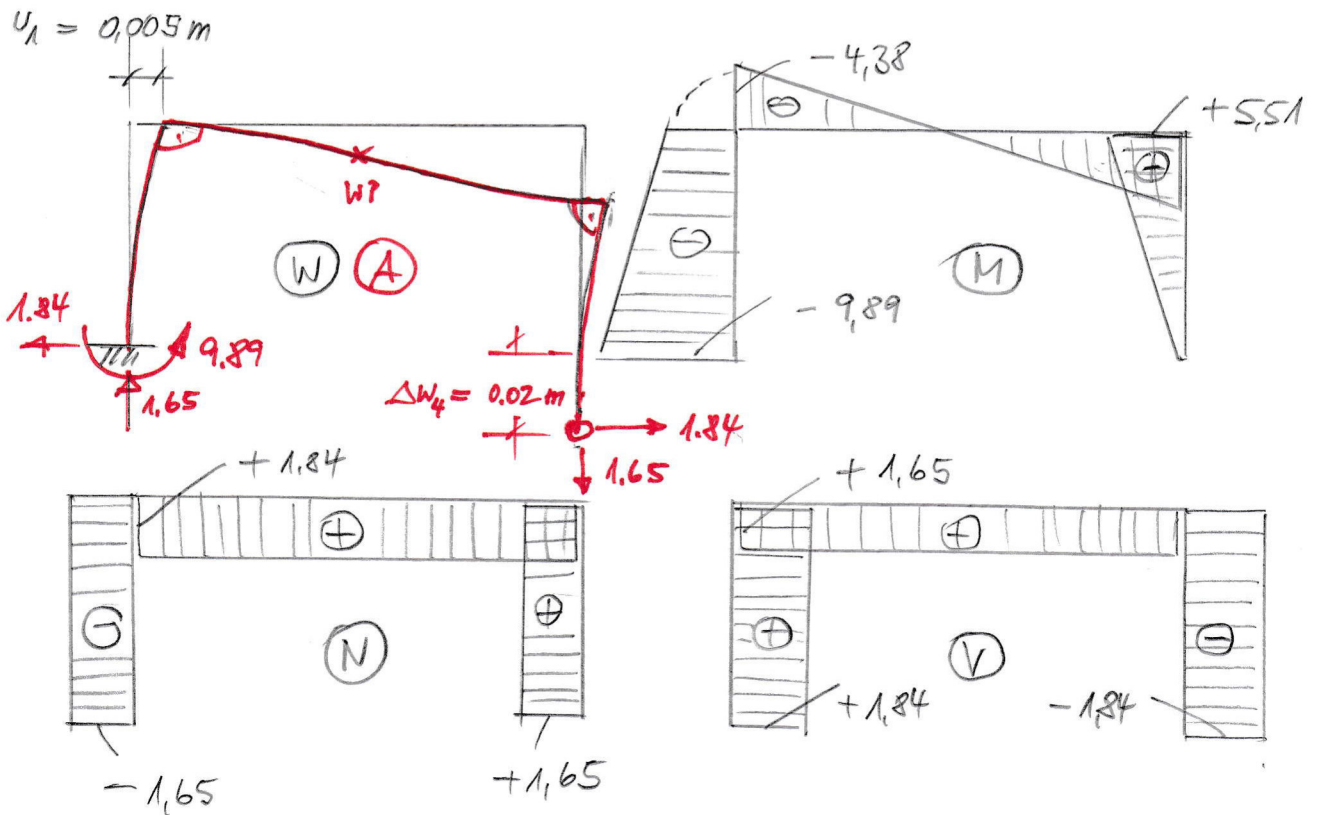
Gleichgewicht an den Orten der Fesseln = OK

- Ergebnisse: (mit Hilfe des Drehwinkelverfahrens)

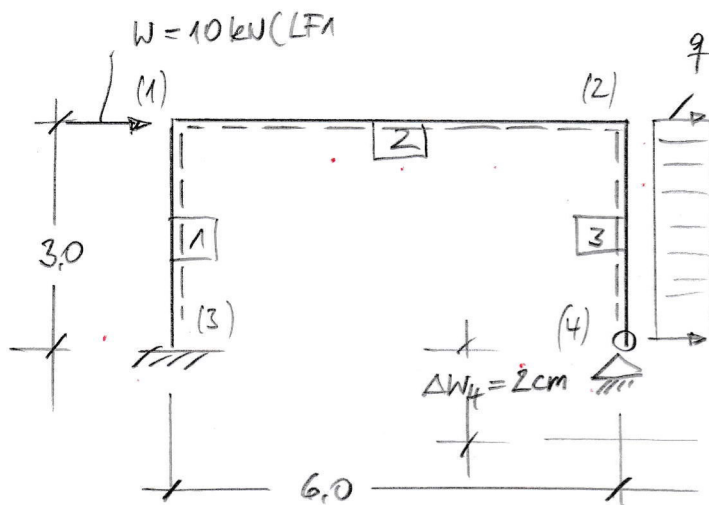
L#1:



L#2:

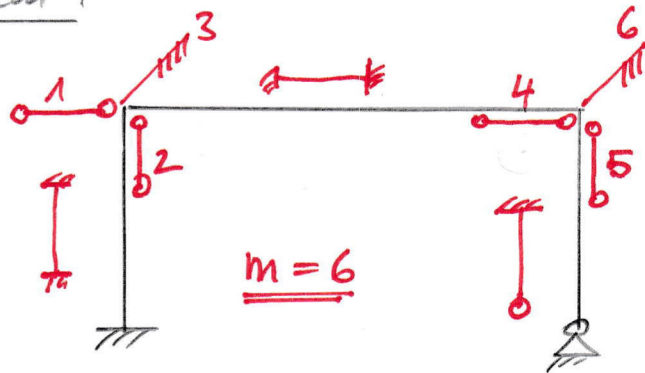


- System i ... mit Hilfe des allgem. WGV (als Handrechn.)

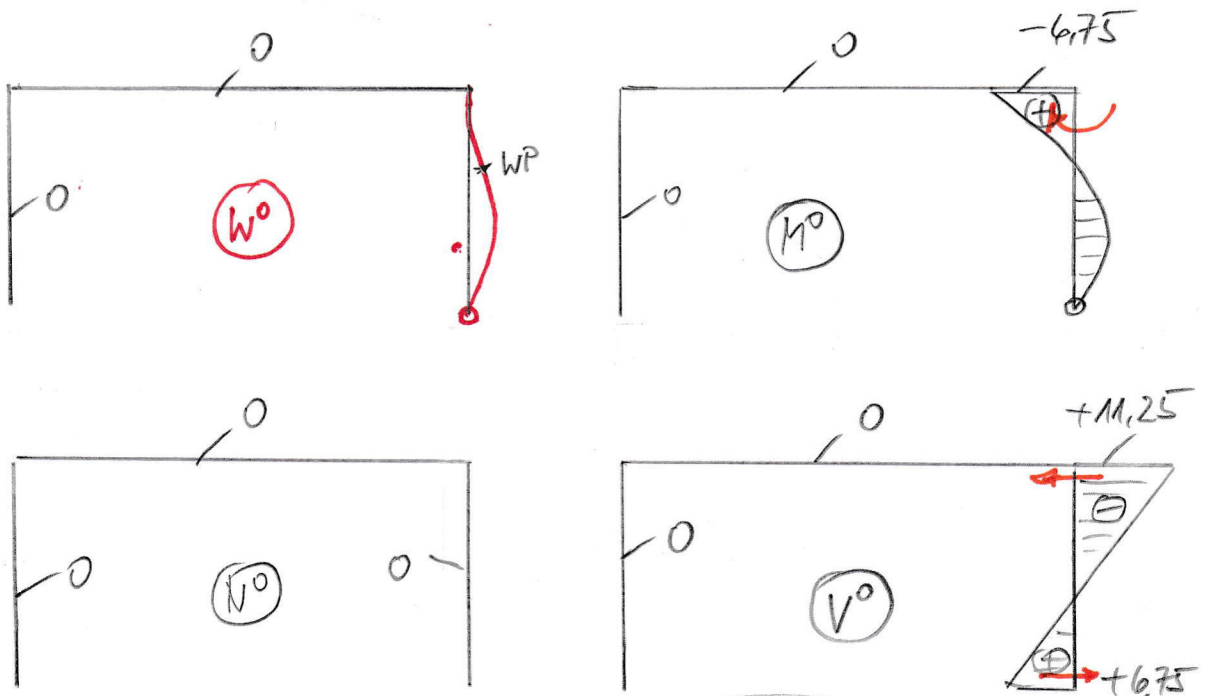


i	a	c	l	EA	EI	β
1	3	1	30	86400	7200	+90°
2	1	2	60	108000	9000	0
3	2	4	30	72000	6000	-90°

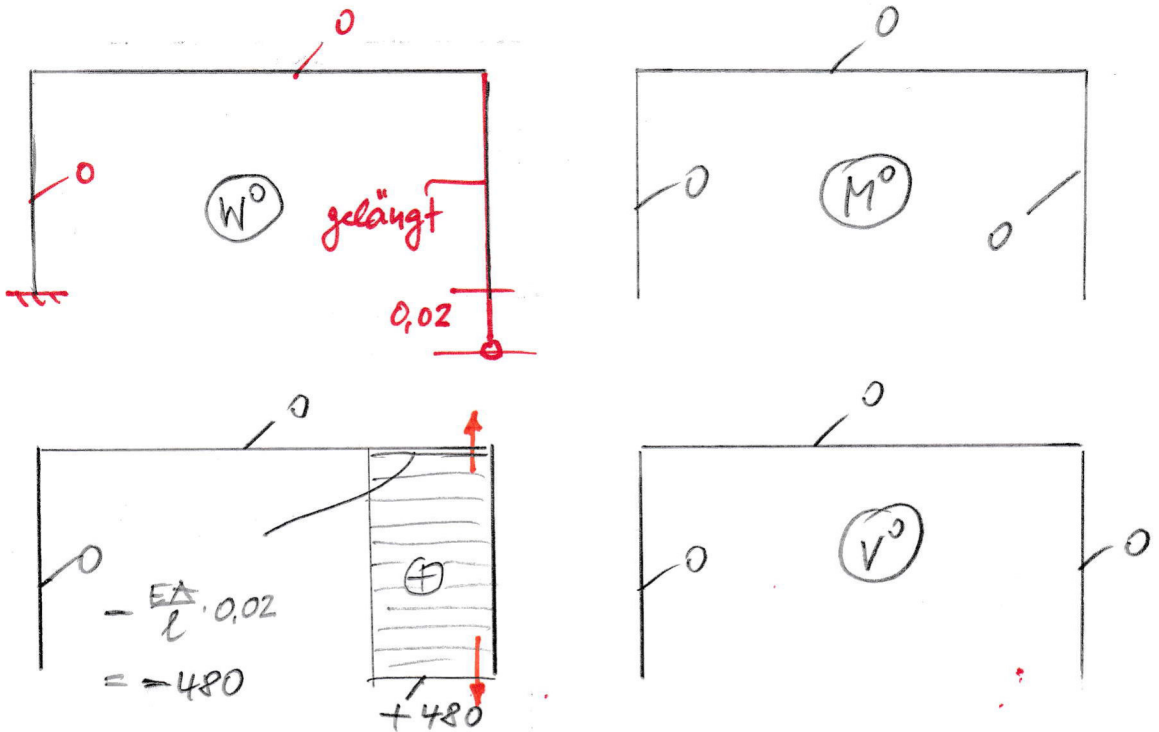
- kin. best. Hauptsystem:



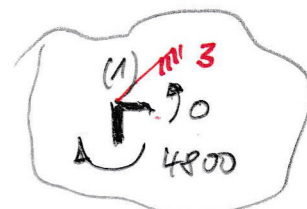
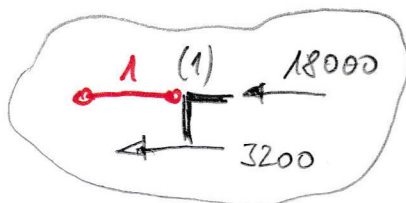
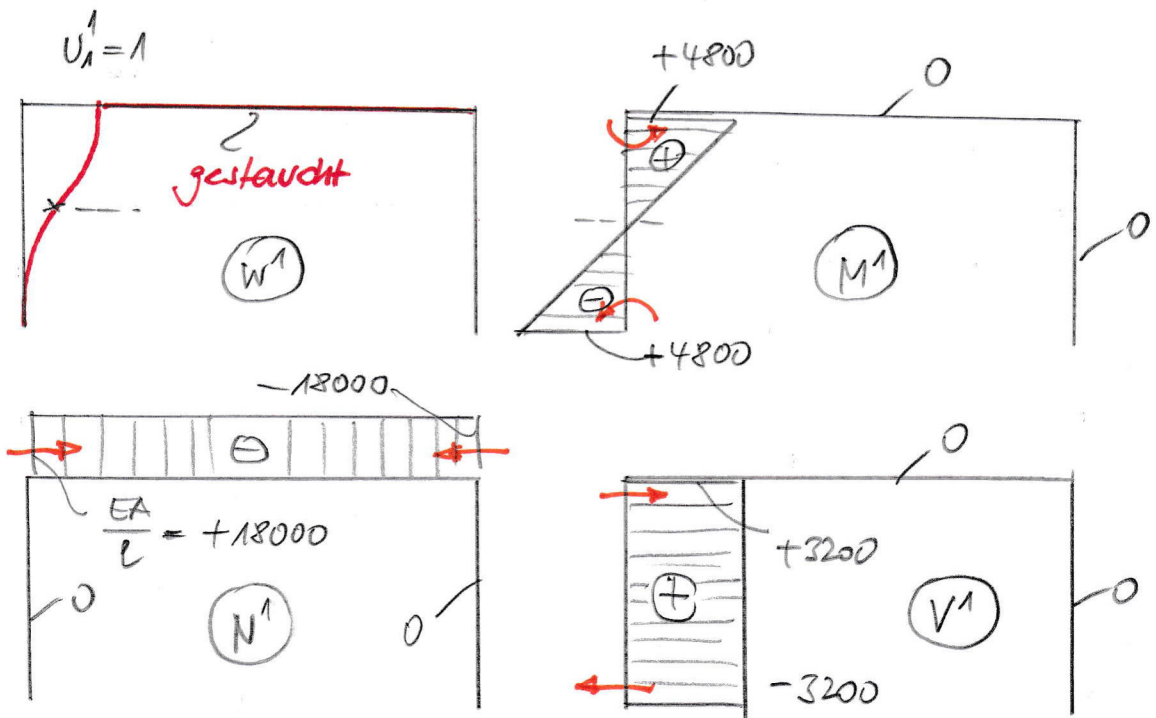
- LVZ1 (Lastfall 1)



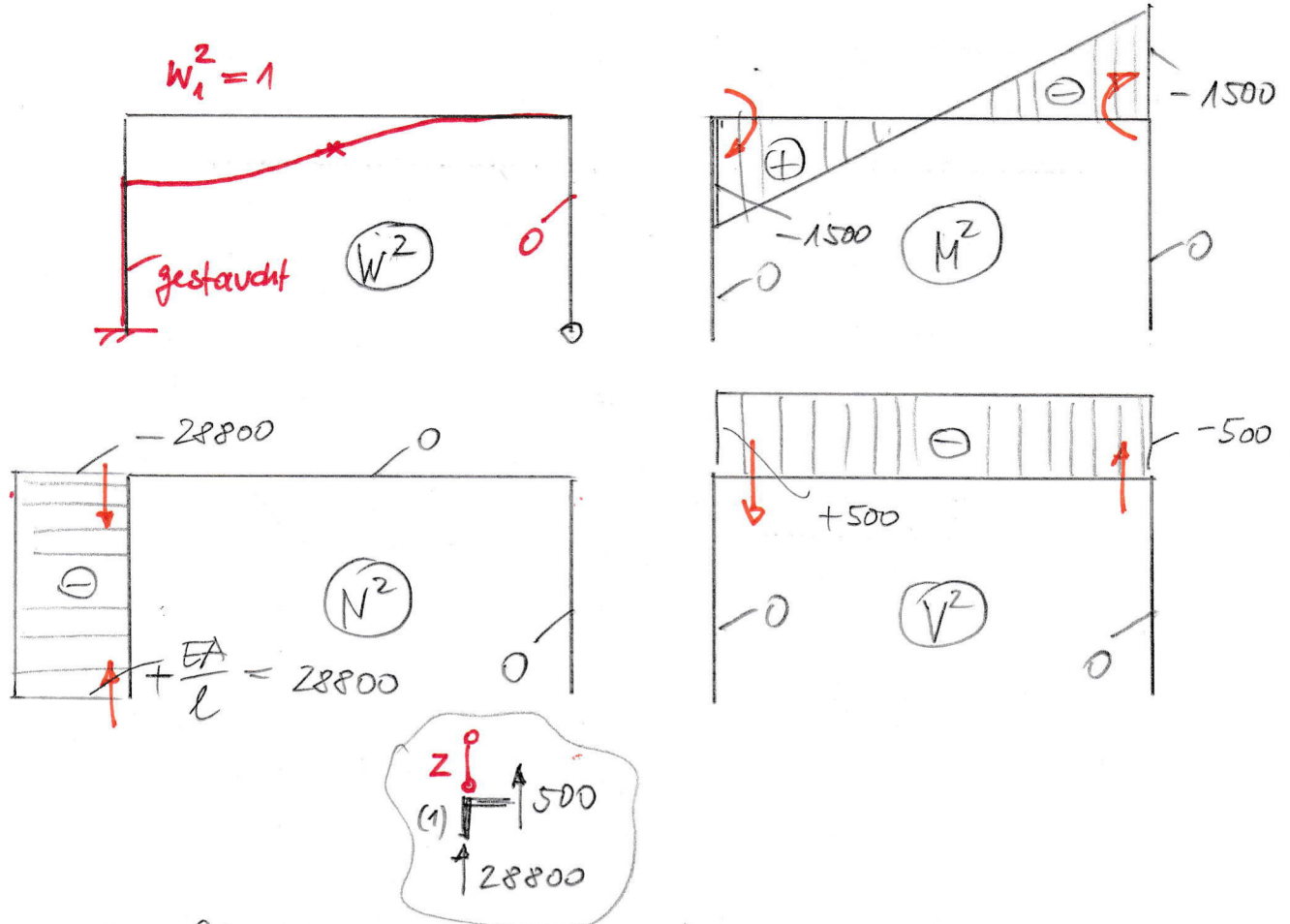
- LVZ2 (LF2) 1



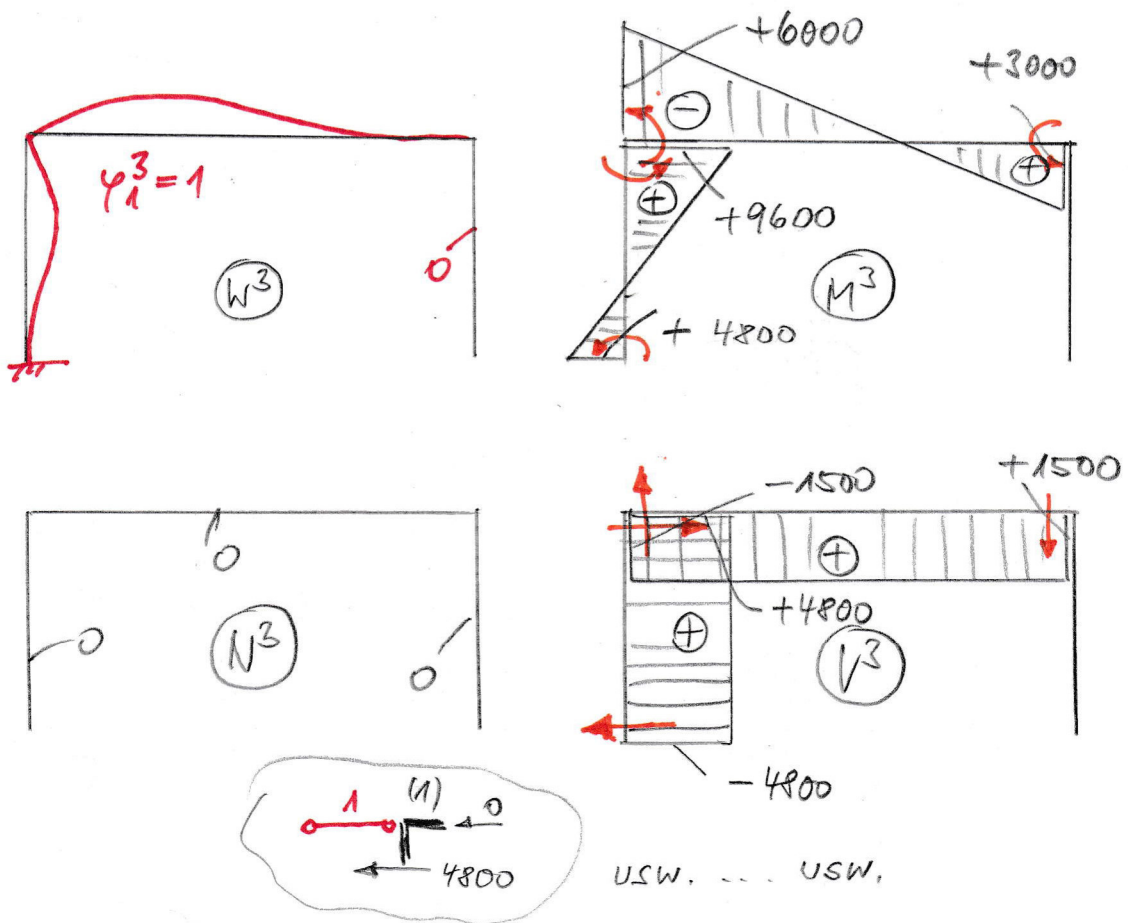
- EVZ1 (horiz. Wegfessel am Knoten 1)



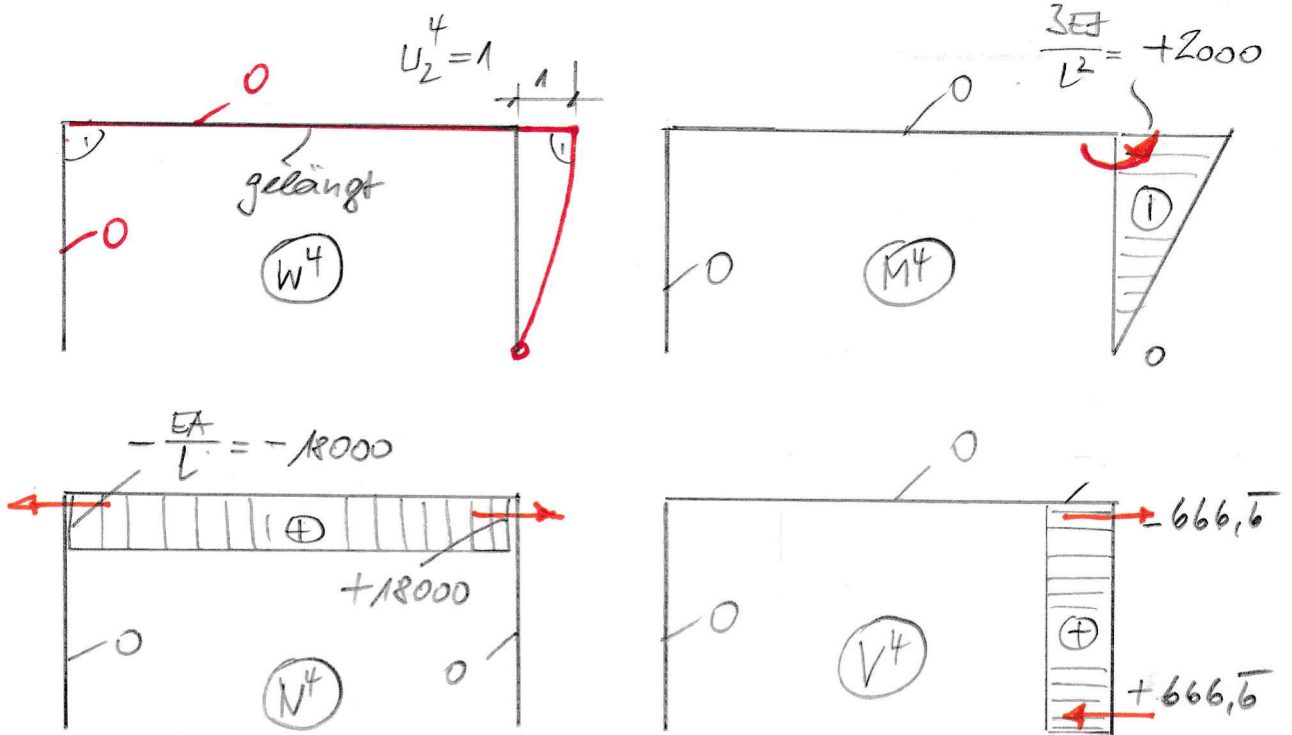
- EVZ2 (vertikale Wegfessel am Kn. 1) :



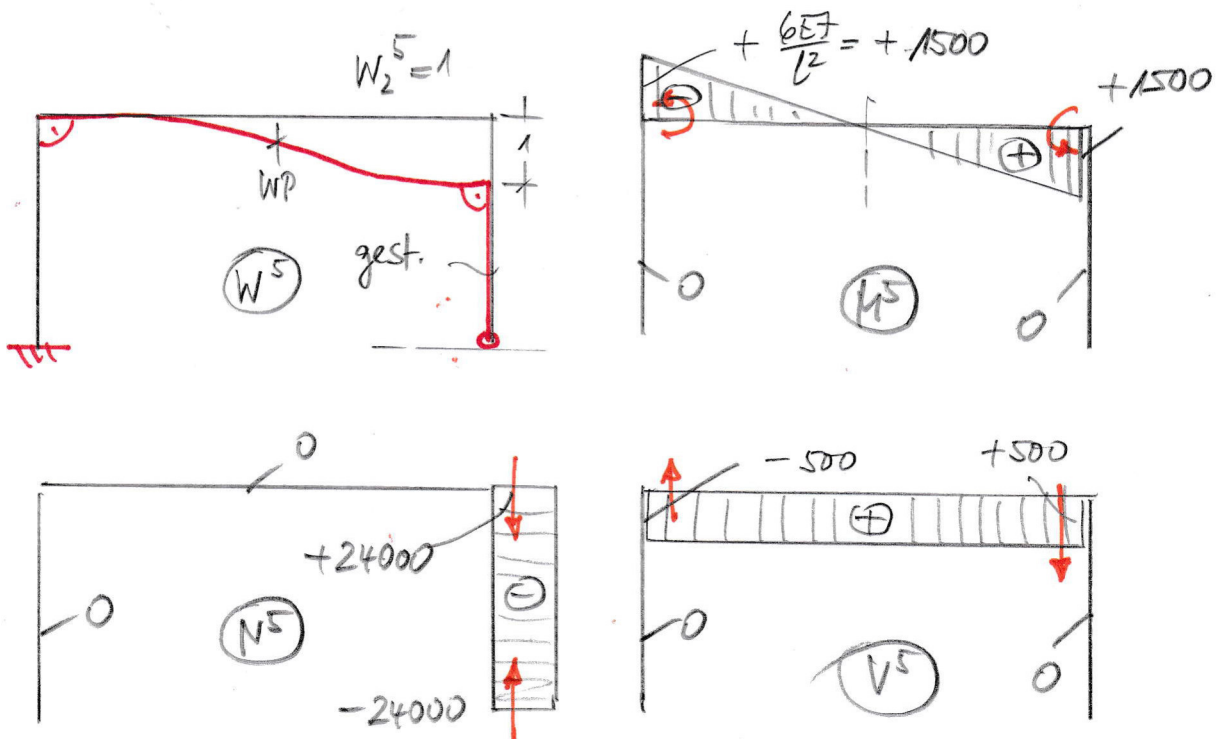
- EVZ3 (Drehfessel am Kn. 1)



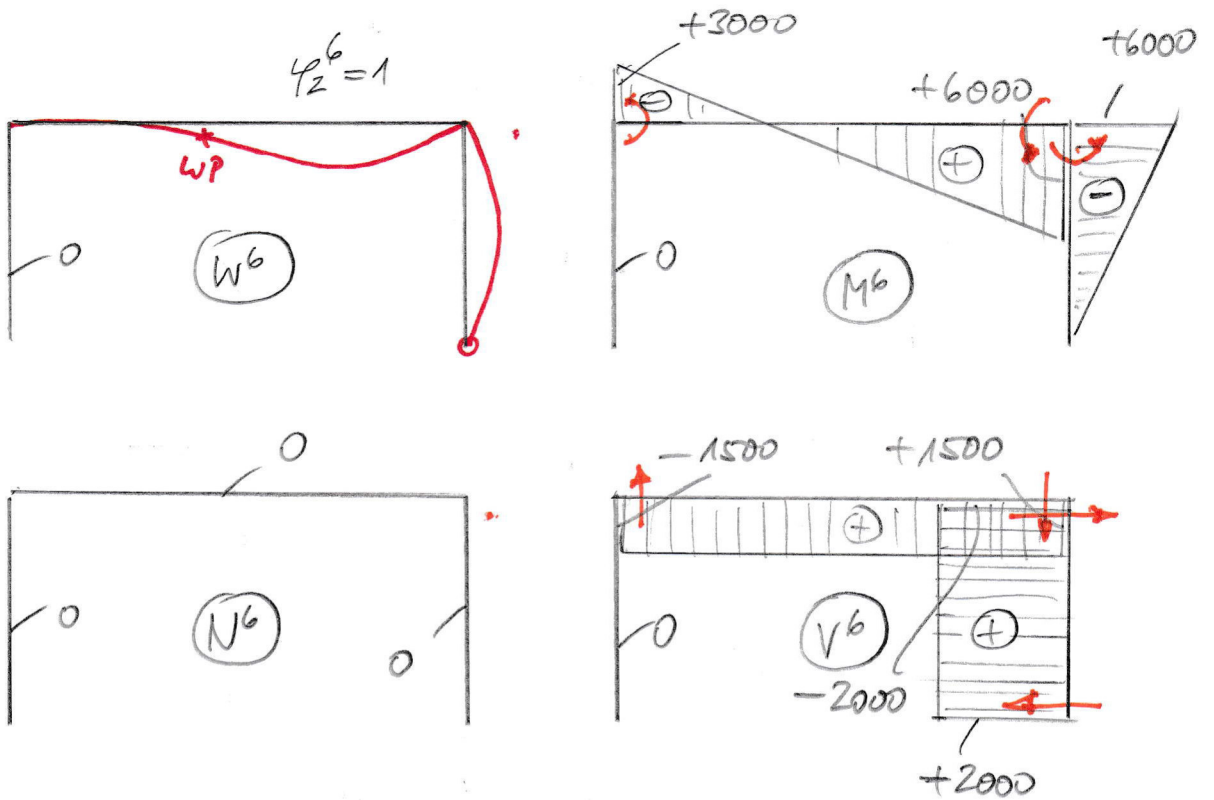
- EVZ 4 (horiz. Biegestiel am Kn. 2) ;



- EVZ 5 (vertikale Biegestiel am Kn. 2)



- EV26 (Drehfessel am Kn. 2) !



- Zusammenstellung der Gleichgewichtsbedingg.

Auf zum
Punkte sammeln!

Knotenlast.	LF1	LF1	$\cdot y_1$	$\cdot y_2$	$\cdot y_3$	$\cdot y_4$	$\cdot y_5$	$\cdot y_6$
$\sum \bar{K}_{x_1} = 0:$	-10,0	0	+18000 +3200	0	+4800	-18000	0	0
$\sum \bar{K}_{z_1} = 0:$	0	0	0	+28800 +500	-1500	0	-500	-1500
$\sum M_1 = 0:$	0	0	+4800	-1500	6000 + 9600	0	+1500	+3000
$\sum \bar{K}_{x_2} = 0:$	-11,25	0	-18000	0	0	18000 +666,6	0	+2000
$\sum K_{z_2} = 0:$	0	-480	0	-500	+1500	0	24000 +500	+1500
$\sum M_2 = 0:$	-675	0	0	-1500	+3000	+2000	+1500	6000 + 6000

HD-Elemente positiv ✓ Matrix symmetrisch ✓

Lösung des Gleichungssystems $[K] \cdot [y] = [r]$

$[K]$ = Steifigkeitsmatrix (pos. Definit + symmetrisch)

21200,000	0,000	4800,000	-18000,000	0,000	0,000
0,000	29300,000	-1500,000	0,000	-500,000	-1500,000
4800,000	-1500,000	15600,000	0,000	1500,000	3000,000
-18000,000	0,000	0,000	18666,667	0,000	2000,000
0,000	-500,000	1500,000	0,000	24500,000	1500,000
0,000	-1500,000	3000,000	2000,000	1500,000	12000,000

LF1 LF2
[r] = Lastvektor (recht Seite)

10,000	0,000
0,000	0,000
0,000	0,000
11,250	0,000
0,000	480,000
6,750	0,000

$[K]^{-1}$ = Inverse Steifigkeitsmatrix

4,442E-04	-8,646E-06	-1,304E-04	4,328E-04	1,038E-05	-4,190E-05
-8,646E-06	3,462E-05	5,112E-06	-8,820E-06	1,178E-07	4,505E-06
-1,304E-04	5,112E-06	1,061E-04	-1,253E-04	-6,134E-06	-4,240E-06
4,328E-04	-8,820E-06	-1,253E-04	4,763E-04	1,058E-05	-5,048E-05
1,038E-05	1,178E-07	-6,134E-06	1,058E-05	4,153E-05	-5,406E-06
-4,190E-05	4,505E-06	-4,240E-06	-5,048E-05	-5,406E-06	9,405E-05

[y] = Lösungsvektor

0,009028	0,004980
-0,000155	0,000057
-0,002743	-0,002944
0,009346	0,005080
0,000186	0,019932
-0,000352	-0,002595

entspricht:

u_1
w_1
ϕ_{11}
u_2
w_2
ϕ_{12}

Nachlaufrechnung (Superposition)

mit Hilfe einer einfachen Matrizenmultiplikation

Stabend- (Vorzeichen nach WGV)
schnittgrößen

	am LVZ1	am EVZ1	am EVZ2	am EVZ3	am EVZ4	am EVZ5	am EVZ6
M _{3,oben}	0,000	4800,000	0,000	4800,000	0,000	0,000	0,000
M _{1,unten}	0,000	4800,000	0,000	9600,000	0,000	0,000	0,000
M _{1,rechts}	0,000	0,000	-1500,000	6000,000	0,000	1500,000	3000,000
M _{2,links}	0,000	0,000	-1500,000	3000,000	0,000	1500,000	6000,000
M _{2,unten}	-6,750	0,000	0,000	0,000	2000,000	0,000	6000,000
M _{4,oben}	0,000	0,000	0,000	0,000	0,000	0,000	0,000
V _{3,oben}	0,000	-3200,000	0,000	-4800,000	0,000	0,000	0,000
V _{1,unten}	0,000	3200,000	0,000	4800,000	0,000	0,000	0,000
V _{1,rechts}	0,000	0,000	500,000	-1500,000	0,000	-500,000	-1500,000
V _{2,links}	0,000	0,000	-500,000	1500,000	0,000	500,000	1500,000
V _{2,unten}	11,250	0,000	0,000	0,000	-666,667	0,000	-2000,000
V _{4,oben}	6,750	0,000	0,000	0,000	666,667	0,000	2000,000
N _{3,oben}	0,000	0,000	28800,000	0,000	0,000	0,000	0,000
N _{1,unten}	0,000	0,000	-28800,000	0,000	0,000	0,000	0,000
N _{1,rechts}	0,000	18000,000	0,000	0,000	-18000,000	0,000	0,000
N _{2,links}	0,000	-18000,000	0,000	0,000	18000,000	0,000	0,000
N _{2,unten}	0,000	0,000	0,000	0,000	0,000	24000,000	0,000
N _{4,oben}	0,000	0,000	0,000	0,000	0,000	-24000,000	0,000

LF1

1,000000
0,009028
-0,000155
-0,002743
0,009346
0,000186
-0,000352

LF1 nach Baustatik

30,169	-1	-30,169
17,002	1	17,002
-17,002	-1	17,002
-9,829	1	-9,829
9,829	-1	-9,829
0,000	1	0,000
-15,724	-1	15,724
15,724	1	15,724
4,472	-1	-4,472
-4,472	1	-4,472
5,724	-1	-5,724
12,276	1	12,276
-4,472	-1	4,472
4,472	1	4,472
-5,724	-1	5,724
5,724	1	5,724
4,472	-1	-4,472
-4,472	1	-4,472

Gleichgewicht an den Orten der Fesseln = OK

Nachlaufrechnung (Superposition)

mit Hilfe einer einfachen Matrizenmultiplikation

Stabend- (Vorzeichen nach WGV)
schnittgrößen

	am LVZ2	am EVZ1	am EVZ2	am EVZ3	am EVZ4	am EVZ5	am EVZ6
M _{3,oben}	0,000	4800,000	0,000	4800,000	0,000	0,000	0,000
M _{1,unten}	0,000	4800,000	0,000	9600,000	0,000	0,000	0,000
M _{1,rechts}	0,000	0,000	-1500,000	6000,000	0,000	1500,000	3000,000
M _{2,links}	0,000	0,000	-1500,000	3000,000	0,000	1500,000	6000,000
M _{2,unten}	0,000	0,000	0,000	0,000	2000,000	0,000	6000,000
M _{4,oben}	0,000	0,000	0,000	0,000	0,000	0,000	0,000
V _{3,oben}	0,000	-3200,000	0,000	-4800,000	0,000	0,000	0,000
V _{1,unten}	0,000	3200,000	0,000	4800,000	0,000	0,000	0,000
V _{1,rechts}	0,000	0,000	500,000	-1500,000	0,000	-500,000	-1500,000
V _{2,links}	0,000	0,000	-500,000	1500,000	0,000	500,000	1500,000
V _{2,unten}	0,000	0,000	0,000	0,000	-666,667	0,000	-2000,000
V _{4,oben}	0,000	0,000	0,000	0,000	666,667	0,000	2000,000
N _{3,oben}	0,000	0,000	28800,000	0,000	0,000	0,000	0,000
N _{1,unten}	0,000	0,000	-28800,000	0,000	0,000	0,000	0,000
N _{1,rechts}	0,000	18000,000	0,000	0,000	-18000,000	0,000	0,000
N _{2,links}	0,000	-18000,000	0,000	0,000	18000,000	0,000	0,000
N _{2,unten}	-480,000	0,000	0,000	0,000	0,000	24000,000	0,000
N _{4,oben}	480,000	0,000	0,000	0,000	0,000	-24000,000	0,000

LF2

1,000000
0,004980
0,000057
-0,002944
0,005080
0,019932
-0,002595

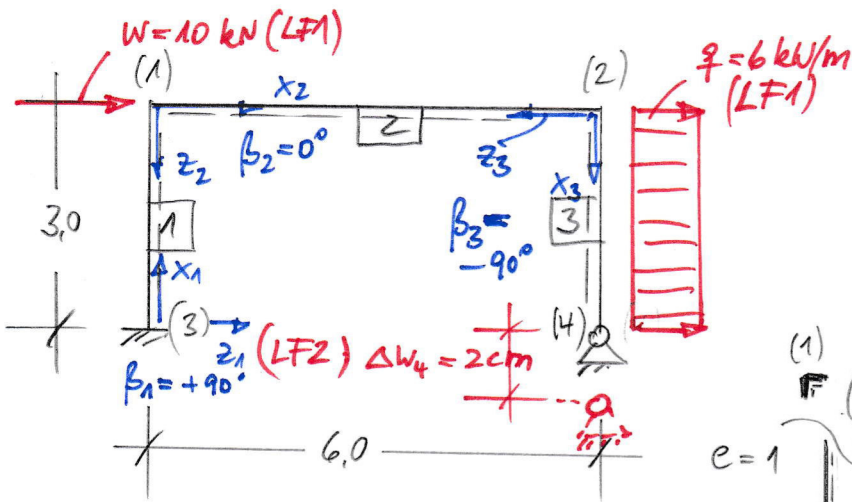
LF2 nach Baustatik

9,771	-1	-9,771
-4,362	1	-4,362
4,362	-1	-4,362
5,410	1	5,410
-5,410	-1	5,410
0,000	1	0,000
-1,803	-1	1,803
1,803	1	1,803
-1,629	-1	1,629
1,629	1	1,629
1,803	-1	-1,803
-1,803	1	-1,803
1,629	-1	-1,629
-1,629	1	-1,629
-1,803	-1	1,803
1,803	1	1,803
-1,629	-1	1,629
1,629	1	1,629

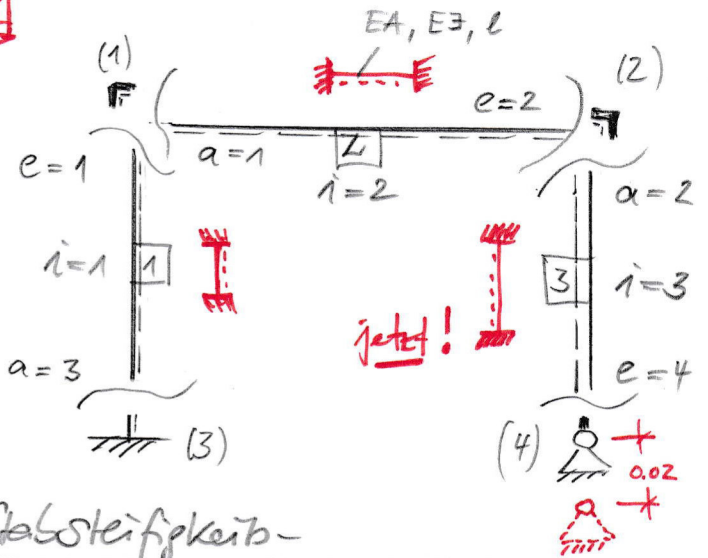
Gleichgewicht an den Orten der Fesseln = OK

Bitte Ergebnisse mit denen des DWV vergleichen → geringe Unterschiede wegen EA ≠ ∞!

- System : ... mit Hilfe des WGV in Matrixdarstell.



vgl. Identitätstafel S 2.1



Stäbe werden vollkommen von Knoten gelöst!
(egal, ob sich kn. 4 absenkt!)

- Schritt 1 : Aufstellen der Stabsteifigkeitsbeziehungen

$$\underline{S}^i = \underline{K}^i \cdot \underline{V}^i + \underline{S}^{i0}$$

Stab 1 :

lokal : $\underline{S}^1 = \underline{K}^1 \cdot \underline{V}^1 + \underline{S}^{10}$

$\underline{S}_a^1 = \underline{S}_3^1$ $a=3; e=1$ \underline{V}_3^1 LF1 | LF2

N_3^1	28800	0	0	-28800	0	0	U_3^1	0	0
V_3^1	0	3200	-4800	0	-3200	-4800	W_3^1	0	0
M_3^1	0	-4800	9600	0	4800	4800	φ_3^1	0	0
N_1^1	-28800	0	0	28800	0	0	U_1^1	0	0
V_1^1	0	-3200	4800	0	3200	4800	W_1^1	0	0
M_1^1	0	-4800	4800	0	4800	9600	φ_1^1	0	0

$\underline{S}_e^1 = \underline{S}_1^1$ \underline{V}_1^1 \underline{S}_1^{10}

$$\left[\begin{array}{c|c} \underline{K}_{33}^1 & \underline{K}_{31}^1 \\ \hline \underline{K}_{13}^1 & \underline{K}_{11}^1 \end{array} \right]$$

$[K]$

28800,0	0,0	0,0	-28800,0	0,0	0,0
0,0	3200,0	-4800,0	0,0	-3200,0	-4800,0
0,0	-4800,0	9600,0	0,0	4800,0	4800,0
-28800,0	0,0	0,0	28800,0	0,0	0,0
0,0	-3200,0	4800,0	0,0	3200,0	4800,0
0,0	-4800,0	4800,0	0,0	4800,0	9600,0

Lastfall 1 Lastfall 2

$[s]^{10}$

0,000	0,000
0,000	0,000
0,000	0,000
0,000	0,000
0,000	0,000
0,000	0,000

Transformationsmatrix für $\beta = 90^\circ$:

$[T]$

0,00000	-1,00000	0	0	0	0
1,00000	0,00000	0	0	0	0
0	0	1	0	0	0
0	0	0	0,00000	-1,00000	0
0	0	0	1,00000	0,00000	0
0	0	0	0	0	1

$\cos(+90^\circ) = 0$
 $\sin(+90^\circ) = 1$

$[T]^T$

0,00000	1,00000	0	0	0	0
-1,00000	0,00000	0	0	0	0
0	0	1	0	0	0
0	0	0	0,00000	1,00000	0
0	0	0	-1,00000	0,00000	0
0	0	0	0	0	1

Transformation auf globales Koordinatensystem (durch zweimalige Matrizenmultiplikation):

$[T]^T * [K]$ (Zwischenergebnis):

0,0	3200,0	-4800,0	0,0	-3200,0	-4800,0
-28800,0	0,0	0,0	28800,0	0,0	0,0
0,0	-4800,0	9600,0	0,0	4800,0	4800,0
0,0	-3200,0	4800,0	0,0	3200,0	4800,0
28800,0	0,0	0,0	-28800,0	0,0	0,0
0,0	-4800,0	4800,0	0,0	4800,0	9600,0

Stabsteifigkeitsmatrix im globalen Koordinatensystem:

Lastvektor im globalen Koordinatensystem:

$[K^1] = ([T]^T * [K]) * [T]$

3200,0	0,0	-4800,0	-3200,0	0,0	-4800,0
0,0	28800,0	0,0	0,0	-28800,0	0,0
-4800,0	0,0	9600,0	4800,0	0,0	4800,0
-3200,0	0,0	4800,0	3200,0	0,0	4800,0
0,0	-28800,0	0,0	0,0	28800,0	0,0
-4800,0	0,0	4800,0	4800,0	0,0	9600,0

$[s^{10}] = [T]^T * [s^0]$

0,000	0,000
0,000	0,000
0,000	0,000
0,000	0,000
0,000	0,000
0,000	0,000

s_3^{10}

s^1

$K^1 = \begin{bmatrix} \underline{K}_{33}^1 & \underline{K}_{31}^1 \\ \underline{K}_{13}^1 & \underline{K}_{11}^1 \end{bmatrix}$

v^1

s_1^{10}

Formeln:

$s^1 = K^1 \cdot v^1 + s^{10}$

lokal

$T^T \cdot s^1 = T^T \cdot K^1 \cdot v^1 + T^T \cdot s^{10}$

$\bar{s}^1 = T^T \cdot K^1 \cdot T \cdot v^1 + \bar{s}^{10}$

$\bar{s}^1 = \bar{K}^1 \cdot \bar{v}^1 + \bar{s}^{10}$

global
 ("Dachgrößen")

Stab 2

wg. $\beta = 0$ gilt: $\underline{S}^2 = \overline{S}^2$; $\underline{K}^2 = \overline{K}^2$; $\underline{S}^{20} = \overline{S}^{20}$

\underline{S}_1^2
\underline{S}_2^2

[K]						
18000,0	0,0	0,0	-18000,0	0,0	0,0	0,0
0,0	500,0	-1500,0	0,0	-500,0	-1500,0	0,0
0,0	-1500,0	6000,0	0,0	1500,0	3000,0	0,0
-18000,0	0,0	0,0	18000,0	0,0	0,0	0,0
0,0	-500,0	1500,0	0,0	500,0	1500,0	0,0
0,0	-1500,0	3000,0	0,0	1500,0	6000,0	0,0

\underline{V}_1^2
\underline{V}_2^2

[s] ⁱ⁰	
Lastfall 1	Lastfall 2
0,000	0,000
0,000	0,000
0,000	0,000
0,000	0,000
0,000	0,000
0,000	0,000

\underline{S}^2

$\underline{K}^2 = \left[\begin{array}{c|c} \underline{K}_{11}^2 & \underline{K}_{12}^2 \\ \hline \underline{K}_{21}^2 & \underline{K}_{22}^2 \end{array} \right]$

\underline{V}^2

\underline{S}^{20}

Stab 3

\underline{K}^3						
24000,0	0,0	0,0	-24000,0	0,0	0,0	0,0
0,0	2666,7	-4000,0	0,0	-2666,7	-4000,0	0,0
0,0	-4000,0	8000,0	0,0	4000,0	4000,0	0,0
-24000,0	0,0	0,0	24000,0	0,0	0,0	0,0
0,0	-2666,7	4000,0	0,0	2666,7	4000,0	0,0
0,0	-4000,0	4000,0	0,0	4000,0	8000,0	0,0

\underline{S}^{30}	
0,000	0,000
9,000	0,000
-4,500	0,000
0,000	0,000
9,000	0,000
4,500	0,000

\underline{S}^{30}

LFA1 | LFA2

$\beta = -90^\circ$!

Transformationsmatrix für beta = -90°:

[T]						
0,00000	1,00000	0	0	0	0	0
-1,00000	0,00000	0	0	0	0	0
0	0	1	0	0	0	0
0	0	0	0,00000	1,00000	0	0
0	0	0	-1,00000	0,00000	0	0
0	0	0	0	0	0	1

[T] ^T						
0,00000	-1,00000	0	0	0	0	0
1,00000	0,00000	0	0	0	0	0
0	0	1	0	0	0	0
0	0	0	0,00000	-1,00000	0	0
0	0	0	1,00000	0,00000	0	0
0	0	0	0	0	0	1

Transformation auf globales Koordinatensystem (durch zweimalige Matrizenmultiplikation):

[T]^T * [K] (Zwischenergebnis):

0,0	-2666,7	4000,0	0,0	2666,7	4000,0	0,0
24000,0	0,0	0,0	-24000,0	0,0	0,0	0,0
0,0	-4000,0	8000,0	0,0	4000,0	4000,0	0,0
0,0	2666,7	-4000,0	0,0	-2666,7	-4000,0	0,0
-24000,0	0,0	0,0	24000,0	0,0	0,0	0,0
0,0	-4000,0	4000,0	0,0	4000,0	8000,0	0,0

Stabsteifigkeitsmatrix im globalen Koordinatensystem:

\underline{S}_3^3
\underline{S}_2^3
\underline{S}_3^3
\underline{S}_4^3

[K] ³						
2666,7	0,0	4000,0	-2666,7	0,0	4000,0	0,0
0,0	24000,0	0,0	0,0	-24000,0	0,0	0,0
4000,0	0,0	8000,0	-4000,0	0,0	4000,0	0,0
-2666,7	0,0	-4000,0	2666,7	0,0	-4000,0	0,0
0,0	-24000,0	0,0	0,0	24000,0	0,0	0,0
4000,0	0,0	4000,0	-4000,0	0,0	8000,0	0,0

\underline{V}_2^3
\underline{V}_3^3
\underline{V}_4^3

\underline{S}^3

$\underline{K}^3 = \left[\begin{array}{c|c} \underline{K}_{22}^3 & \underline{K}_{24}^3 \\ \hline \underline{K}_{42}^3 & \underline{K}_{44}^3 \end{array} \right]$

\underline{V}^3

Lastvektor im globalen Koordinatensystem:

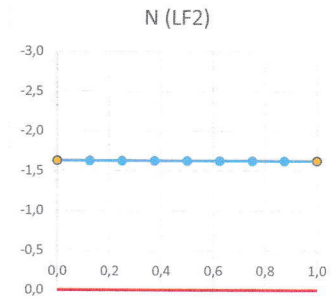
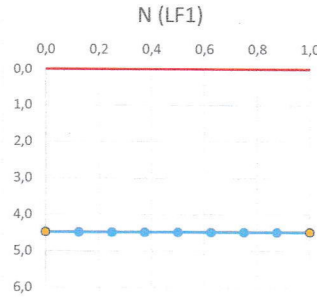
[s] ⁱ⁰ = [T] ^T * [s] ⁱ⁰	
Lastfall 1	Lastfall 2
-9,000	0,000
0,000	0,000
-4,500	0,000
-9,000	0,000
0,000	0,000
4,500	0,000

- Schritt 5: Nachlaufrechnung

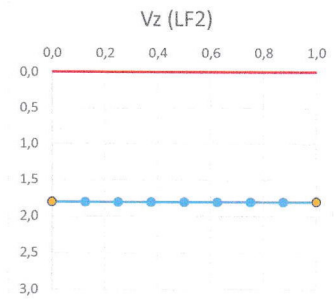
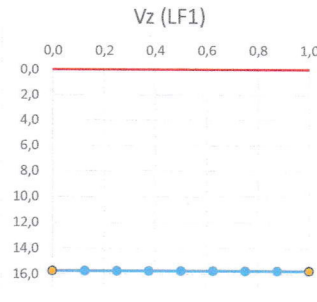
Darstellung der Schnittgrößenverläufe (Stabachse in horizontaler Richtung in normierter Länge):

Stab 1

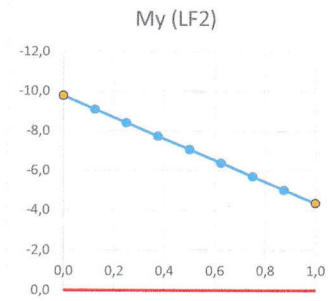
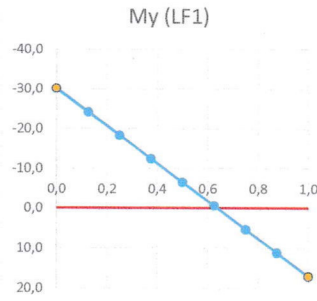
	Lastfall 1	Lastfall 2	
min N =	4,472	-1,629	kN
max N =	4,472	-1,629	kN
Schalter	0	0	
min Y	0,000	-3,000	
max Y	6,000	0,000	
Diagramm	6	7	



	Lastfall 1	Lastfall 2	
min Vz =	15,724	1,803	kN
max Vz =	15,724	1,803	kN
Schalter	0	0	
min Y	0,000	0,000	
max Y	17,000	3,000	
Diagramm	4	5	



	Lastfall 1	Lastfall 2	
min My =	-30,169	-9,771	kNm
max My =	17,002	-4,362	kNm
Schalter	1	1	
min Y	-30,169	-9,771	
max Y	17,002	-4,362	
Diagramm	2	3	



Auswertung:

$$\underline{S}^1 = \underline{K}^1 \cdot \underline{V}^1 + \underline{S}^{10}$$

mit $\underline{V}^1 = \begin{bmatrix} V_3 \\ V_1 \end{bmatrix}$

$a=3$
 $e=1$

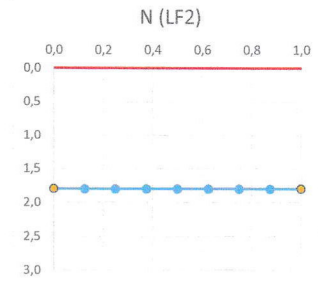
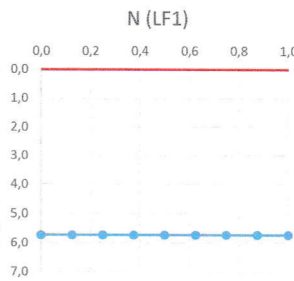
\underline{K}^1	\underline{V}^1	\underline{S}^{10}	\underline{S}^1																																																							
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>28800,000</td><td>0,000</td><td>0,000</td><td>-28800,000</td><td>0,000</td><td>0,000</td></tr> <tr><td>0,000</td><td>3200,000</td><td>-4800,000</td><td>0,000</td><td>-3200,000</td><td>-4800,000</td></tr> <tr><td>0,000</td><td>-4800,000</td><td>9600,000</td><td>0,000</td><td>4800,000</td><td>4800,000</td></tr> <tr><td>-28800,000</td><td>0,000</td><td>0,000</td><td>28800,000</td><td>0,000</td><td>0,000</td></tr> <tr><td>0,000</td><td>-3200,000</td><td>4800,000</td><td>0,000</td><td>3200,000</td><td>4800,000</td></tr> <tr><td>0,000</td><td>-4800,000</td><td>4800,000</td><td>0,000</td><td>4800,000</td><td>9600,000</td></tr> </table>	28800,000	0,000	0,000	-28800,000	0,000	0,000	0,000	3200,000	-4800,000	0,000	-3200,000	-4800,000	0,000	-4800,000	9600,000	0,000	4800,000	4800,000	-28800,000	0,000	0,000	28800,000	0,000	0,000	0,000	-3200,000	4800,000	0,000	3200,000	4800,000	0,000	-4800,000	4800,000	0,000	4800,000	9600,000	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>0,000E+00</td><td>0,000E+00</td><td>0,000E+00</td><td>1,553E-04</td><td>9,028E-03</td><td>-2,743E-03</td></tr> </table>	0,000E+00	0,000E+00	0,000E+00	1,553E-04	9,028E-03	-2,743E-03	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>0,000</td><td>0,000</td><td>0,000</td><td>0,000</td><td>0,000</td><td>0,000</td></tr> </table>	0,000	0,000	0,000	0,000	0,000	0,000	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>-4,472</td><td>-15,724</td><td>30,169</td><td>4,472</td><td>15,724</td><td>17,002</td></tr> </table>	-4,472	-15,724	30,169	4,472	15,724	17,002	LF1
28800,000	0,000	0,000	-28800,000	0,000	0,000																																																					
0,000	3200,000	-4800,000	0,000	-3200,000	-4800,000																																																					
0,000	-4800,000	9600,000	0,000	4800,000	4800,000																																																					
-28800,000	0,000	0,000	28800,000	0,000	0,000																																																					
0,000	-3200,000	4800,000	0,000	3200,000	4800,000																																																					
0,000	-4800,000	4800,000	0,000	4800,000	9600,000																																																					
0,000E+00	0,000E+00	0,000E+00	1,553E-04	9,028E-03	-2,743E-03																																																					
0,000	0,000	0,000	0,000	0,000	0,000																																																					
-4,472	-15,724	30,169	4,472	15,724	17,002																																																					
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>28800,000</td><td>0,000</td><td>0,000</td><td>-28800,000</td><td>0,000</td><td>0,000</td></tr> <tr><td>0,000</td><td>3200,000</td><td>-4800,000</td><td>0,000</td><td>-3200,000</td><td>-4800,000</td></tr> <tr><td>0,000</td><td>-4800,000</td><td>9600,000</td><td>0,000</td><td>4800,000</td><td>4800,000</td></tr> <tr><td>-28800,000</td><td>0,000</td><td>0,000</td><td>28800,000</td><td>0,000</td><td>0,000</td></tr> <tr><td>0,000</td><td>-3200,000</td><td>4800,000</td><td>0,000</td><td>3200,000</td><td>4800,000</td></tr> <tr><td>0,000</td><td>-4800,000</td><td>4800,000</td><td>0,000</td><td>4800,000</td><td>9600,000</td></tr> </table>	28800,000	0,000	0,000	-28800,000	0,000	0,000	0,000	3200,000	-4800,000	0,000	-3200,000	-4800,000	0,000	-4800,000	9600,000	0,000	4800,000	4800,000	-28800,000	0,000	0,000	28800,000	0,000	0,000	0,000	-3200,000	4800,000	0,000	3200,000	4800,000	0,000	-4800,000	4800,000	0,000	4800,000	9600,000	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>0,000E+00</td><td>0,000E+00</td><td>0,000E+00</td><td>-5,655E-05</td><td>4,980E-03</td><td>-2,944E-03</td></tr> </table>	0,000E+00	0,000E+00	0,000E+00	-5,655E-05	4,980E-03	-2,944E-03	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>0,000</td><td>0,000</td><td>0,000</td><td>0,000</td><td>0,000</td><td>0,000</td></tr> </table>	0,000	0,000	0,000	0,000	0,000	0,000	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>1,629</td><td>-1,803</td><td>9,771</td><td>-1,629</td><td>1,803</td><td>-4,362</td></tr> </table>	1,629	-1,803	9,771	-1,629	1,803	-4,362	LF2
28800,000	0,000	0,000	-28800,000	0,000	0,000																																																					
0,000	3200,000	-4800,000	0,000	-3200,000	-4800,000																																																					
0,000	-4800,000	9600,000	0,000	4800,000	4800,000																																																					
-28800,000	0,000	0,000	28800,000	0,000	0,000																																																					
0,000	-3200,000	4800,000	0,000	3200,000	4800,000																																																					
0,000	-4800,000	4800,000	0,000	4800,000	9600,000																																																					
0,000E+00	0,000E+00	0,000E+00	-5,655E-05	4,980E-03	-2,944E-03																																																					
0,000	0,000	0,000	0,000	0,000	0,000																																																					
1,629	-1,803	9,771	-1,629	1,803	-4,362																																																					

| * (-1) → Baustatik

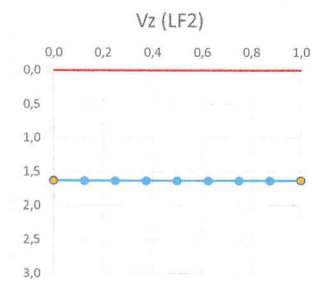
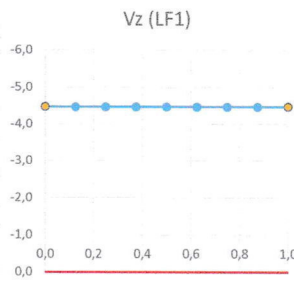
Darstellung der Schnittgrößenverläufe (Stabachse in horizontaler Richtung in normierter Länge):

Stab 2

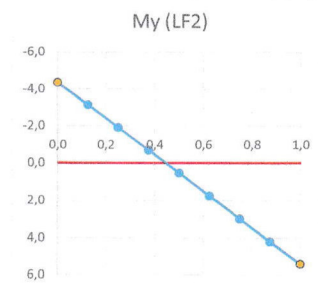
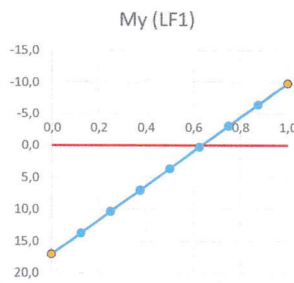
	Lastfall 1	Lastfall 2	
min N =	5,724	1,803	kN
max N =	5,724	1,803	kN
Schalter	0	0	
min Y	0,000	0,000	
max Y	7,000	3,000	
Diagramm	13	12	



	Lastfall 1	Lastfall 2	
min Vz =	-4,472	1,629	kN
max Vz =	-4,472	1,629	kN
Schalter	0	0	
min Y	-6,000	0,000	
max Y	0,000	3,000	
Diagramm	9	10	



	Lastfall 1	Lastfall 2	
min My =	-9,829	-4,362	kNm
max My =	17,002	5,410	kNm
Schalter	1	1	
min Y	-18,643	-4,362	
max Y	17,002	5,410	
Diagramm	7	8	



Auswertung:

$$S^2 = K^2 \cdot V^2 + S^{20}$$

mit $V^2 = \begin{bmatrix} V_1^2 \\ V_2^2 \end{bmatrix}$

$a = 1$
 $e = 2$

K^2						V^2		S^{20}		S^2	
18000,000	0,000	0,000	-18000,000	0,000	0,000	9,028E-03	0,000	0,000	-5,724	LF1	
0,000	500,000	-1500,000	0,000	-500,000	-1500,000	-1,553E-04	0,000	4,472			
0,000	-1500,000	6000,000	0,000	1500,000	3000,000	-2,743E-03	0,000	-17,002			
-18000,000	0,000	0,000	18000,000	0,000	0,000	9,346E-03	0,000	5,724			
0,000	-500,000	1500,000	0,000	500,000	1500,000	1,863E-04	0,000	-4,472			
0,000	-1500,000	3000,000	0,000	1500,000	6000,000	-3,521E-04	0,000	-9,829			

K^2						V^2		S^{20}		S^2	
18000,000	0,000	0,000	-18000,000	0,000	0,000	4,980E-03	0,000	0,000	-1,803	LF2	
0,000	500,000	-1500,000	0,000	-500,000	-1500,000	5,655E-05	0,000	-1,629			
0,000	-1500,000	6000,000	0,000	1500,000	3000,000	-2,944E-03	0,000	4,362			
-18000,000	0,000	0,000	18000,000	0,000	0,000	5,080E-03	0,000	1,803			
0,000	-500,000	1500,000	0,000	500,000	1500,000	1,993E-02	0,000	1,629			
0,000	-1500,000	3000,000	0,000	1500,000	6000,000	-2,595E-03	0,000	5,410			

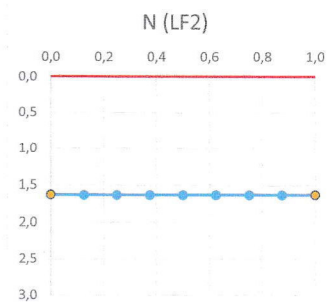
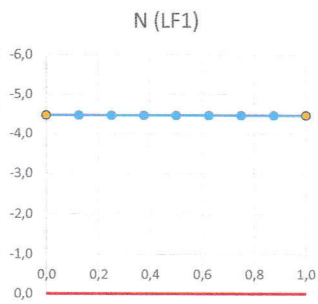
$1 \times (-1) \rightarrow$ Jaustatik

-3.8-

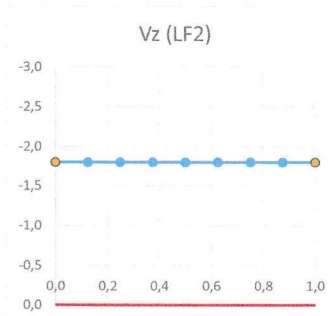
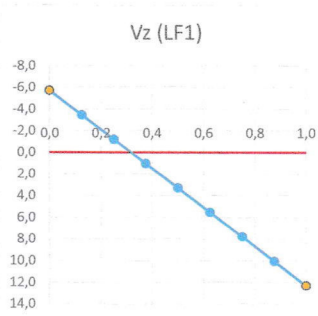
Darstellung der Schnittgrößenverläufe (Stabachse in horizontaler Richtung in normierter Länge):

Stab 3

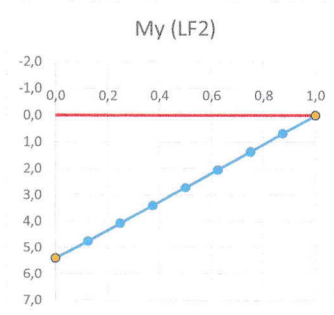
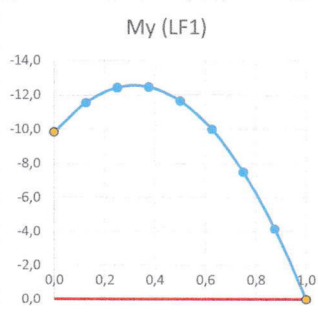
	Lastfall 1	Lastfall 2	
min N =	-4,472	1,629	kN
max N =	-4,472	1,629	kN
Schalter	0	0	
min Y	-6,000	0,000	
max Y	0,000	3,000	
Diagramm	5	6	



	Lastfall 1	Lastfall 2	
min Vz =	-5,724	-1,803	kN
max Vz =	12,276	-1,803	kN
Schalter	1	0	
min Y	-5,724	-3,000	
max Y	12,276	0,000	
Diagramm	3	4	



	Lastfall 1	Lastfall 2	
min My =	-12,472	0,000	kNm
max My =	0,000	5,410	kNm
Schalter	1	0	
min Y	-12,472	-2,000	
max Y	0,000	7,000	
Diagramm	1	2	



Auswertung:

$$\underline{S^3} = \underline{K^3} \cdot \underline{V^3} + \underline{S^30}$$

mit $\underline{V^3} = \begin{bmatrix} \underline{V_2^3} \\ \underline{V_4^3} \end{bmatrix}$

a = 2
e = 4

24000,000	0,000	0,000	-24000,000	0,000	0,000
0,000	2666,667	-4000,000	0,000	-2666,667	-4000,000
0,000	-4000,000	8000,000	0,000	4000,000	4000,000
-24000,000	0,000	0,000	24000,000	0,000	0,000
0,000	-2666,667	4000,000	0,000	2666,667	4000,000
0,000	-4000,000	4000,000	0,000	4000,000	8000,000

1,863E-04
-9,346E-03
-3,521E-04
0,000E+00
0,000E+00
-5,059E-03

0,000
9,000
-4,500
0,000
9,000
4,500

4,472
5,724
9,829
-4,472
12,276
0,000

LF1

24000,000	0,000	0,000	-24000,000	0,000	0,000
0,000	2666,667	-4000,000	0,000	-2666,667	-4000,000
0,000	-4000,000	8000,000	0,000	4000,000	4000,000
-24000,000	0,000	0,000	24000,000	0,000	0,000
0,000	-2666,667	4000,000	0,000	2666,667	4000,000
0,000	-4000,000	4000,000	0,000	4000,000	8000,000

1,993E-02
-5,080E-03
-2,595E-03
2,000E-02
1,225E-18
-1,243E-03

0,000
0,000
0,000
0,000
0,000
0,000

-1,629
1,803
-5,410
1,629
-1,803
0,000

LF2

1 * (-1) -> Baustatik