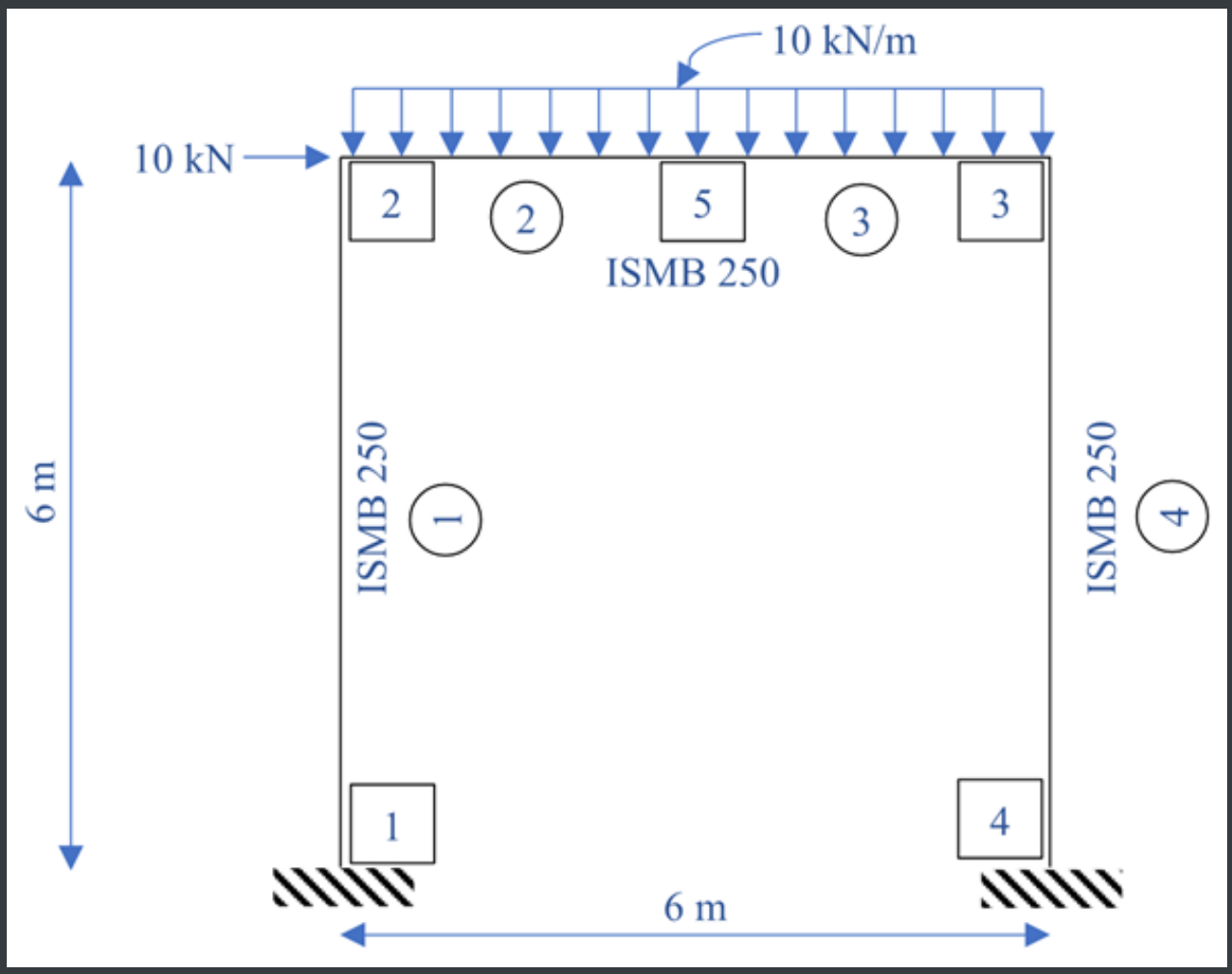
Portal Frame (Elastic)

This example is of an elastic frame structure, as shown in the figure, subject to static loads. (Portal_Frame_Linear_Elastic_1.tcl)



Units

For this example units are kN, m, sec

```
# Units: [kN, m, sec]
```

Parameters

Defination of variables and expression evaluation. We are using the tcl **set** and **expr** commands.

```
set L 6.0
set H 6.0
set E [expr 2.100*pow(10,8)]  # Modulus Elasticity of Steel
set A [expr 4.755*pow(10,-3)] # Cross-section are of ISMB 250
set I [expr 5.132*pow(10,-5)] # Moment of inertia of ISMB 250 about
major axis
```

Model

The model consist of 5 nodes, 4 elastic beam-column elements and loading as per above figure

```
#----------------------------------
# Start of model generation
#----------------------------------
logFile "Portal_Frame.log"
# Create ModelBuilder (with two-dimensions and 3 DOF/node)
model BasicBuilder -ndm 2 -ndf 3

# Define geometry for model
#---------------------------------

# node $tag $xCrd $yCrd
node 1 0.0 0.0
node 2 0.0 $H
node 3 $L $H
node 4 $L 0.0
node 5 [expr $L/2] $H
# set the boundary conditions
```

```
# fix $tag $DX $DY
fix 1 1 1 1
fix 2 0 0 0
fix 3 0 0 0
fix 4 1 1 1
fix 5 0 0 0

# Define geometric tranformation (Linear)
geomTransf Linear 1

# Create elements - command:
# element elasticBeamColumn $eleTag $iNode $jNode $A $E $Iz $transfTag
<-mass $massDens> <-cMass>
element elasticBeamColumn 1 1 2 $A $E $I 1;
element elasticBeamColumn 2 2 5 $A $E $I 1;
element elasticBeamColumn 3 5 3 $A $E $I 1;
element elasticBeamColumn 4 3 4 $A $E $I 1;

# LOADS
# -----------------------------
#create a Linear TimeSeries (load factor varies linearly with time):
command timeSeries Linear $tag
timeSeries Linear 1
# Create a Plain load pattern with a linear TimeSeries: command pattern
Plain $tag $timeSeriesTag { $loads }
pattern Plain 1 1 {
    # Create the nodal load - command: load nodeID xForce yForce mForce
    load 2 10 0 0
    # Create the distributed load : eleLoad -ele $eleTag1 <$eleTag2
....> -type -beamUniform $Wy <$Wx>
    eleLoad -ele 2 3 -type -beamUniform -10.
}
```

Analysis – Gravity Load

Commands to perform a gravity load analysis

```
# Analysis definitions:

# Create the constraint handler, a Plain handler is used as homo
constraints
constraints Plain

# Create the DOF numberer, the plain algorithm is used
numberer Plain

# Create the system of equation, a SPD using a band storage scheme
system BandSPD

# Create the convergenge test, norm of the right hand side of the matrix
equation
# test NormUnbalance 1e-6 1000

# Create the solution algorithm, a Linear algorithm is created
algorithm Linear

# Create the integration scheme, the LoadControl scheme using steps of
1.0
integrator LoadControl 1.

# create the analysis object
analysis Static
```

Perform The Gravity Analysis

After the objects for the model, analsysis and output has been defined we now perform the analysis

```
analyze 1
```

Recorder

Recorder to record the forces and displacement

```
# RECORDER
# ----------------------------

# create a Recorder object for the nodal displacements at node 2
recorder Node -file D_Free.out -time -node 2 5 3 -dof 1 2 3 disp

# Create a recorder for element forces, one in global and the other
local system
recorder Element -file eleGlobal1.out -time -ele 1 2 3 4 forces
```

Screen Print

```
# Print the current state at node 3 & 4 and at all elements
puts "node 2 displacement: [nodeDisp 2]"
puts "node 3 displacement: [nodeDisp 3]"
puts "E= $E"
puts "displacement at the midspan: [nodeDisp 5]"
print ele
```

Results

After runing this script, you should see the following printed to the screen

```
C:\Windows\System32\cmd.exe - opensees
Microsoft Windows [Version 10.0.19042.1348]
(c) Microsoft Corporation. All rights reserved.

D:\Work_Folder\Initial OpenSees Practice\Portal_Frame>opensees


        OpenSees -- Open System For Earthquake Engineering Simulation
                Pacific Earthquake Engineering Research Center
                       Version 3.0.0a (rev 6692) 64-Bit

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OpenSees > source Portal_Frame_Linear_Elastic_1.tcl
node 2 displacement:              0.01198201407208311815           -0.00015453619609778296           -0.00398900192967018528
node 3 displacement:              0.01192198093979740872           -0.00020598656190131572            0.00158831235532142672
E= 210000000.0
displacement at the midspan:              0.01195199750594026430           -0.00749485827189925492            0.00058730980213630643

ElasticBeam2d: 1
        Connected Nodes: 1 2
        CoordTransf: 1
        mass density:  0, cMass: 0
        End 1 Forces (P V M): 25.7187 0.00898596 7.192
        End 2 Forces (P V M): -25.7187 -0.00898596 -7.13809

ElasticBeam2d: 2
        Connected Nodes: 2 5
        CoordTransf: 1
        mass density:  0, cMass: 0
        End 1 Forces (P V M): 9.99101 25.7187 7.13809
        End 2 Forces (P V M): -9.99101 4.28131 25.018

ElasticBeam2d: 3
        Connected Nodes: 5 3
        CoordTransf: 1
        mass density:  0, cMass: 0
        End 1 Forces (P V M): 9.99101 -4.28131 -25.018
        End 2 Forces (P V M): -9.99101 34.2813 -32.826

ElasticBeam2d: 4
        Connected Nodes: 3 4
        CoordTransf: 1
        mass density:  0, cMass: 0
        End 1 Forces (P V M): 34.2813 9.99101 32.826
        End 2 Forces (P V M): -34.2813 -9.99101 27.1201
OpenSees >
```