Analysis of a frame using python

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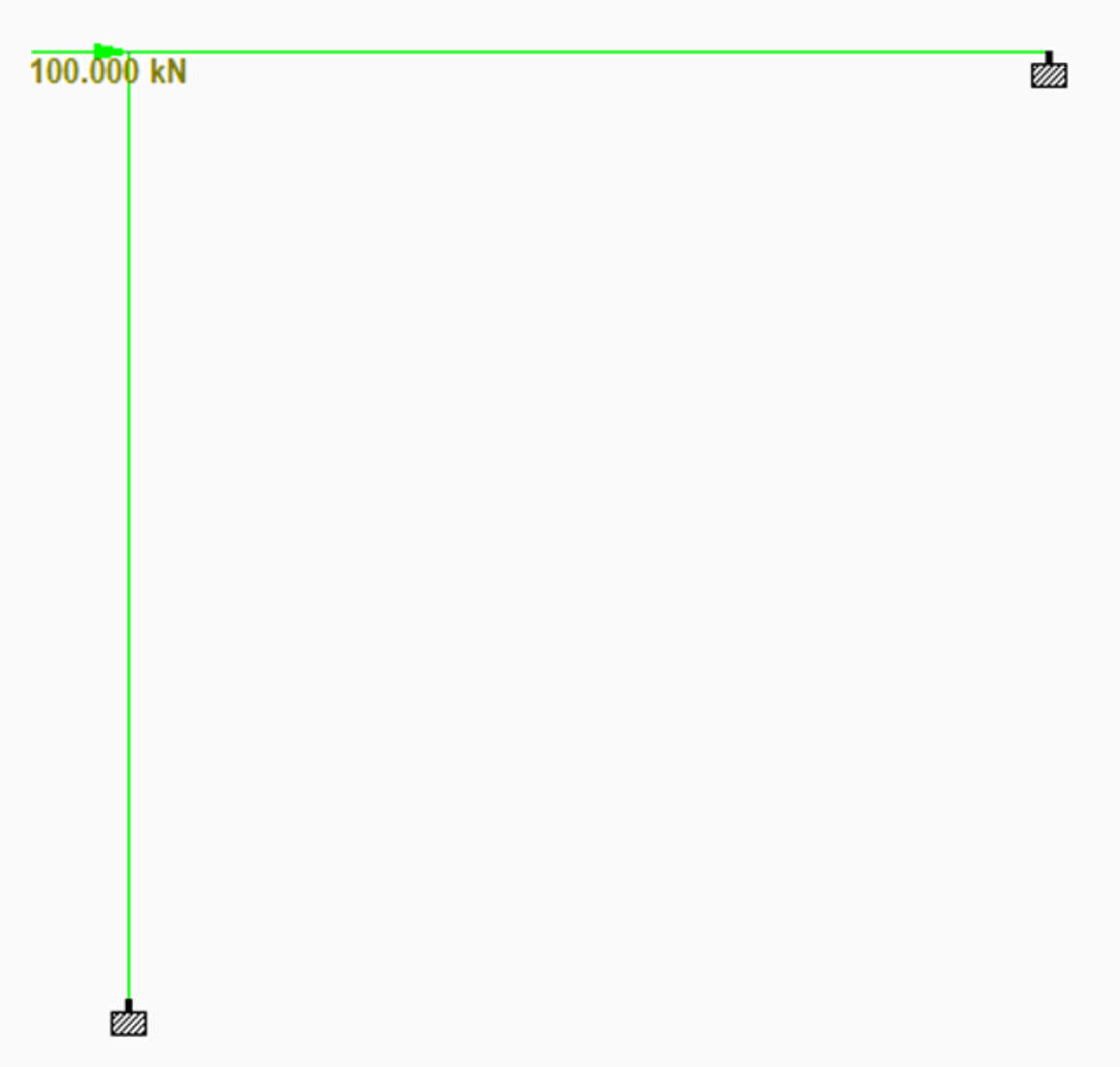
Aim:

Analysis of a frame

Objective:

To develop a generic Python/MATLAB code that takes geometry and loading details as input and performs elastic structural analysis using the direct stiffness method.



Methodology:

Details about the structure :

- [ ] Cross section-200 mm x 200 mm
- [ ] $E = 200000\ MPa$
- [ ] Degree of Indeterminacy = 3
- [ ] Indeterminate Structure

Inputs:

Serial No.	X	Y	Fx	Fy	Mz	u_x	v_y	theta_z
1	0	0	0	0	0	0	0	
2	0	5	100000	0	0	1	1	1
3	5	5	0	0	0	0	0	

Code Link: Frame_Analysis.ipynb

Procedure:

Code:

- DataAcquisition and Preprocessing: The data is imported from an Excel file named "input2.xlsx", which contains two sheets "Member" and "Node" containing data of members and node respectively
- Initialization: set matrices to zero
- For every member, distributed loads and point loads are computed, as well as the matching bending moments and shear forces.
- Basedonthe member attributes, transformation matrices and local stiffness matrices are created and calculated.
- At themember ends, shear forces and moments resulting from distributed and point loads are calculated.
- The stiffness matrices of the various components are transformed and added together to create the global stiffness matrix.

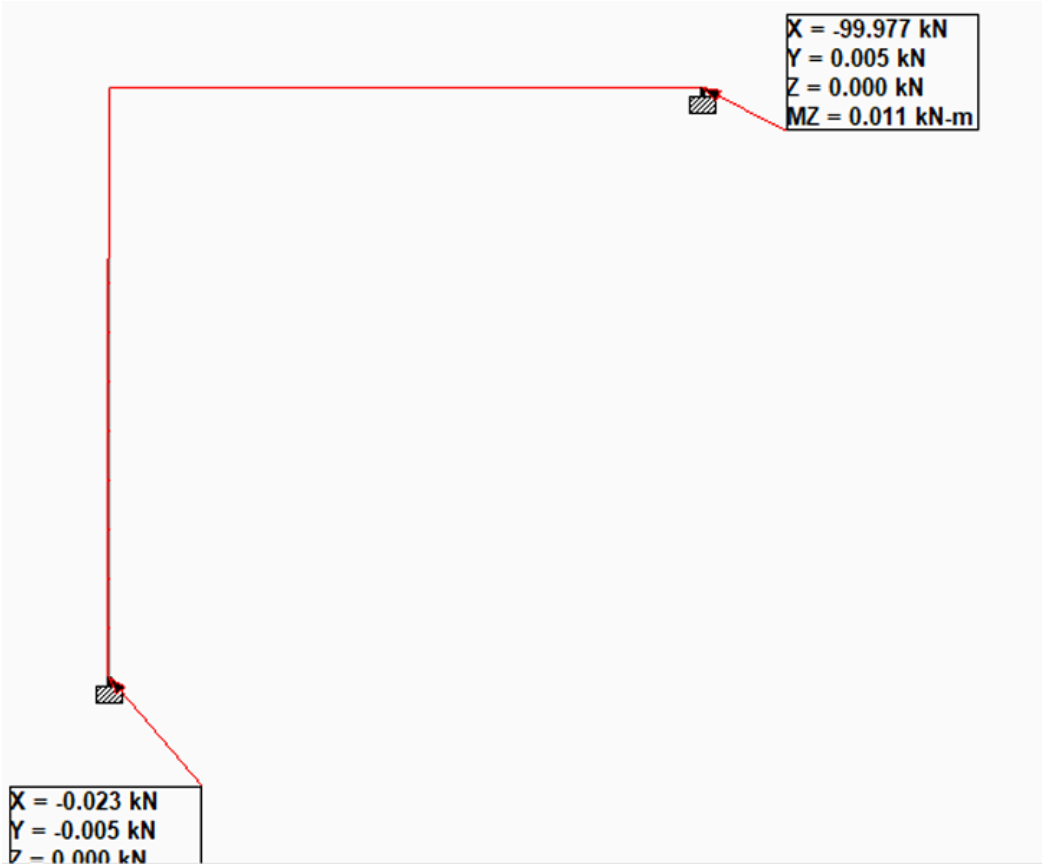
- Matrix inversion and displacement compatibility are used to solve unknown displacements at limited nodes.
- Reactions and internal forces are calculated using the solved displacements and global stiffness matrix.

STAAD Pro Version:

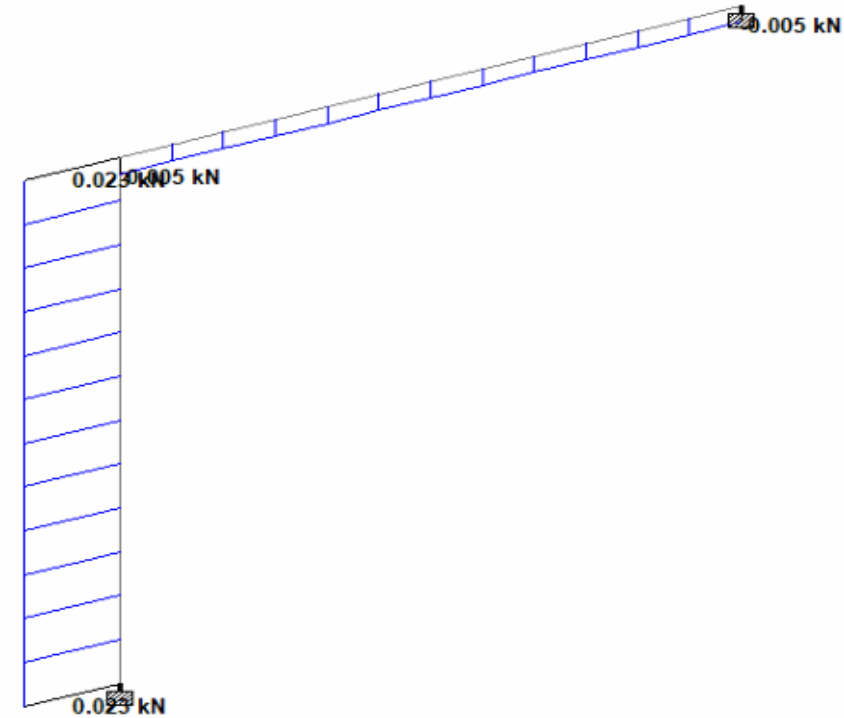
- *Step 1: Go to nodes in the right, Assign Nodes Position*
- *Step 2: Go to add beam, Click from one node to other node.*
- *Step 3: Go to "Properties" - click on Define in the right hand side → Rectangle → Yd = 0.2 m and Zd = 0.2m → Select property - assign to view - assign - click on beam*
- *Step 4: Go to "materials" → Create → Give Title: "CUSTOM", E = 2 x 10^8 KN/m^2 →*
  Ok → Select "Custom" → assign to view - assign - click on beam.
- *Step 5: Go to Support → Create - Fixed - Add*
  - *Press Shift + K - Nodes are visible*
  - *Select support 1 - Use cursor to assign - click assign-touch on node 1,3*
- *Step 6: Go to loading - Load case details - Add - Live Load - Add - Close - Select the Live Load - Add - Member Load*
  Select Load case 1 - Add → Go to concentrated force → 100KN, Direction GX, d1 = 0
  Select concentrated load - Select cursor to assign - assign
- *Step 7: Go to Analysis → Click on Analysis command → click onPerform Analysis → Click on No print → Add → Close, then Post Analysis commands → Define commands*
- *Step 8: Analysis results → Add → Close → Run Analysis → Save. An Output window will be popped → click on View output file → select Done.*
  Close the new window → select the Post processing option → Select 1 live load → Ok

Verification:

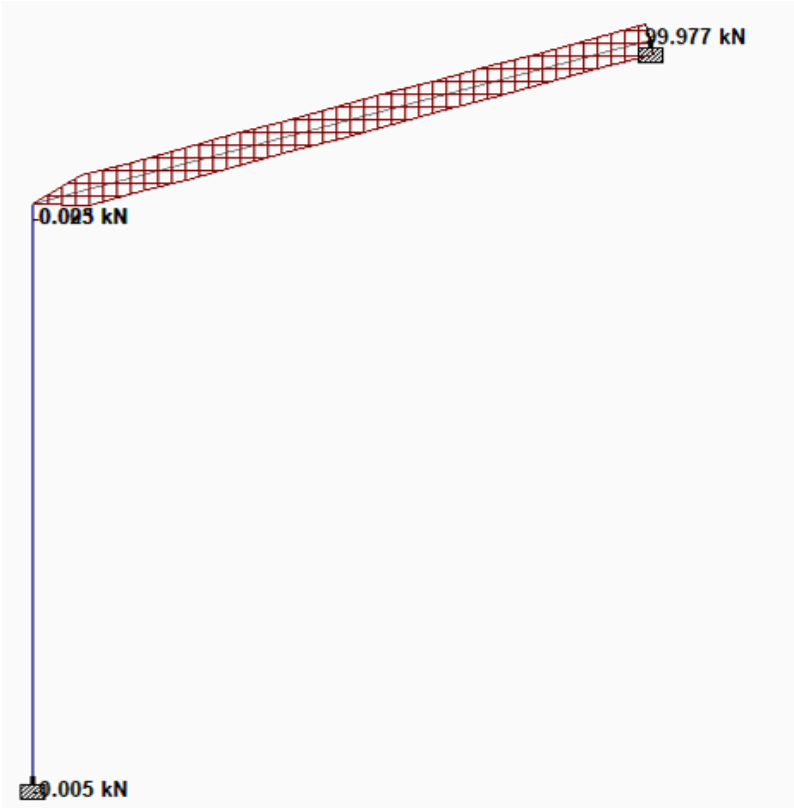
Reactions Diagram:



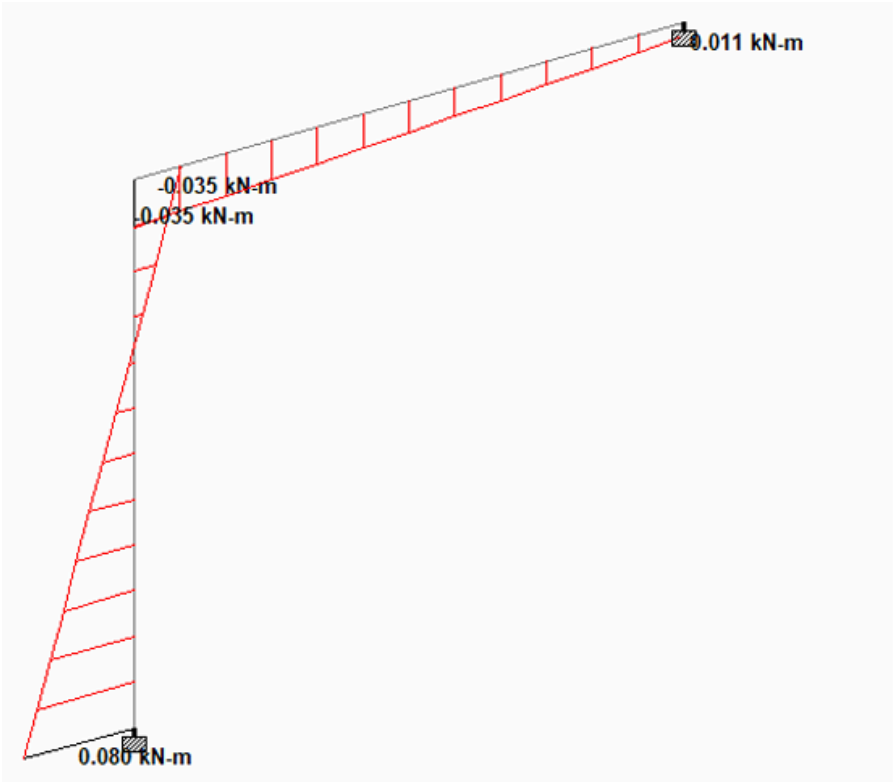
Shear Force Diagram:



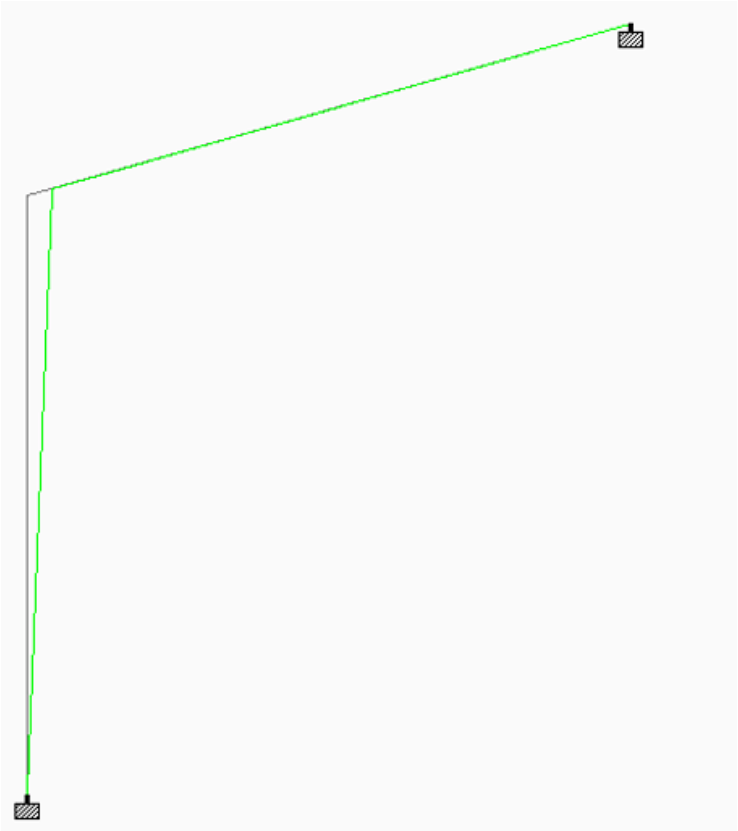
Axial Force Diagram:



Bending Moment Diagram:



Deflection:



Force Vector from Code:

```
[88] force=F_fg_final+np.matmul(K_final_global,displacement)
     print(force)
```

```
                  0
0 -9.986421e+01
1 -5.988020e+01
2  2.996405e+02
3  1.000000e+05
4  7.105427e-15
5  7.738254e-14
6 -9.990014e+04
7  5.988020e+01
8 -9.972050e+01
```

Force from Nodes:

Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
1	1 LIVE LOAD	1	-0.005	0.023	0.000	0.000	0.000	0.080
		2	0.005	-0.023	0.000	0.000	0.000	0.035
2	1 LIVE LOAD	2	-0.023	-0.005	0.000	0.000	0.000	-0.035
		3	-99.977	0.005	0.000	0.000	0.000	0.011

Reactions:

		Horizontal	Vertical	Horizontal	Moment		
Node	L/C	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
1	1 LIVE LOAD	-0.023	-0.005	0.000	0.000	0.000	0.080
3	1 LIVE LOAD	-99.977	0.005	0.000	0.000	0.000	0.011

Displacement:

```
displacement

array([[ 0.00000000e+00],
       [ 0.00000000e+00],
       [ 0.00000000e+00],
       [ 6.24375849e-05],
       [ 3.74251258e-08],
       [-9.37125150e-06],
       [ 0.00000000e+00],
       [ 0.00000000e+00],
       [ 0.00000000e+00]])
```

Result:

The staad pro and code calculation matches.