CalculiX Simulation

For

Spring Problem

Version 1.0

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Revision history

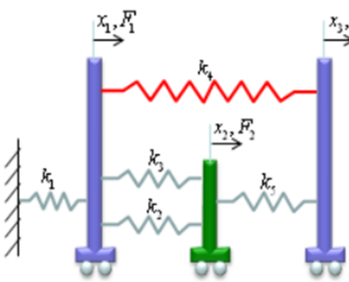
Version Number	Comments
1.0	Original Publication

1. Project Description

The project deals with the static simulation of a spring system. The purpose of the simulation is to calculate the deflections x_1, x_2, x_3 due to the application of forces F_1, F_2, F_3. The deflections are calculated both using FE and hand calculation.

2. Hand Calculation

The system consists of five springs. The loads can be applied at three different locations. The spreadsheet calculates the deflection at the these three points under the applied loads.



Spring stiffness

$k_1 := 10 \frac{N}{mm}$ $\quad k_2 := 20 \frac{N}{mm}$ $\quad k_3 := 30 \frac{N}{mm}$ $\quad k_4 := 40 \frac{N}{mm}$ $\quad k_5 := 50 \frac{N}{mm}$

Loads applied

$F_1 := 5.25\ N$ $\quad F_2 := 6.32\ N$ $\quad F_3 := -1.25\ N$

The global stiffness matrix is computed as follows

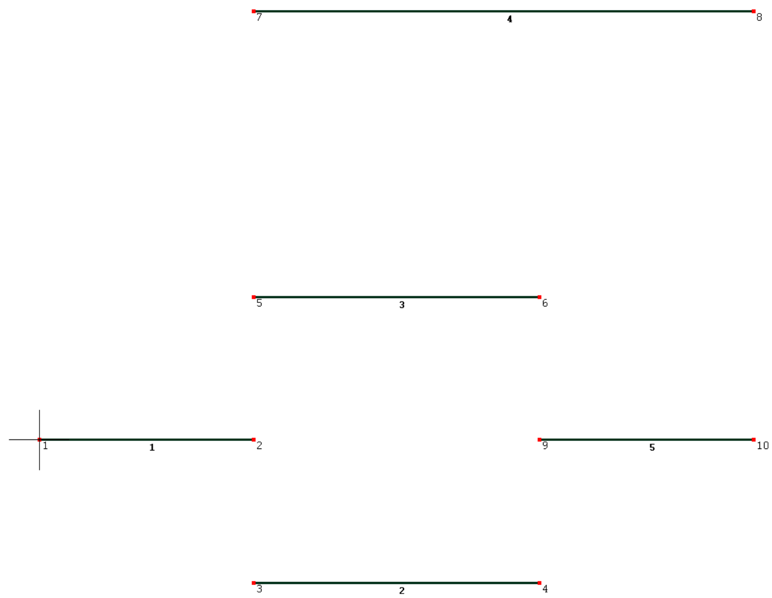
$$K_{global} := \begin{bmatrix} k_1 + k_2 + k_3 + k_4 & -k_2 - k_3 & -k_4 \\ -k_2 - k_3 & k_2 + k_3 + k_5 & -k_5 \\ -k_4 & -k_5 & k_4 + k_5 \end{bmatrix} = \begin{bmatrix} 1 \cdot 10^5 \frac{kg}{s^2} & -50000 \frac{kg}{s^2} & -40000 \frac{kg}{s^2} \\ -50000 \frac{kg}{s^2} & 1 \cdot 10^5 \frac{kg}{s^2} & -50000 \frac{kg}{s^2} \\ -40000 \frac{kg}{s^2} & -50000 \frac{kg}{s^2} & 90000 \frac{kg}{s^2} \end{bmatrix}$$

The deflection at the three points calculated as follows

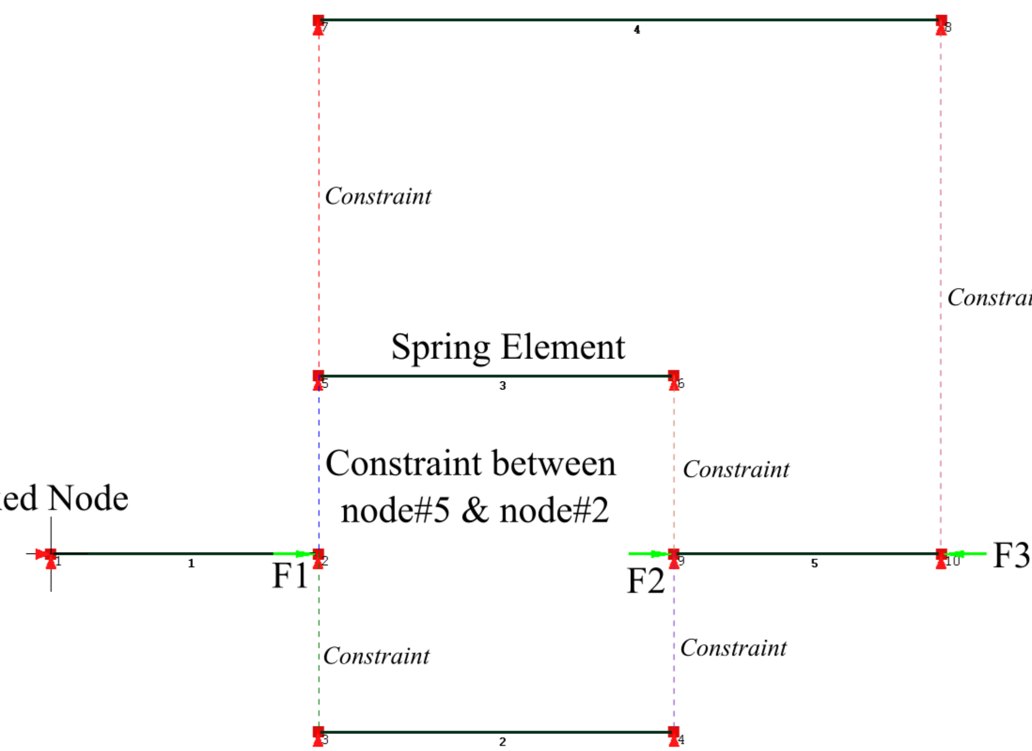
$$\begin{bmatrix} x_2 \\ x_9 \\ x_{10} \end{bmatrix} := \text{invert}\left(K_{global}\right) \cdot \begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = \begin{bmatrix} 1.032 \\ 1.1099 \\ 1.0614 \end{bmatrix} mm$$

3. Finite Element Model

The actual finite element model looks like the picture below.

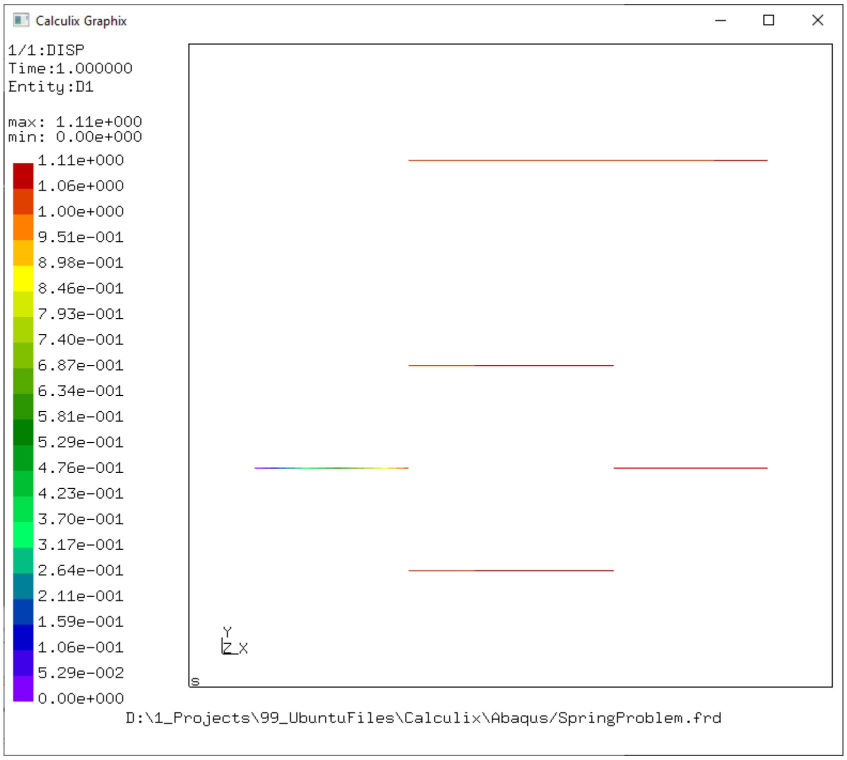


For the purposes of explanation, the changed and annotated image is shown below



4. Results

The following plot shows the calculix results.



The results from the dat file are as follows

```
displacements (vx,vy,vz) for set NODESINTEREST and time
0.1000000E+01

        2  1.032000E+00  0.000000E+00  0.000000E+00
        9  1.109892E+00  0.000000E+00  0.000000E+00
       10  1.061385E+00  0.000000E+00  0.000000E+00
```

5. Conclusion

The deflection from hand calculation matches the FE results as shown below

Node Number	FE - Deflection	Hand Calculation
2	1.0320	1.0320
9	1.1098	1.1099
10	1.0614	1.0614

6. Input file

```
**NODE DEFINITIONS
**-----------------
*NODE, NSET=NALL
1, 0.0,  0.0, 0.0
2, 3.0,  0.0, 0.0
3, 3.0, -2.0, 0.0
4, 7.0, -2.0, 0.0
5, 3.0,  2.0, 0.0
6, 7.0,  2.0, 0.0
7, 3.0,  6.0, 0.0
8, 10.0, 6.0, 0.0
9, 7.0,  0.0, 0.0
10,10.0, 0.0, 0.0
**ELEMENT DEFINITIONS
**--------------------
*ELEMENT, TYPE=SPRINGA, ELSET=EALL
1, 1, 2
2, 3, 4
3, 5, 6
4, 7, 8
5, 9, 10
**NODE SET DEFINITIONS
**---------------------
*NSET, NSET=F1
2
*NSET, NSET=F2
9
*NSET, NSET=F3
10
*NSET, NSET=NODESINTEREST
2,9,10
**ELEMENT SET DEFINITIONS
**------------------------
*ELSET, ELSET=SPRING1
1
*ELSET, ELSET=SPRING2
2
*ELSET, ELSET=SPRING3
3
*ELSET, ELSET=SPRING4
4
*ELSET, ELSET=SPRING5
5
**MATERIAL DEFINITIONS
* --------------------
*SPRING, ELSET=SPRING1
10.0
*SPRING, ELSET=SPRING2
```

```
20.0
*SPRING, ELSET=SPRING3
30.0
*SPRING, ELSET=SPRING4
40.0
*SPRING, ELSET=SPRING5
50.0
**CONSTRAINTS
**-----------
*EQUATION
2
3,1,1.0,2,1,-1.0
*EQUATION
2
5,1,1.0,2,1,-1.0
*EQUATION
2
7,1,1.0,2,1,-1.0
*EQUATION
2
6,1,1.0,9,1,-1.0
*EQUATION
2
4,1,1.0,9,1,-1.0
*EQUATION
2
8,1,1.0,10,1,-1.0
**BOUNDARY CONDITIONS
**-------------------
*BOUNDARY
1,1,1
NALL,2,3
**STEP DEFINITION
**---------------
*STEP
*STATIC
**LOAD
**----
*CLOAD
F1,1,5.25
F2,1,6.32
F3,1,-1.25
**OUTPUT REQUESTS
**---------------
*NODE FILE,GLOBAL=YES
U,RF
*EL FILE
S
*NODE PRINT, NSET=NODESINTEREST
U
*END STEP
```