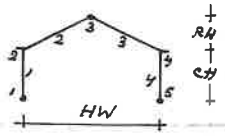
Part 14

Program **FRAMEPROGMATRIXS5** 1 4A

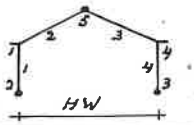
Member stiffmess matrices S5 of frames.

Many possibilities of member and joint numbering.



3HFRAME1

NL(1)=0 NL(4)=0 NH(2)=0 NL(3)=0
NL(1)=1 NH(4)=1 NH(2)=1 NL(3)=1



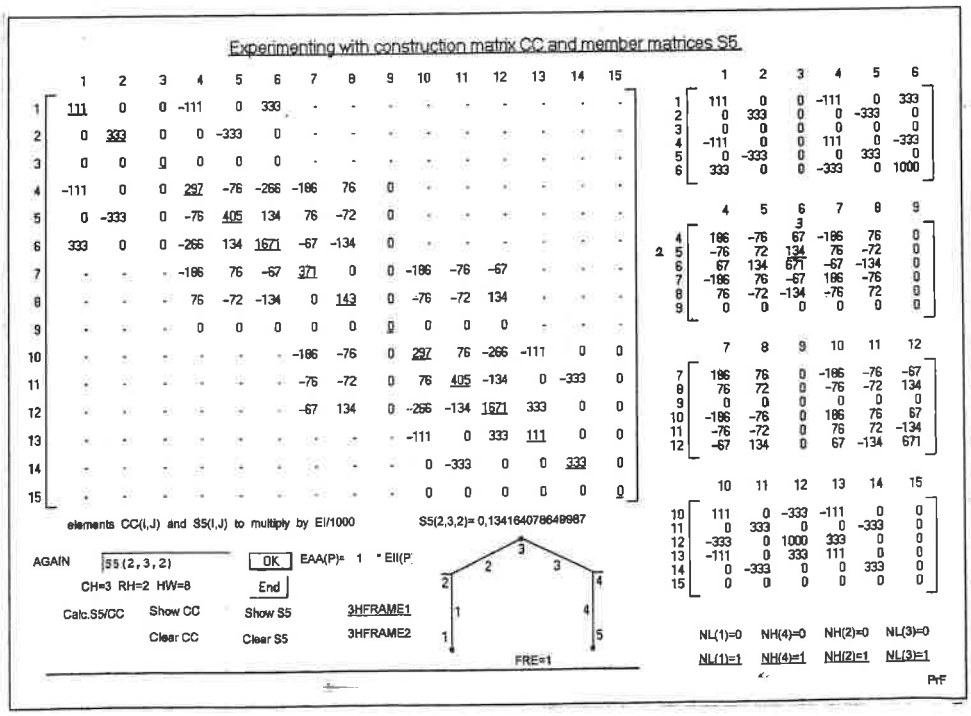
3HFRAME2

NH(1)=0 NL(4)=0 NH(2)=0 NH(3)=0
NH(1)=1 NL(4)=1 NH(3)=1 NH(3)=1

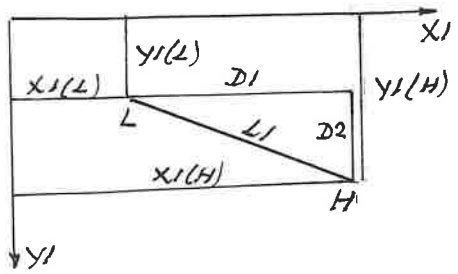
Program **FRAMEPROGMATRIXCCS5** 5 -21

Composing the construction stiffness matrix CC with member stiffness matrices S5.

Example the 'three hinge arche'.



Showing here one of the many possible compositions of the construction matrix CC with matrices S5.



R='EA/L1' EA= ...EI Fig.1.

A1	A2	A3	-A1	-A2	A3
A2	A4	A5	-A2	-A4	A5
A3	A5	D	-A3	-A5	E
-A1	-A2	-A3	A1	A2	-A3
-A2	-A4	-A5	A2	A4	-A5
A3	A5	E	-A3	-A5	D

A= 12EI/L1^3
B= 6EI/L1^2
D= 4EI/L1
E= 2EI/L1

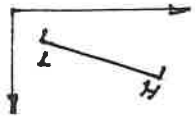


Fig.2.

A1	A2	.	-A1	-A2	A3
A2	A4	.	-A2	-A4	A5
.	.	.	.	.	.
-A1	-A2	.	A1	A2	-A3
-A2	-A4	.	A2	A4	-A5
A3	A5	.	-A3	-A5	D

A= 3EI/L1^3
B= 3EI/L1^2
D= 3EI/L1

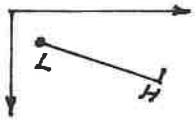


Fig.3a.

A1	A2	A3	-A1	-A2	.
A2	A4	A5	-A2	-A4	.
A3	A5	D	-A3	-A5	.
-A1	-A2	-A3	A1	A2	.
-A2	-A4	-A5	A2	A4	.
.	.	.	.	.	.

A= 3EI/L1^3
B= 3EI/L1^2
D= 3EI/L1

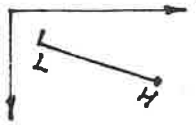


Fig.3b.

RC^2	RSC	.	-RC^2	-RSC	.
RSC	RS^2	.	-RSC	-RS^2	.
.	.	.	.	.	.
-RC^2	-RSC	.	RC^2	RSC	.
-RSC	-RS^2	.	RSC	RS^2	.
.	.	.	.	.	.

R= EA/L1
C= D1/L1
S= D2/L1

Fig.4.

FRAMEPROGMATRIXS5

Member stiffness matrix S5.

(See displacement method, part 2 page 58-60.)

Fig.1.
Member length L1=Sqr(D1^2+D2^2)
L is lowest member end number,
H is highest member end number.

D1=XI(H)-XI(L) and D2=YI(H)-YI(L)
C=cos(h) C=D1/L1 and S=sin(h) S=D2/L1.

FLHX		A1	A2	A3	-A1	-A2	A3	ULX
FLHY		A2	A4	A5	-A2	-A4	A5	ULY
MLH		A3	A5	D	-A3	-A5	E	URL
FHLX	=	-A1	-A2	-A3	A1	A2	-A3	UHX
FHLY		-A2	-A4	-A5	A2	A4	-A5	UHY
MHL		A3	A5	E	-A3	-A5	D	URH

f S5 u

A1= R*C^2 +A*S^2 A2= R*S*C-A*S*C

A3= -B*S A4= R*S^2 +A*C^2 A5= B*C

Fig.2.
Both member ends seen as real joints, indicated with the little stripes. NL(P)=0 and NH(P)=0.

A=12EI/L1^3 B=6*EI/L1^2 D=4EI/L1 E=2EI/L1

Fig.3a.
Member end L is a hinge, member end H is a real joint. NL(P)=1 and NH(P)=0.

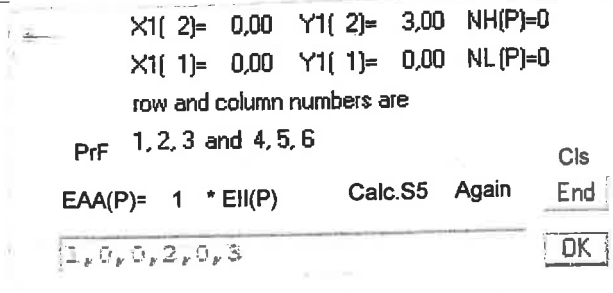
A=3EI/L1^3 B=3EI/L1^2 D=4EI/L1

Fig.3b.
Member end H is a hinge, member end L is a real joint. NL(P)=0 and NH(P)=1.

R= EA/L1 C= D1/L1 S=D2/L1

Fig.4.
Member end L and member end H is a hinge.
NL(P)=1 and NH(P)=1.
EA will be assumed 1 time EI, EA=1*EI.

At the start of the program, and after clicking Again are NL(P)=0 and NH(P)=0.



After typing the necessary data in text box TSTRING NL(P) and NH(P) can be changed, e.g. NL(P)=1 Enter before clicking Calc.S5.

/

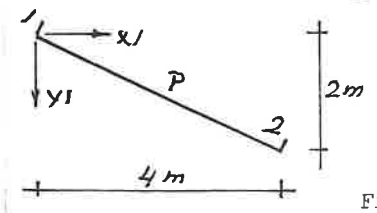


Fig.5a.

experiments with frame matrix S5

	1	2	3	4	5	6
1	27	-54	-134	-27	54	-134
2	-54	107	268	54	-107	268
3	-134	268	894	134	-268	447
4	-27	54	134	27	-54	134
5	54	-107	-268	-54	107	-268
6	-134	268	447	134	-268	894

First S5

	1	2	3	4	5	6
1	179	89	0	-179	-89	0
2	89	45	0	-89	-45	0
3	0	0	0	0	0	0
4	-179	-89	0	179	89	0
5	-89	-45	0	89	45	0
6	0	0	0	0	0	0

Second S5

	1	2	3	4	5	6
1	206	36	-134	-206	-36	-134
2	36	152	268	-36	-152	268
3	-134	268	894	134	-268	447
4	-206	-36	134	206	36	134
5	-36	-152	-268	36	152	-268
6	-134	268	447	134	-268	894

Third S5

X1(2)= 4,00 Y1(2)= 2,00 NH(P)=0
X1(1)= 0,00 Y1(1)= 0,00 NL(P)=0
row and column numbers are
1, 2, 3 and 4, 5, 6

PrF | exchanging joint numbers | Calc.S5 | Again | Cls | End

1,0,0,2,4,2 | OK

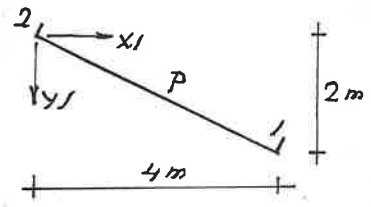


Fig.5b.

experiments with frame matrix S5

	1	2	3	4	5	6
1	27	-54	134	-27	54	134
2	-54	107	-268	54	-107	-268
3	134	-268	894	-134	268	447
4	-27	54	-134	27	-54	-134
5	54	-107	268	-54	107	268
6	134	-268	447	-134	268	894

+

	1	2	3	4	5	6
1	179	89	0	-179	-89	0
2	89	45	0	-89	-45	0
3	0	0	0	0	0	0
4	-179	-89	0	179	89	0
5	-89	-45	0	89	45	0
6	0	0	0	0	0	0

=

	1	2	3	4	5	6
1	206	36	134	-206	-36	134
2	36	152	-268	-36	-152	-268
3	134	-268	894	-134	268	447
4	-206	-36	-134	206	36	-134
5	-36	-152	268	36	152	268
6	134	-268	447	-134	268	894

X1(2)= 0,00 Y1(2)= 0,00 NH(P)=0
X1(1)= 4,00 Y1(1)= 2,00 NL(P)=0
row and column numbers are
1, 2, 3 and 4, 5, 6

PrF | exchanging joint numbers | Calc.S5 | Again | Cls | End

1,4,2,2,0,0 | OK

Exampple.

Fig.5a.

L	X1(L)	Y1(L)	H	X1(H)	Y1(H)	
1	0	0	2	4	2	in TSTRING

1,0,0,2,4,2 Enter and click Calc.S5 to get the print with the three matrices.

Calculation of the elements A1 etc. given on the preceding page.

member P
H=2 L=1 D1=X1(H)-X1(L) D2=Y1(H)-Y1(L)
Length L1= Sqr(2^2+4^2)= 4,47 m

X1(2)= 4 X1(1)= 0 D1= 4-0= 4
Y1(2)= 2 Y1(1)= 0 D2= 2-0= 2
C=D1/L1= 4/4,47= 0,895
S=D2/L1= 2/4,47= 0,447
Assumption EA=1EI R='EA/L1'= 1EI/4,47=0,224EI

First matrix S5 with EI=1, EA=0 so R=0.

A1= R*C^2 +A*S^2=
0*C^2 + (12EI/4,47^3)*(0,447^2)= 0,0268 EI
A1= 27 *EI/1000

A2= R*S*C -A*S*C=
0*(0,447*0,895 -(12EI/4,47^3)*(0,447)*(0,895)=
A2= -54 *EI/1000

A3= -B*S= -(6EI/4,47^2)*(0,447)=
A3= -134 *EI/1000

A4= R*S^2 +A*C^2=
0*(S^2) +(12EI/4,47^3)*(0,895^2)=
A4= 107 *EI/1000

A5= B*C= (6EI/4,47^2)*(0,895)=
A5= 269 *EI/1000

D= 4EI/4,47= D= 894 *EI/1000

E= 2EI/4,47= E= 447 *EI/1000

Second matrix S5 with EI=0, EA=1EI.

R= EA/L1= 1EI/4,47= 0,224EI

RC^2= 0,224EI*(0,895^2)= 179 *EI/1000

RSC= 0,224EI*(0,447)*(0,895)= 89 *EI/1000

RS^2= 0,224EI*(0,447^2)= 45 *EI/1000

Third matrix S5, first and second together.

Fig.5b. with exchanged member end numbers.

X1(2)= 0 X1(1)= 4 D1= 0-4= -4
Y1(2)= 0 Y1(1)= 2 D2= 0-2= -2
C=D1/L1= -4/4,47= -0,895
S=D2/L1= -2/4,47= -0,447

Click Again, 1,4,2,2,0,0 Enter, Calc.S5.
Comparing the two toal S5's, some values with + sign got a minus - sign.

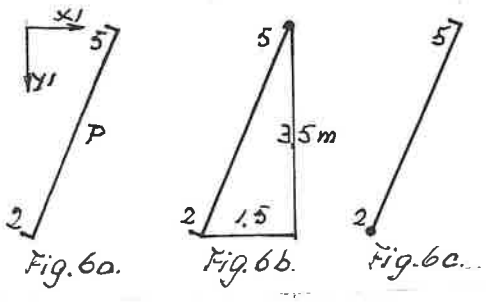


Fig.6a. Fig.6b. Fig.6c.

row and column nunbers of
a construction matrix CC

joint number 2
2*3-2= 4 2*3-1= 3 2*3= 6

joint number 5
5*3-2=13 5*3-1=14 5*3=15

Example.

Fig.6a, 6b en 5c.
L1= Sqr(2,1^2+1,5^2)= 2,58 m

Fig.6a with NL(P)=0 and NH(P)=0.
L X1(L) Y1(L) H X1(H) Y1(H)
2 0 3.5 5 1.5 0
2,0,3.5,5,1.5,0 Enter, Calc.S5

Fig.6b with NL(P)=0 and NH(P)=**1**.
2 0 3.5 5 1.5 0 First Again,
2,0,3.5,5,1.5,0 Enter, double click TSTRING to make it empty, NH(P)=1 Enter and Calc.S5.

Fig.6c with NL(P)=**1** and NH(P)=0.
2 0 3.5 5 1.5 0 First Again,
2,0,3.5,5,1.5,0 Enter, double click TSTRING to make it empty, NL(P)=1 Enter and Calc.S5.

experiments with frame matrix S5

	1	2	3	4	5	6
1	184	79	380	-184	-79	380
2	79	34	163	-79	-34	163
3	380	163	1050	-380	-163	525
4	-184	-79	-380	184	79	-380
5	-79	-34	-163	79	34	-163
6	380	163	525	-380	-163	1050

	1	2	3	4	5	6
1	41	-95	0	-41	95	0
2	-95	222	0	95	-222	0
3	0	0	0	0	0	0
4	-41	95	0	41	-95	0
5	95	-222	0	-95	222	0
6	0	0	0	0	0	0

	1	2	3	4	5	6
1	224	-16	380	-224	16	380
2	-16	256	163	16	-256	163
3	380	163	1050	-380	-163	525
4	-224	16	-380	224	-16	-380
5	16	-256	-163	-16	256	-163
6	380	163	525	-380	-163	1050

X1(5)= 1,50 Y1(5)= 0,00 NH(P)=0
X1(2)= 0,00 Y1(2)= 3,50 NL(P)=0
row and column numbers are
4, 5, 6 and 13, 14, 15
PrF exchanging joint numbers Calc.S5 Again Cls End
2,0,3.5,5,1.5,0 OK

experiments with frame matrix S5

	1	2	3	4	5	6
1	46	20	190	-46	-20	0
2	20	8	82	-20	-8	0
3	190	82	788	-190	-82	0
4	-46	-20	-190	46	20	0
5	-20	-8	-82	20	8	0
6	0	0	0	0	0	0

	1	2	3	4	5	6
1	41	-95	0	-41	95	0
2	-95	222	0	95	-222	0
3	0	0	0	0	0	0
4	-41	95	0	41	-95	0
5	95	-222	0	-95	222	0
6	0	0	0	0	0	0

	1	2	3	4	5	6
1	87	-75	190	-87	75	0
2	-75	230	82	75	-230	0
3	190	82	788	-190	-82	0
4	-87	75	-190	87	-75	0
5	75	-230	-82	-75	230	0
6	0	0	0	0	0	0

X1(5)= 1,50 Y1(5)= 0,00 NH(P)=1
X1(2)= 0,00 Y1(2)= 3,50 NL(P)=0
row and column numbers are
4, 5, 6 and 13, 14, 15
PrF exchanging joint numbers Calc.S5 Again Cls End
OK

experiments with frame matrix S5

	1	2	3	4	5	6
1	46	20	0	-46	-20	190
2	20	8	0	-20	-8	82
3	0	0	0	0	0	0
4	-46	-20	0	46	20	-190
5	-20	-8	0	20	8	-82
6	190	82	0	-190	-82	788

	1	2	3	4	5	6
1	41	-95	0	-41	95	0
2	-95	222	0	95	-222	0
3	0	0	0	0	0	0
4	-41	95	0	41	-95	0
5	95	-222	0	-95	222	0
6	0	0	0	0	0	0

	1	2	3	4	5	6
1	87	-75	0	-87	75	190
2	-75	230	0	75	-230	82
3	0	0	0	0	0	0
4	-87	75	0	87	-75	-190
5	75	-230	0	-75	230	-82
6	190	82	0	-190	-82	788

X1(5)= 1,50 Y1(5)= 0,00 NH(P)=0
X1(2)= 0,00 Y1(2)= 3,50 NL(P)=1
row and column numbers are
4, 5, 6 and 13, 14, 15
PrF exchanging joint numbers Calc.S5 Again Cls End
OK

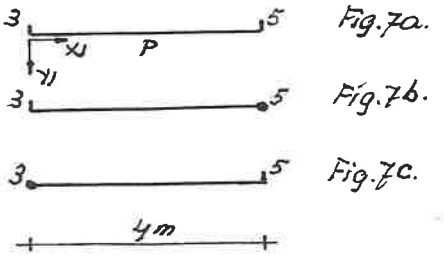


Fig.7a.
Fig.7b.
Fig.7c.

Fig.7a.
L X1 Y1 H X1 Y1(
3 0 0 5 4 0 3,0,0,5,4,0 Enter
NL(P)=0 Enter and NH(P)=0 Enter.

Fig.7b.
L X1 Y1 H X1 Y1(
3 0 0 5 4 0 3,0,0,5,4,0 Enter
NL(P)=0 Enter and NH(P)=1 Enter.

Fig.7c. with NL(P)=1 and NH(P)=0.

	1	2	3	4	5	6
1	250	0	0	-250	0	0
2	0	188	375	0	-188	375
3	0	375	1000	0	-375	500
4	-250	0	0	250	0	0
5	0	-188	-375	0	188	-375
6	0	375	500	0	-375	1000

X1(5)= 4,00 Y1(5)= 0,00 NH(P)=0
X1(3)= 0,00 Y1(3)= 0,00 NL(P)=0
row and column numbers are
7, 8, 9 and 13, 14, 15
PrF exchanging joint numbers Calc.S5 Again Cls End
3,0,0,5,4,0 OK

	1	2	3	4	5	6
1	250	0	0	-250	0	0
2	0	47	188	0	-47	0
3	0	188	750	0	-188	0
4	-250	0	0	250	0	0
5	0	-47	-188	0	47	0
6	0	0	0	0	0	0

X1(5)= 4,00 Y1(5)= 0,00 NH(P)=1
X1(3)= 0,00 Y1(3)= 0,00 NL(P)=0
row and column numbers are
7, 8, 9 and 13, 14, 15
PrF exchanging joint numbers Calc.S5 Again Cls End
OK

	1	2	3	4	5	6
1	250	0	0	-250	0	0
2	0	47	0	0	-47	188
3	0	0	0	0	0	0
4	-250	0	0	250	0	0
5	0	-47	0	0	47	-188
6	0	188	0	0	-188	750

X1(5)= 4,00 Y1(5)= 0,00 NH(P)=0
X1(3)= 0,00 Y1(3)= 0,00 NL(P)=1
row and column numbers are
7, 8, 9 and 13, 14, 15
PrF exchanging joint numbers Calc.S5 Again Cls End
OK

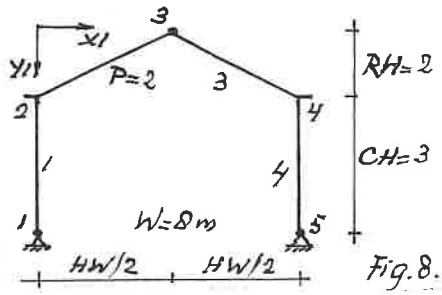


Fig.8.

Example.

Fig.8.

A 3-hinge frame, in this example with CH=3 m RH=2 m and HW=8 m.

To determine the member stiffness matrix S5, the axis system X1-Y1 can be arbitrarily placed. For matrix S5 the member number itself is not important.
With Again start values NL(P)=0 and NH(P)=0, member ends assumed as 'real joints'.

First S5 print.
member 1 with NL(P)=1 and NH(P)=0.

L	X1(L)	Y1(L)	H	X1(H)	Y1(H)
1	0	5	2	0	2

1,0,5,2,0,2 Enter, double click TSTRING to make it empty, NL(P)=1 Enter and Calc.S5.
Member end 1 is a hinge, so no joint rotation UR1, therefore the elements of row 3 and column 3 are zeros.

Second S5 print.
member 2 with NL(P)=0 and NH(P)=1. Again

L	X1(L)	Y1(L)	H	X1(H)	Y1(H)
2	0	2	3	4	0

2,0,2,3,4,0 Enter, NH(P)=1 Enter, Calc.S5.
Member end 3 is a hinge, no real joint, no UR(3), row 6 and column 6 with zeros.

Third S5 print.
member 3 with NL(P)=1 and NH(P)=0. Again

L	X1(L)	Y1(L)	H	X1(H)	Y1(H)
3	4	0	4	8	2

3,4,0,4,8,2 Enter, NL(P)=1 Enter, Calc.S5.
Member end 3 is a hinge, no joint rotation UR(3), row 3 and column 3 with zeros. Etc.

member 4 4,8,2,5,8,5 Enter
NL(P)=0 and NH(P)=1.

experiments with frame matrix S5

	1	2	3	4	5	6	
1	111	0	0	-111	0	333	UH1
2	0	0	0	0	0	0	UV1
3	0	0	0	0	0	0	UR1
4	-111	0	0	111	0	-333	UH2
5	0	0	0	0	0	0	UV2
6	333	0	0	-333	0	1000	UR2

	1	2	3	4	5	6
1	0	0	0	0	0	0
2	0	333	0	0	-333	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	-333	0	0	333	0
6	0	0	0	0	0	0

	1	2	3	4	5	6
1	111	0	0	-111	0	333
2	0	333	0	0	-333	0
3	0	0	0	0	0	0
4	-111	0	0	111	0	-333
5	0	-333	0	0	333	0
6	333	0	0	-333	0	1000

X1(2)= 0,00 Y1(2)= 2,00 NH(P)=0
X1(1)= 0,00 Y1(1)= 5,00 NL(P)=1
row and column numbers are
PrF 1, 2, 3 and 4, 5, 6 Cls

experiments with frame matrix S5

	1	2	3	4	5	6	
1	7	13	67	-7	-13	0	UH2
2	13	27	134	-13	-27	0	UV2
3	67	134	671	-67	-134	0	UR2
4	-7	-13	-67	7	13	0	UH3
5	-13	-27	-134	13	27	0	UV3
6	0	0	0	0	0	0	UR3

	1	2	3	4	5	6
1	179	-89	0	-179	89	0
2	-89	45	0	89	-45	0
3	0	0	0	0	0	0
4	-179	89	0	179	-89	0
5	89	-45	0	-89	45	0
6	0	0	0	0	0	0

	1	2	3	4	5	6
1	186	-76	67	-186	76	0
2	-76	72	134	76	-72	0
3	67	134	671	-67	-134	0
4	-186	76	-67	186	-76	0
5	76	-72	-134	-76	72	0
6	0	0	0	0	0	0

X1(3)= 4,00 Y1(3)= 0,00 NH(P)=1
X1(2)= 0,00 Y1(2)= 2,00 NL(P)=0
row and column numbers are
PrF 4, 5, 6 and 7, 8, 9 Cls

experiments with frame matrix S5

	1	2	3	4	5	6	
1	7	-13	0	-7	13	-67	UH3
2	-13	27	0	13	-27	134	UV3
3	0	0	0	0	0	0	UR3
4	-7	13	0	7	-13	67	UH4
5	13	-27	0	-13	27	-134	UV4
6	-67	134	0	67	-134	671	UR4

	1	2	3	4	5	6
1	179	89	0	-179	-89	0
2	89	45	0	-89	-45	0
3	0	0	0	0	0	0
4	-179	-89	0	179	89	0
5	-89	-45	0	89	45	0
6	0	0	0	0	0	0

	1	2	3	4	5	6
1	186	76	0	-186	-76	-67
2	76	72	0	-76	-72	134
3	0	0	0	0	0	0
4	-186	-76	0	186	76	67
5	-76	-72	0	76	72	-134
6	-67	134	0	67	-134	671

X1(4)= 8,00 Y1(4)= 2,00 NH(P)=0
X1(3)= 4,00 Y1(3)= 0,00 NL(P)=1
row and column numbers are
PrF 7, 8, 9 and 10, 11, 12

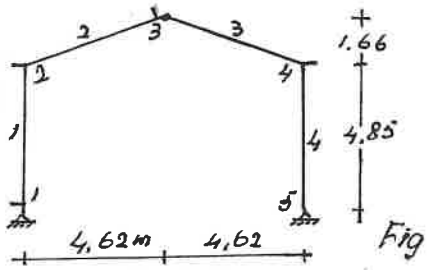


Fig.8a.

experiments with frame matrix S5

	1	2	3	4	5	6
1	105	0	255	-105	0	255
2	0	0	0	0	0	0
3	255	0	825	-255	0	412
4	-105	0	-255	105	0	-255
5	0	0	0	0	0	0
6	255	0	412	-255	0	825

	1	2	3	4	5	6
1	0	0	0	0	0	0
2	0	61856	0	0	-61856	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	-61856	0	0	61856	0
6	0	0	0	0	0	0

	1	2	3	4	5	6
1	105	0	255	-105	0	255
2	0	61856	0	0	-61856	0
3	255	0	825	-255	0	412
4	-105	0	-255	105	0	-255
5	0	-61856	0	0	61856	0
6	255	0	412	-255	0	825

X1(2)= 0,00 Y1(2)= 0,00 NH(P)=0
X1(1)= 0,00 Y1(1)= 4,85 NL(P)=0
row and column numbers are
PrF 1,2,3 and 4,5,6 Cls
EAA(P)= 300 * EII(P) Calc.S5 Again End
1,0,4.85,2,0,0 OK

experiments with frame matrix S5

	1	2	3	4	5	6
1	12	32	84	-12	-32	84
2	32	90	234	-32	-90	234
3	84	234	815	-84	-234	407
4	-12	-32	-84	12	32	-84
5	-32	-90	-234	32	90	-234
6	84	234	407	-84	-234	815

	1	2	3	4	5	6
1	54123	-19447	0	-54123	19447	0
2	-19447	6987	0	19447	-6987	0
3	0	0	0	0	0	0
4	-54123	19447	0	54123	-19447	0
5	19447	-6987	0	-19447	6987	0
6	0	0	0	0	0	0

	1	2	3	4	5	6
1	54134	-19414	84	-54134	19414	84
2	-19414	7077	234	19414	-7077	234
3	84	234	815	-84	-234	407
4	-54134	19414	-84	54134	-19414	-84
5	19414	-7077	-234	-19414	7077	-234
6	84	234	407	-84	-234	815

X1(3)= 4,62 Y1(3)= 0,00 NH(P)=0
X1(2)= 0,00 Y1(2)= 1,66 NL(P)=0
row and column numbers are
PrF 4,5,6 and 7,8,9 Cls
EAA(P)= 300 * EII(P) Calc.S5 Again End
2,0,1.66,3,4.62,0 OK

Example. See part 15 page 11 and 12.

Fig.8a.
At the start, and Again, NL(P)=0 and NH(P)=0.
Until now EA= 1EI. But it can be changed with EAA(P)= 1 * EII(P).
A click on 1 makes it 100, with each other click the number increases with 100, with a click with the right button the number increases with 10, and a click on Again makes the number again 1 to start with.

First S5 print.
member 1 is member P with NL(P)=0 and NH(P)=0.

L	X1(L)	Y1(L)	H	X1(H)	Y1(H)
1	0	4.85	2	0	0

1,0,4.85,2,0,0 Enter. Calc.S5.
Click 1 to EAA(P)= 300 *EII(P), next Calc.S5.

Second S5 print.
member 2 with NL(P)=0 and NH(P)=0. EA= 300*EI

L	X1(L)	Y1(L)	H	X1(H)	Y1(H)
2	0	1.66	3	4.62	0

2,0,1.66,3,4.62,0 Enter. Calc.S5.

Third S5 print.
Member 3 with NL(P)=1 and NH(P)=0. EA= 300*EI.

L	X1(L)	Y1(L)	H	X1(H)	Y1(H)
3	0	0	4	4.62	1.66

3,0,0,4,4.62,1.66 Enter.
Double click in TSTRING, and type in TSTRING
NL(P)=1 Enter. Calc.S5.

Suppose A=53,8 cm2 is 53,8*10^-4 m2
I= 3692 cm4 is 3692*10^-8 m4
EA= a *EI 53,8*10^-4= a * 3692*10*-8

a = (53,8*10^-4)/(3692*10^^-8)= 145 EA= 145EI

experiments with frame matrix S5

	1	2	3	4	5	6
1	3	-8	0	-3	8	-42
2	-8	22	0	8	-22	117
3	0	0	0	0	0	0
4	-3	8	0	3	-8	42
5	8	-22	0	-8	22	-117
6	-42	117	0	42	-117	611

	1	2	3	4	5	6
1	54123	19447	0	-54123	-19447	0
2	19447	6987	0	-19447	-6987	0
3	0	0	0	0	0	0
4	-54123	-19447	0	54123	19447	0
5	-19447	-6987	0	19447	6987	0
6	0	0	0	0	0	0

	1	2	3	4	5	6
1	54126	19439	0	-54126	-19439	-42
2	19439	7010	0	-19439	-7010	117
3	0	0	0	0	0	0
4	-54126	-19439	0	54126	19439	42
5	-19439	-7010	0	19439	7010	-117
6	-42	117	0	42	-117	611

X1(4)= 4,62 Y1(4)= 1,66 NH(P)=0
X1(3)= 0,00 Y1(3)= 0,00 NL(P)=1
row and column numbers are
PrF 7,8,9 and 10,11,12 Cls
EAA(P)= 300 * EII(P) Calc.S5 Again End
OK

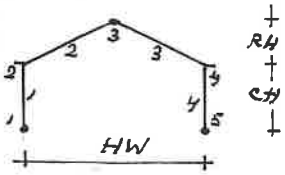


Fig.9a.

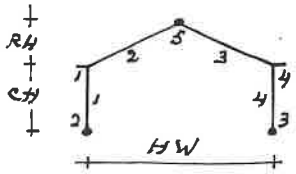


Fig.9b.

3HFRAME1

NL(1)=0 NL(4)=0 NH(2)=0 NL(3)=0
NL(1)=1 NH(4)=1 NH(2)=1 NL(3)=1

3HFRAME2 next page

NH(1)=0 NL(4)=0 NH(2)=0 NH(3)=0
NH(1)=1 NL(4)=1 NH(3)=1 NH(3)=1

One can get the 'real value' of an element of matrix CC, type in TSTRING CC(7,10) Enter, the value appears below the large matrix CC.

CC(7,10)= -0,185593642132483

And for an element of a matrix S5 with S5(P,R,C), R for row and C for column number, 1 to 6.

S5(2,3,2)= 0,134164078649987
printed above the 3 hinge frame.

FRAMEPROGMATRIXCCS5

Fig.9a 3HFRAME1 and 9b SHFRAME2, two given possibilities with member and joint numbering. All members EI and EA=1EI.

Fig.9a, see the frame at the bottom with given member and joint numbering, and member end indications, these member ends are hinges.
NL(1)=1 NH(4)=1 NH(2)=1 NL(3)=1

These values can be changed by clicking on it, except with member end numbers 2 and 4, in this case fig,9a, 1 and 4 in case fig.9b.

See page 7, NH(1)=1 clicked to NH(1)=0 and NH(1)=1 without underlining, a hinge becomes a 'real joint'.

CH=3 m RH=2 m HW=8 m to type in TSTRING 3,2,8 Enter, under TSTRING appear
CH=3 RH=2 HW=8.

Click 3HFRAME1, gets underlined, S5 and CC numbering appears. S5 row and column numbers where they appear, with addition or not, in matrix CC.
Click Calc.S5/CC and Show CC and Show S5 to see the matrix elements appear like shown here below

CC(6,6)= P=1,S5(6,6) +P=2,S5(3,3)=
= 1000 + 671 = 1671

Experimenting with construction matrix CC and member matrices S5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	111	0	0	-111	0	333	.	.	.	.	.	.	.	.	.
2	0	333	0	0	-333	0	.	.	.	.	.	.	.	.	.
3	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
4	-111	0	0	297	-76	-266	-186	76	0	.	.	.	.	.	.
5	0	-333	0	-76	405	134	76	-72	0	.	.	.	.	.	.
6	333	0	0	-266	134	1671	-67	-134	0	.	.	.	.	.	.
7	.	.	.	-186	76	-67	371	0	0	-186	-76	-67	.	.	.
8	.	.	.	76	-72	-134	0	143	0	-76	-72	134	.	.	.
9	.	.	.	0	0	0	0	0	0	0	0	0	.	.	.
10	.	.	.	.	.	.	-186	-76	0	297	76	-266	-111	0	0
11	.	.	.	.	.	.	-76	-72	0	76	405	-134	0	-333	0
12	.	.	.	.	.	.	-67	134	0	-266	-134	1671	333	0	0
13	.	.	.	.	.	.	.	.	.	-111	0	333	111	0	0
14	.	.	.	.	.	.	.	.	.	0	-333	0	0	333	0
15	.	.	.	.	.	.	.	.	.	0	0	0	0	0	0

elements CC(I,J) and S5(I,J) to multiply by EI/1000

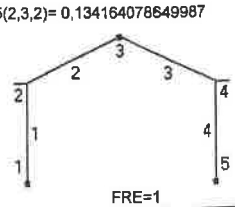
S5(2,3,2)= 0,134164078649987

AGAIN S5(2,3,2) OK EAA(P)= 1 * EII(P

CH=3 RH=2 HW=8 End

Calc.S5/CC Show CC Show S5 3HFRAME1

Clear CC Clear S5 3HFRAME2



FRE=1

	1	2	3	4	5	6
1	111	0	0	-111	0	333
2	0	333	0	0	-333	0
3	0	0	0	0	0	0
4	-111	0	0	111	0	-333
5	0	-333	0	0	333	0
6	333	0	0	-333	0	1000

	4	5	6	7	8	9
4	186	-76	67	-186	76	0
5	-76	72	134	76	-72	0
6	67	134	671	-67	-134	0
7	-186	76	-67	186	-76	0
8	76	-72	-134	-76	72	0
9	0	0	0	0	0	0

	7	8	9	10	11	12
7	186	76	0	-186	-76	-67
8	76	72	0	-76	-72	134
9	0	0	0	0	0	0
10	-186	-76	0	186	76	67
11	-76	-72	0	76	72	-134
12	-67	134	0	67	-134	671

	10	11	12	13	14	15
10	111	0	-333	-111	0	0
11	0	333	0	0	-333	0
12	-333	0	1000	333	0	0
13	-111	0	333	111	0	0
14	0	-333	0	0	333	0
15	0	0	0	0	0	0

NL(1)=0 NH(4)=0 NH(2)=0 NL(3)=0
NL(1)=1 NH(4)=1 NH(2)=1 NL(3)=1

PrF

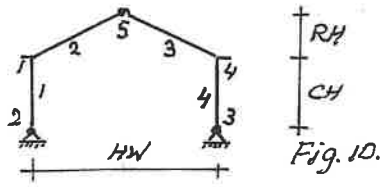


Fig. 10.

CC(R,C)

S5(P,R,C) P is member number.

R is row number, C is column number.

Elements of the member matrices S5 are put in construction matrix CC.

member 1
CC(5,2)= S5(1,5,2)= -333

member 3
CC(12,13)= S5(4,12,13)= -67

member 9
CC(9,9)= S5(4,9,9)= 0

member 1 and member 2
CC(2,3)= S5(1,2,3) + S5(2,2,3)
= 0 + 134 = 134

Umember 3 and 4
CC(10,12)= S5(3,10,12) + S5(4,10,12)
= 67 - 333= -266

Example.

Fig.10 is fig.9b.

Members same numbering as fig.9a 3HFRAME1 with 1-2-3-4 but joint numbering now 2-1-5-4-3.

Click Again, in TSTRING 3,2,8 Enter, next

click 3HFRAM2 gets underlined, 3HFRAME2, the 3hinge frame on the right of it gets new joint numbering.
The member matrices S5 get 'new' row and column numbers.

The member end indications are diiferent from 3HFRAMEB because of different joint numbering.
NH(1)=0 NL(4)=0 NH(2)=0 NH(3)=0
NH(1)=1 NL(4)=1 NH(2)=1 NH(3)=1

To type in TSTRING 3,2,8 Enter,
Next Calc.S5CC, ShowCC and Show S5 to get the print here below.

Matrix CC looks different comparing with that of the preceding page.
The elements of member 2 are not placed as a 6 x 6 matrix but divided into four quarters.

Coinciding values are added like
CC(14,14)= S5(2,14,14) +S5(3,14,14)
= 72 + 72 = 144 (143)

Experimenting with construction matrix CC and member matrices S5.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	297	-76	-266	-111	0	0	.	.	.	.	.	.	-186	76	0
2	-76	405	134	0	-333	0	.	.	.	.	.	.	76	-72	0
3	-266	134	1671	333	0	0	.	.	.	.	.	.	-67	-134	0
4	-111	0	333	111	0	0	.	.	.	.	.	.	.	.	.
5	0	-333	0	0	333	0	.	.	.	.	.	.	.	.	.
6	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	111	0	0	-111	0	333	.	.	.
8	.	.	.	.	.	.	0	333	0	0	-333	0	.	.	.
9	.	.	.	.	.	.	0	0	0	0	0	0	.	.	.
10	.	.	.	.	.	.	-111	0	0	297	76	-266	-186	-76	0
11	.	.	.	.	.	.	0	-333	0	76	405	-134	-76	-72	0
12	.	.	.	.	.	.	333	0	0	-266	-134	1671	-67	134	0
13	-186	76	-67	.	.	.	.	.	.	-186	-76	-67	371	0	0
14	76	-72	-134	.	.	.	.	.	.	-76	-72	134	0	143	0
15	0	0	0	.	.	.	.	.	.	0	0	0	0	0	0

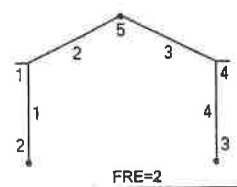
elements CC(I,J) and S5(I,J) to multiply by EI/1000

AGAIN 3,2,8 OK EAA(P)= 1 * EII(P

CH=3 RH=2 HW= End

Calc.S5/CC Show CC Show S5 3HFRAME1

Clear CC Clear S6 3HFRAME2



FRE=2

	1	2	3	4	5	6
1	111	0	-333	-111	0	0
2	0	333	0	0	-333	0
3	-333	0	1000	333	0	0
4	-111	0	333	111	0	0
5	0	-333	0	0	333	0
6	0	0	0	0	0	0

P=2

	1	2	3	13	14	15
1	186	-76	67	-186	76	0
2	-76	72	134	76	-72	0
3	67	134	671	-67	-134	0
13	-186	76	-67	186	-76	0
14	76	-72	-134	-76	72	0
15	0	0	0	0	0	0

P=3

	10	11	12	13	14	15
10	186	76	67	-186	-76	0
11	76	72	-134	-76	-72	0
12	67	-134	671	-67	134	0
13	-186	-76	-67	186	76	0
14	-76	-72	134	76	72	0
15	0	0	0	0	0	0

	7	8	9	10	11	12
7	111	0	0	-111	0	333
8	0	333	0	0	-333	0
9	0	0	0	0	0	0
10	-111	0	0	111	0	-333
11	0	-333	0	0	333	0
12	333	0	0	-333	0	1000

NH(1)=0 NL(4)=0 NH(2)=0 NH(3)=0
NH(1)=1 NL(4)=1 NH(2)=1 NH(3)=1

PrF

Experimenting with construction matrix CC and member matrices S5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	444	0	667	-444	0	667	.	.	.	.	.	.	.	.	.
2	0	333	0	0	-333	0	.	.	.	.	.	.	.	.	.
3	667	0	1333	-667	0	667	.	.	.	.	.	.	.	.	.
4	-444	0	-667	630	-76	-600	-186	76	0	.	.	.	.	.	.
5	0	-333	0	-76	405	134	76	-72	0	.	.	.	.	.	.
6	667	0	667	-600	134	2004	-67	-134	0	.	.	.	.	.	.
7	.	.	.	-186	76	-67	371	0	0	-186	-76	-67	.	.	.
8	.	.	.	76	-72	-134	0	143	0	-76	-72	134	.	.	.
9	.	.	.	0	0	0	0	0	0	0	0	0	.	.	.
10	.	.	.	.	.	.	-186	-76	0	630	76	-600	-444	0	-667
11	.	.	.	.	.	.	-76	-72	0	76	405	-134	0	-333	0
12	.	.	.	.	.	.	-67	134	0	-600	-134	2004	667	0	667
13	.	.	.	.	.	.	.	.	.	-444	0	667	444	0	667
14	.	.	.	.	.	.	.	.	.	0	-333	0	0	333	0
15	.	.	.	.	.	.	.	.	.	-667	0	667	667	0	1333

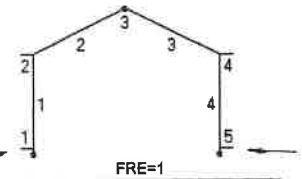
elements CC(I,J) and S5(I,J) to multiply by EI/1000

AGAIN [3,2,8] OK EAA(P)= 1 * EII(P

CH=3 RH=2 HW= End

Calc.S5/CC Show CC Show S5 3HFRAME1

Clear CC Clear S5 3HFRAME2



	1	2	3	4	5	6
1	444	0	667	-444	0	667
2	0	333	0	0	-333	0
3	667	0	1333	-667	0	667
4	-444	0	-667	444	0	-667
5	0	-333	0	0	333	0
6	667	0	667	-667	0	1333

	4	5	6	7	8	9
4	186	-76	67	-186	76	0
5	-76	72	134	76	-72	0
6	67	134	671	-67	-134	0
7	-186	76	-67	186	-76	0
8	76	-72	-134	-76	72	0
9	0	0	0	0	0	0

	7	8	9	10	11	12
7	186	76	0	-186	-76	-67
8	76	72	0	-76	-72	134
9	0	0	0	0	0	0
10	-186	-76	0	186	76	67
11	-76	-72	0	76	72	-134
12	-67	134	0	67	-134	671

	10	11	12	13	14	15
10	444	0	-667	-444	0	-667
11	0	333	0	0	-333	0
12	-667	0	1333	667	0	667
13	-444	0	667	444	0	667
14	0	-333	0	0	333	0
15	-667	0	667	667	0	1333

NL(1)=0 NH(4)=0 NH(2)=0 NL(3)=0

NL(1)=1 NH(4)=1 NH(2)=1 NL(3)=1

to click on PrF

Experimenting with construction matrix CC and member matrices S5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	630	-76	-600	-444	0	-667	.	.	.	.	.	.	-186	76	0
2	-76	405	134	0	-333	0	.	.	.	.	.	.	76	-72	0
3	-600	134	2004	667	0	667	.	.	.	.	.	.	-67	-134	0
4	-444	0	667	444	0	667	.	.	.	.	.	.	.	.	.
5	0	-333	0	0	333	0	.	.	.	.	.	.	.	.	.
6	-667	0	667	667	0	1333	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	444	0	667	-444	0	667	.	.	.
8	.	.	.	.	.	.	0	333	0	0	-333	0	.	.	.
9	.	.	.	.	.	.	667	0	1333	-667	0	667	.	.	.
10	.	.	.	.	.	.	-444	0	-667	630	76	-600	-186	-76	0
11	.	.	.	.	.	.	0	-333	0	76	405	-134	-76	-72	0
12	.	.	.	.	.	.	667	0	667	-600	-134	2004	-67	134	0
13	-186	76	-67	.	.	.	.	.	.	-186	-76	-67	371	0	0
14	76	-72	-134	.	.	.	.	.	.	-76	-72	134	0	143	0
15	0	0	0	.	.	.	.	.	.	0	0	0	0	0	0

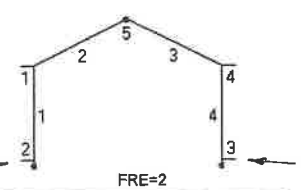
elements CC(I,J) and S5(I,J) to multiply by EI/1000

AGAIN [3,2,8] OK EAA(P)= 1 * EII(P

CH=3 RH=2 HW= End

Calc.S5/CC Show CC Show S5 3HFRAME1

Clear CC Clear S5 3HFRAME2



	1	2	3	4	5	6
1	444	0	-667	-444	0	-667
2	0	333	0	0	-333	0
3	-667	0	1333	667	0	667
4	-444	0	667	444	0	667
5	0	-333	0	0	333	0
6	-667	0	667	667	0	1333

	1	2	3	13	14	15
1	186	-76	67	-186	76	0
2	-76	72	134	76	-72	0
3	67	134	671	-67	-134	0
13	-186	76	-67	186	-76	0
14	76	-72	-134	-76	72	0
15	0	0	0	0	0	0

	10	11	12	13	14	15
10	186	76	67	-186	-76	0
11	76	72	-134	-76	-72	0
12	67	-134	671	-67	134	0
13	-186	-76	-67	186	76	0
14	-76	-72	134	76	72	0
15	0	0	0	0	0	0

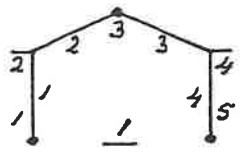
	7	8	9	10	11	12
7	444	0	667	-444	0	667
8	0	333	0	0	-333	0
9	667	0	1333	-667	0	667
10	-444	0	-667	444	0	-667
11	0	-333	0	0	333	0
12	667	0	667	-667	0	1333

NH(1)=0 NL(4)=0 NH(2)=0 NH(3)=0

NH(1)=1 NL(4)=1 NH(2)=1 NH(3)=1

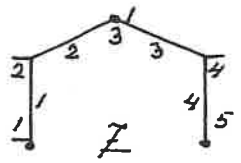
PrF

NH(1)=0, NL(2)=0, NH(3)=0, ML(4)=0, for all twelve cases here below.



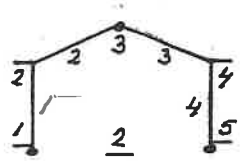
NL(1)=1 NH(2)=1

NL(3)=1 NH(4)=1



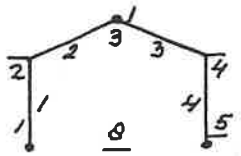
NL(1)=0 NH(2)=1

NL(3)=0 NH(4)=1



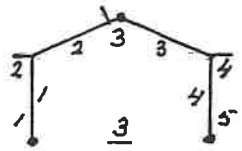
NL(1)=0 NH(2)=1

NL(3)=1 NH(4)=0



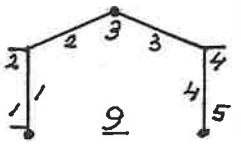
NL(1)=1 NH(2)=1

NL(3)=0 NH(4)=0



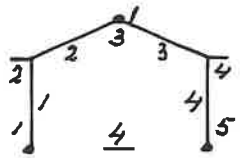
NL(1)=1 NH(2)=0

NL(3)=1 NH(4)=1



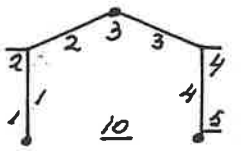
NL(1)=0 NH(2)=1

NL(3)=1 NH(4)=1



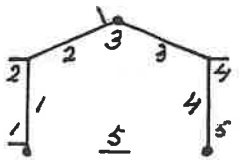
NL(1)=1 NH(2)=1

NL(3)=0 NH(4)=1



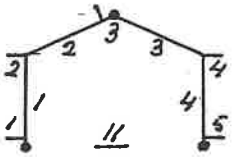
NL(1)=1 NH(2)=1

NL(3)=1 NH(4)=0



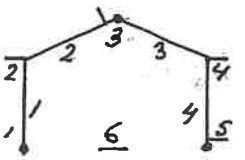
NL(1)=0 NH(2)=0

NL(3)=1 NH(4)=1



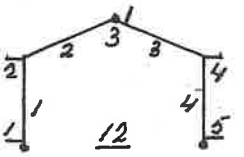
NL(1)=0 NH(2)=0

NL(3)=1 NH(4)=0



NL(1)=1 NH(2)=0

NL(3)=1 NH(4)=0



NL(1)=0 NH(2)=1

NL(3)=0 NH(4)=0

The 3HFRAME with twelve different member end indications NL(P) and NH(P).

1) NL(1)=1 NH(4)=1 NH(2)=1 NL(3)=1
One or more of these indications are changed for the next eleven cases,

This case has 8 unknowns to be calculated,
UH(2) UV(2) UR(2) of joint 2,
UH(3) UV(3) of 'joint 3'
UH(4) UV(4) UR(4) of joint 4. 8 eq.
The slopes/member end rotations in case of a hinge are separately calculated, here HE(1,2), HE(3,2), HE(3,4) and HE(5,4).

2) UH(2) UV(2) UR(2) UR(1)
UH(3) UV(3)
UH(4) UV(4) UR(4) UR(5) 10 eq.
HE(3,2) and HE(3,4)

3) UH(2) UV(2) UR(2)
UH(3) UV(3) UR(3)
UH(4) UV(4) UR(4) 9 eq.
HE(1,2) HE(3,4) HE(5,4)

4) UH(2) UV(2) UR(2)
UH(3) UV(3) UR(3)
UH(4) UV(4) UR(4) 9 eq.
HE(1,2) HE(3,2) HE(5,4)

5) UH(2) UV(2) UR(2)
UH(3) UV(3) UR(3)
UH(4) UV(4) UR(4) 10 eq.
HE(3,4) HE(5,4)

6) UH(2) UV(2) UR(2)
UH(3) UV(3) UR(3)
UH(4) UV(4) UR(4) UR(5) 10 eq.
HE(1,2 HE(3,4)

7) UH(2) UV(2) UR(2) UR(1)
UH(3) UV(3) UR(3)
UH(4) UV(4) UR(4) 10 eq.
HE(3,2) HE(5,4)

8) UH(2) UV(2) UR(2)
UH(3) UV(3) UR(3)
UH(4) UV(4) UR(4) UR(5) 10 eq.
HE(1,2) HE(3,2)

9) UH(2) UV(2) UR(2) UR(1)
UH(3) UV(3)
UH(4) UV(4) UR(4) 9 eq.
HE(3,2) HE(3,4) HE(5,4)

10) 9 eq. 11) 11 eq. 12) 11 eq.

Etc.

Member numbers 1 2 3 4 can be numbered in arbitrarily order, that gives for each of the 12 1*2*3*4= 24 possible orders of numbering.
Jont numbers 1 2 3 4 5 can be numbered in arbitrarily order, that gives for each of the twelve 1*2*3*4*5= 120 possible orders of numbering.
The total possible orders of numbering is 12 * 24 * 120= 34560! All cases will give same final results of the calculation.

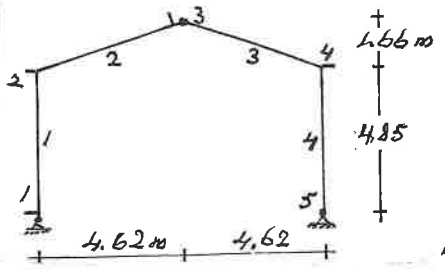


Fig.11.

R='EA/L1'= 300EI/4.85= 61,9

D1=X1(H)-X1(L)= 0-0= 0
D2=Y1(H)-Y1(L)= 0-4,85= -4.85

C=D1/L1= 0/4,85= 0
S=D2/L1= -4,85/4,85= -1

A= 12EI/L1^3
B= 6EI/L1^2
D= 4EI/L1
E= 2EI/L1

A4= R*S^2 +A*C^2

A= 12EI/4,85^3= 0,105

A4= [61,9*(-1)^2 +0,105*(0)^2]EI
= (61,9 +0)EI= 61,9EI

CC(2,2)*EI/1000= S5(1,2,2)*EI/1000=
61856EI/1000= 61,9EI

Example.

Fig.11.

Members and joints are numbered as 3HFRAME1.
First input in TSTRING,
4.85,1.66,9.24 Enter.

Click 3HFRAME1 to 3HFRAME1.

With EAA(P)= 1 *EII(P), click 1 to 300.

Click NL(1)=0 to NL(1)=0, member end 1 of member 1 is assumed to be a 'real joint', see the little stripe.
NL(1)=1 lost the underlining.

Click NH(2)=0 to NH(2)=0, member end 3 of member 2 is assumed to be a 'real joint', see the little stripe.
NH(2)=1 lost the underlining.

Click Calc.S5/CC, Show CC and Show S5 to get the results shown here nelow.
Ah, some crazylarge numbers...

CC(8,7)= 24
CC(8,7)= S5(2,8,7(+ S5(3,8,7)
= S5(2,5,4) + S5(3,2,1)
CC(8,7)= -19414 + 19439 = 25 is 24 ok
All to be multiplied by EI/1000.

Experimenting with construction matrix CC and member matrices S5.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	105	0	255	-105	0	255	-	-	-	-	-	-	-	-	-
2	0	61856	0	0	-61856	0	-	-	-	-	-	-	-	-	-
3	255	0	825	-255	0	412	-	-	-	-	-	-	-	-	-
4	-105	0	-255	54240	-19414	-171	-54134	19414	84	-	-	-	-	-	-
5	0	-61856	0	-19414	68933	234	19414	-7077	234	-	-	-	-	-	-
6	255	0	412	-171	234	1640	-84	-234	407	-	-	-	-	-	-
7	-	-	-	-54134	19414	-84	108260	24	-84	-54126	-19439	-42	-	-	-
8	-	-	-	19414	-7077	-234	24	14087	-234	-19439	-7010	117	-	-	-
9	-	-	-	84	234	407	-84	-234	815	0	0	0	-	-	-
10	-	-	-	-	-	-	-54126	-19439	0	54152	19439	-85	-26	0	0
11	-	-	-	-	-	-	-19439	-7010	0	19439	68865	-117	0	-61856	0
12	-	-	-	-	-	-	-42	117	0	-85	-117	1230	128	0	0
13	-	-	-	-	-	-	-	-	-	-26	0	128	26	0	0
14	-	-	-	-	-	-	-	-	-	0	-61856	0	0	61856	0
15	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0

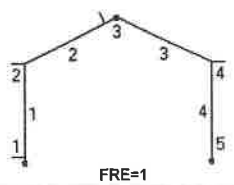
elements CC(I,J) and S5(I,J) to multiply by EI/1000

AGAIN 4.85,1.66,9.24 OK EAA(P)= 300 * EII(P

CH=4,85 RH=1,66 HW=9,24 End

Calc.S5/CC Show CC Show S5 3HFRAME1

Clear CC Clear S5 3HFRAME2



FRE=1

	1	2	3	4	5	6
1	105	0	255	-105	0	255
2	0	61856	0	0	-61856	0
3	255	0	825	-255	0	412
4	-105	0	-255	105	0	-255
5	0	-61856	0	0	61856	0
6	255	0	412	-255	0	825

	4	5	6	7	8	9
4	54134	-19414	-84	-54134	19414	84
5	-19414	7077	234	19414	-7077	234
6	-84	234	815	-84	-234	407
7	-54134	19414	-84	54134	-19414	-84
8	19414	-7077	-234	-19414	7077	-234
9	84	234	407	-84	-234	815

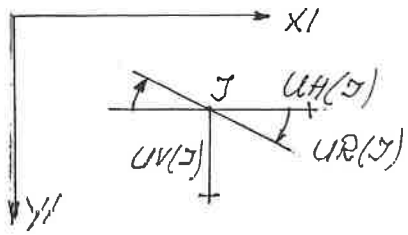
	7	8	9	10	11	12
7	54126	19439	0	-54126	-19439	-42
8	19439	7010	0	-19439	-7010	117
9	0	0	0	0	0	0
10	-54126	-19439	0	54126	19439	42
11	-19439	-7010	0	19439	7010	-117
12	-42	117	0	42	-117	611

	10	11	12	13	14	15
10	26	0	-128	-26	0	0
11	0	61856	0	0	-61856	0
12	-128	0	619	128	0	0
13	-26	0	128	26	0	0
14	0	-61856	0	0	61856	0
15	0	0	0	0	0	0

NL(1)=0 NH(4)=0 NH(2)=0 NL(3)=0

NL(1)=1 NH(4)=1 NH(2)=1 NL(3)=1

PrF

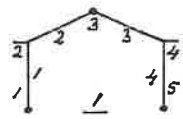


Possible ways of data input for the 3HFRAME.

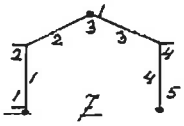
For 'real joints' calculation of

a) joint rotation UR(I),
b) horizontal joint displacement UH(I) and
c) vertical joint displacement UV(I).

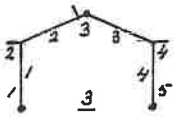
(Slope deflection HE(,) if member end is a hinge.)



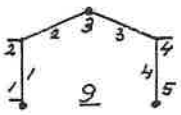
NL(1)=1 NH(2)=1
NL(3)=1 NH(4)=1



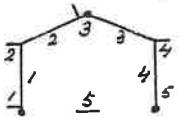
NL(1)=0 NH(2)=1
NL(3)=0 NH(4)=1



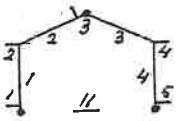
NL(1)=1 NH(2)=0
NL(3)=1 NH(4)=1



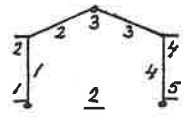
NL(1)=0 NH(2)=1
NL(3)=1 NH(4)=1



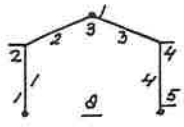
NL(1)=0 NH(2)=0
NL(3)=1 NH(4)=1



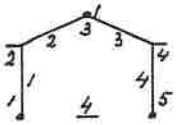
NL(1)=0 NH(2)=0
NL(3)=1 NH(4)=0



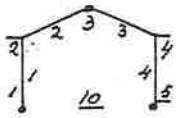
NL(1)=0 NH(2)=1
NL(3)=1 NH(4)=0



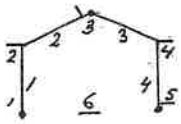
NL(1)=1 NH(2)=1
NL(3)=0 NH(4)=0



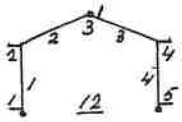
NL(1)=1 NH(2)=1
NL(3)=0 NH(4)=1



NL(1)=1 NH(2)=1
NL(3)=1 NH(4)=0



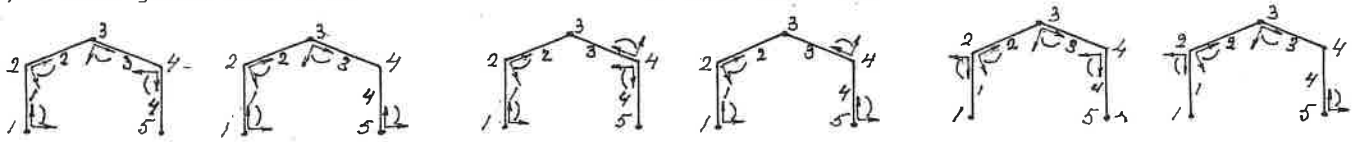
NL(1)=1 NH(2)=0
NL(3)=1 NH(4)=0

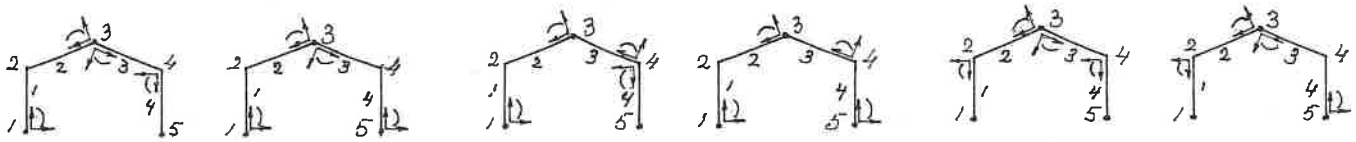


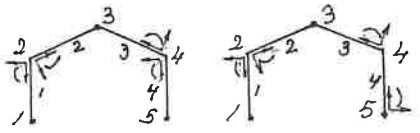
NL(1)=0 NH(2)=1
NL(3)=0 NH(4)=0

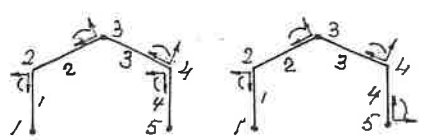
These twelve possibilities give all the same final results. They can be arbitrarily applied, just put in the correct data. Member end a hinge then a 1, a real joint then a 0.

A member end may be a hinge, in that case one may consider it as a hinge, or a real joint which is indicated in the figures with a short little stripe. At the top can be a real joint at left end 3 fig. 3 or right end 3 fig. 4.









But there are more possibilities. For each member the beam axis system ↻ can be assumed at one of both member ends. With 4 members there are 4^2=16 possibilities for each of the twelve hinge frames just discussed.
So together 12*16=192 possible ways of data input... with same final results!

But joint numberig is for all 192 cases the same. The order of joint numbering can be arbitrarily done. With 5 joints then 5*4*3*2*1=120 possible number orders for each of the 192, so 120*192=23040 possibilities.

But member numbering for all these cases the same, can be also arbitrarily done, 4mebers makes 4*3*2*1=24 possibilities for each case so far, thus all together 24*23040=552960, more than half a million possible ways of data input to get the same results with the same program!

4*3*2*1=24 member number orders

11	11	11	22	22	22	33	33	33	44	44	44
22	33	44	11	33	44	11	22	44	11	22	33
34	24	23	34	14	13	24	14	12	23	13	12
43	42	32	43	41	31	42	41	21	32	31	21