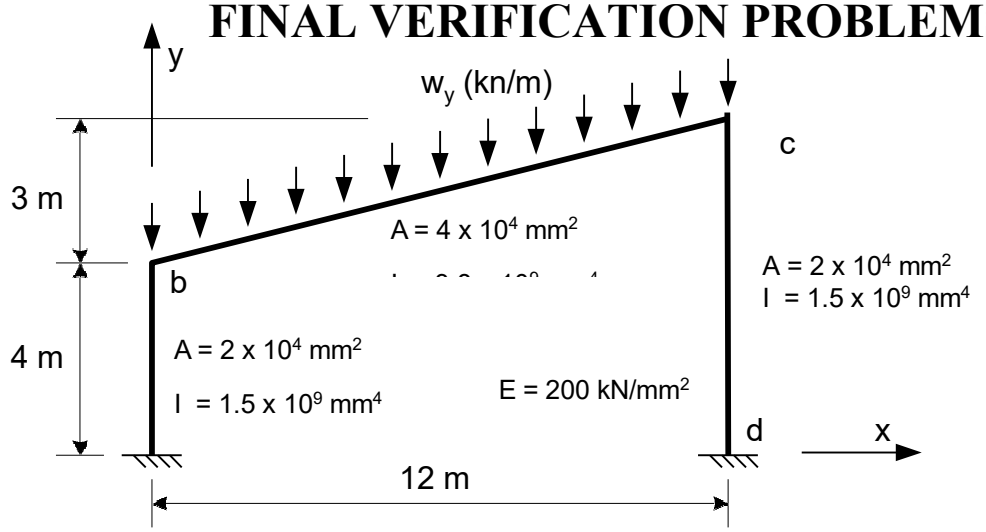
FINAL VERIFICATION PROBLEMS



Notes:

1) The load W_y = 15 kN/m is a vertical distributed load along the length of the member, which you will need to convert to equivalent amounts of distributed load in the local x' and y' axis of the member.

Report the following information:

- Deflections at points *b* and *c* (Δx, Δy, θz)
- Reactions at points *a* and *d* (Fx, Fy, Mz)
- Sketch of bending moment diagram showing numeric values at member ends and midspan of *b-c*.

Solution

Deflections at points b and c (our results are shown up to 6 significant digits)

point b [WRITE UNITS]

	MASTAN results	your results
Δx	-3.6 mm	-3.59974 mm
Δy	-0.08283 mm	-0.0828263 mm
θz	0.0006034 mm/mm	0.000603418 mm/mm

point c [WRITE UNITS]

	MASTAN results	your results
Δx	-3.715 mm	-3.71541 mm
Δy	-0.007041 mm	-0.00704142 mm
θz	0.0002667 mm/mm	0.000266686 mm/mm

Reactions at points a and d

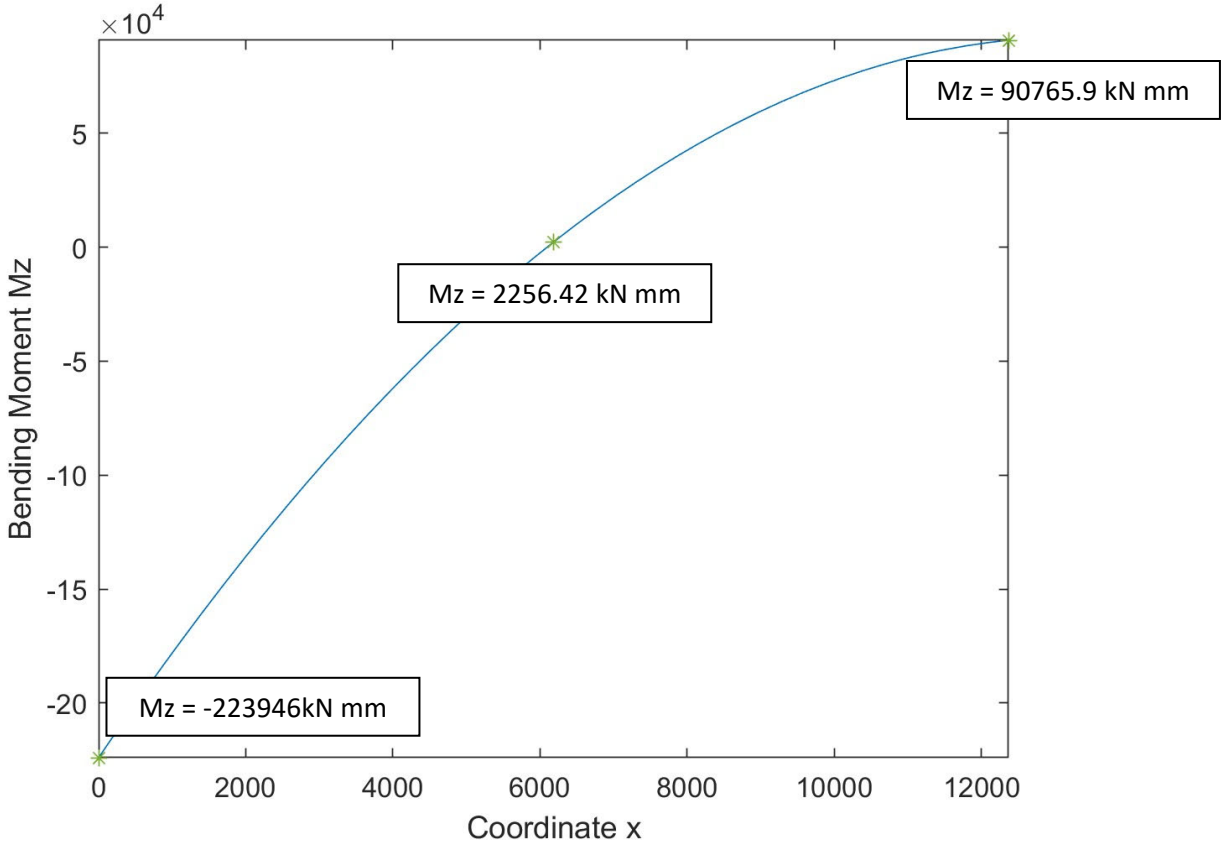
point a [WRITE UNITS]

	MASTAN results	your results
Fx	134.601 kN	134.6 kN
Fy	82.8263 kN	82.83 kN
Mz	-314459.0 kN mm	-3.145e5 kN mm

point d [WRITE UNITS]

	MASTAN results	your results
Fx	29.1989 kN	29.2 kN
Fy	4.02367 kN	4.024 kN
Mz	-113625.0 kN mm	-1.136e5 kN mm

Sketch of bending moment diagram



Verification Problem 1b (Extra Credit):

Repeat Verification Problem 1a for the following cases:

1. The *left end* of member *bc* is flexurally released.
2. The *right end* of member *bc* is flexurally released.

Verification Problem 1b-1 (Left end of member *bc* released)

Deflections at points b and c

point b [WRITE UNITS]

	MASTAN results	your results
Δx	-8.213 mm	-8.21254 mm
Δy	-0.06216 mm	-0.0621645 mm
θz	0.00308 mm/mm	-0.0000547257 mm/mm

point c [WRITE UNITS]

	MASTAN results	your results
Δx	-8.276 mm	-8.27646 mm
Δy	-0.0432 mm	-0.0431996 mm
θz	0.00105 mm/mm	0.00104956 mm/mm

Reactions at points a and d

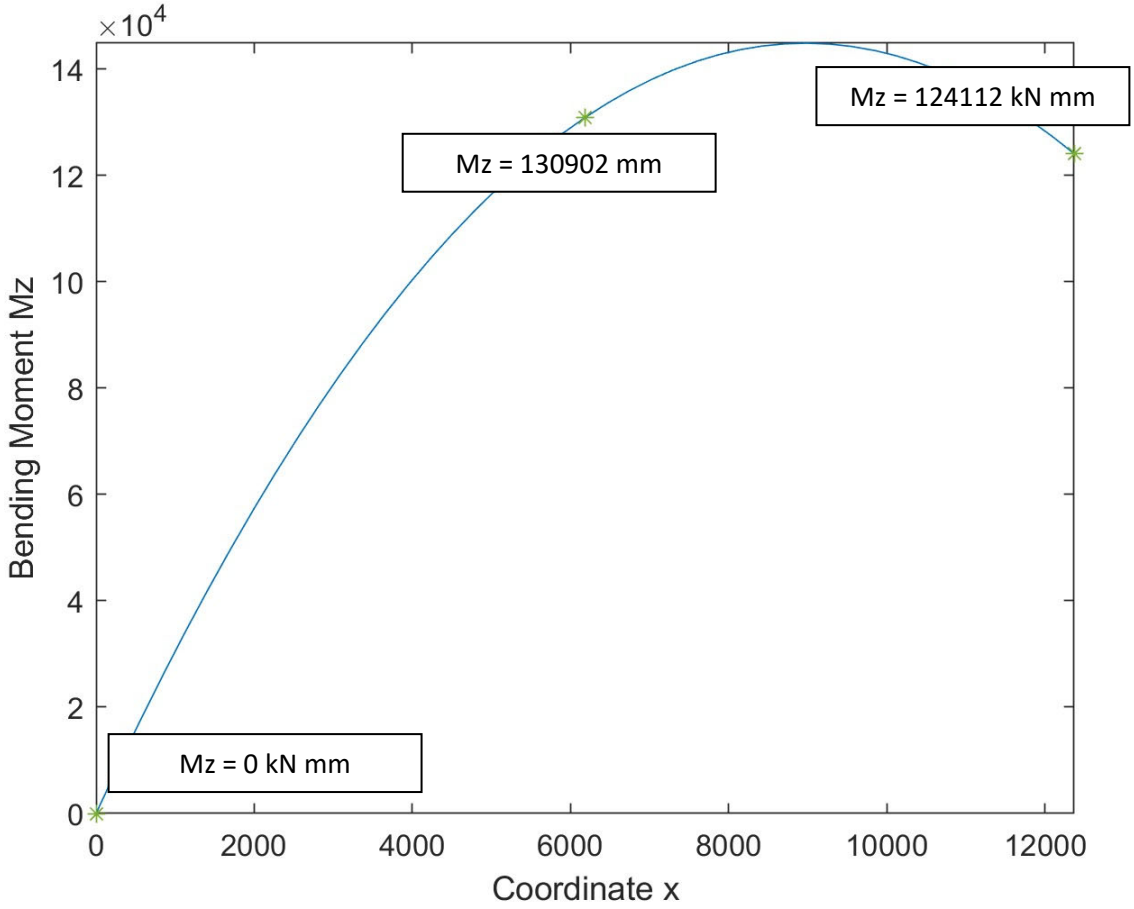
point a [WRITE UNITS]

	MASTAN results	your results
Fx	115.5 kN	115.489 kN
Fy	62.16 kN	62.1645 kN
Mz	-4.62e5 kN mm	-461955.0 kN mm

point d [WRITE UNITS]

	MASTAN results	your results
Fx	48.31 kN	48.3112 kN
Fy	24.69 kN	24.6855 kN
Mz	-2.141e5 kN mm	-214070.0 kN mm

Sketch of bending moment diagram



Deflections at points b and c

point b [WRITE UNITS]

	MASTAN results	your results
Δx	-4.514 mm	-4.51377 mm
Δy	-0.08043 mm	-0.0804289 mm
θz	0.0009094 mm/mm	0.000909412 mm/mm

point b [WRITE UNITS]

	MASTAN results	your results
Δx	-4.653 mm	-4.65312 mm
Δy	-0.001124 mm	-0.0112369 mm
θz	0.0009971 mm/mm	0.000997098 mm/mm

Reactions at points a and d

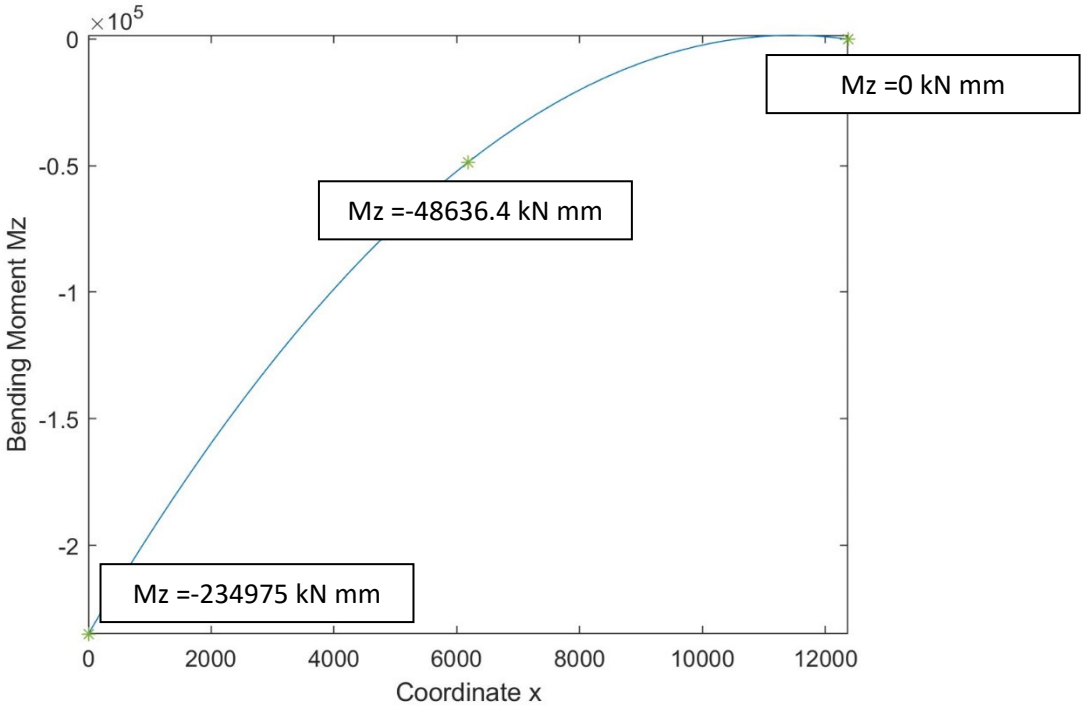
point a [WRITE UNITS]

	MASTAN results	your results
Fx	151.6 kN	151.591 kN
Fy	80.43 kN	80.4289 kN
Mz	-3.714e5 kN mm	-371387.0 kN mm

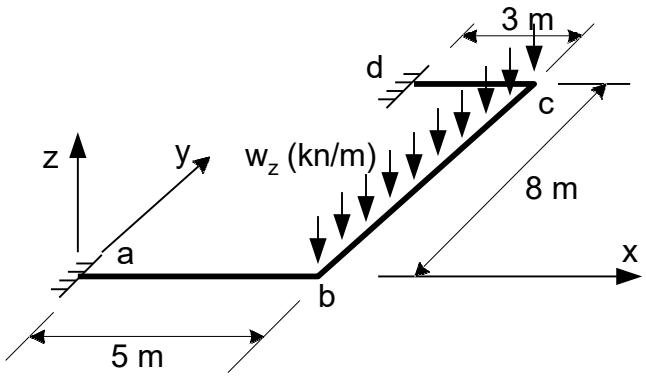
point d [WRITE UNITS]

	MASTAN results	your results
Fx	12.21 kN	12.2094 kN
Fy	6.421 kN	6.42106 kN
Mz	-8.547e4 kN mm	-85465.5 kN mm

Sketch of bending moment diagram



Verification Problem 2:



Notes:

1) The structure consists of a horizontal grid of rectangular tubular members measuring 100 mm wide x 300 mm deep. The members are all oriented with their tall dimension (web direction or local y axis) parallel to the global z-axis (vertical direction). The tubular members have the following properties: A = 11,000 mm^2, Izz= 1.06 x 10^8 mm^4, Iyy= 1.74 x 10^7 mm^4 , J = 5.29 x 10^7 mm^4
2) Members are steel with E = 200 kN/mm^2 and $\nu = 0.3$.
3) The load W_z = 5 kN/m is a vertical distributed load along the length of the member.

Report the following information:

- Deflections at point b (Δx, Δy, Δz, θz, θy, θz)
- Reactions at point a (Fx, Fy, Fz, Mx, My, Mz)
- Value of torsion (Mx') in member a-b.
- Sketch diagram of major axis bending moment for each member with key numerical values indicated.

Solutions

Deflections at point b

point b [WRITE UNITS]

	MASTAN results	your results
Δx	2.18203e-15 mm	1.84e-18 mm
Δy	-2.92599e-15 mm	-2.263e-15 mm
Δz	-35.503 mm	-35.5 mm
θx	-0.00107847 mm/mm	-0.001078 mm/mm
θy	0.0104828 mm/mm	0.01048 mm/mm
θz	-5.35138e-19 mm/mm	-3.801e-19 mm/mm

Reactions at point a

point a [WRITE UNITS]

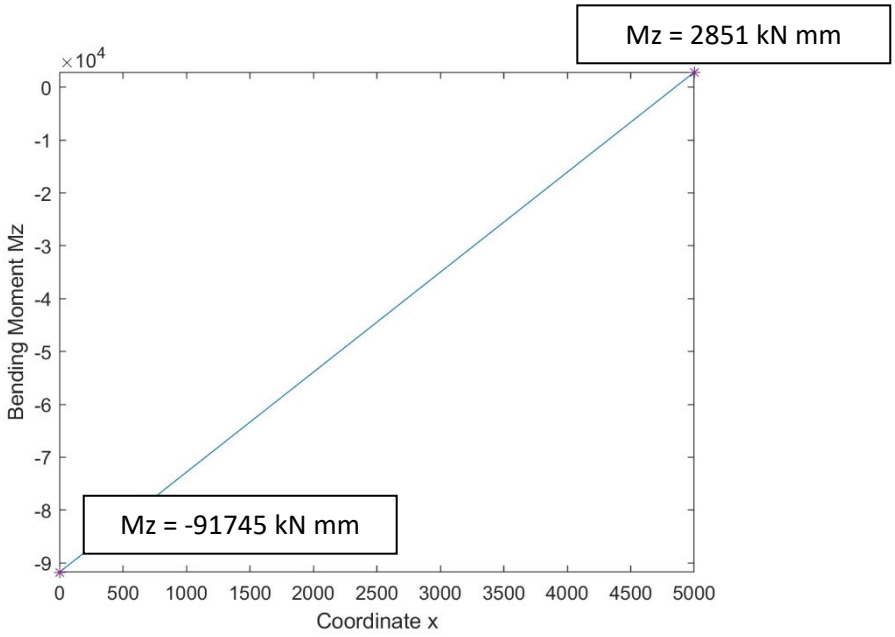
	MASTAN results	your results
Fx	-2.40499e-15 kN	-8.095e-16 kN
Fy	1.44372e-15 kN	1.407e-15 kN
Fz	18.9192 kN	18.92 kN
Mx	877.709 kN mm	877.7 kN mm
My	-91745.0 kN mm	-9.174e04 kN mm
Mz	5.10005e-12 kN mm	6.056e-12 kN mm

Value of torsion Mx'

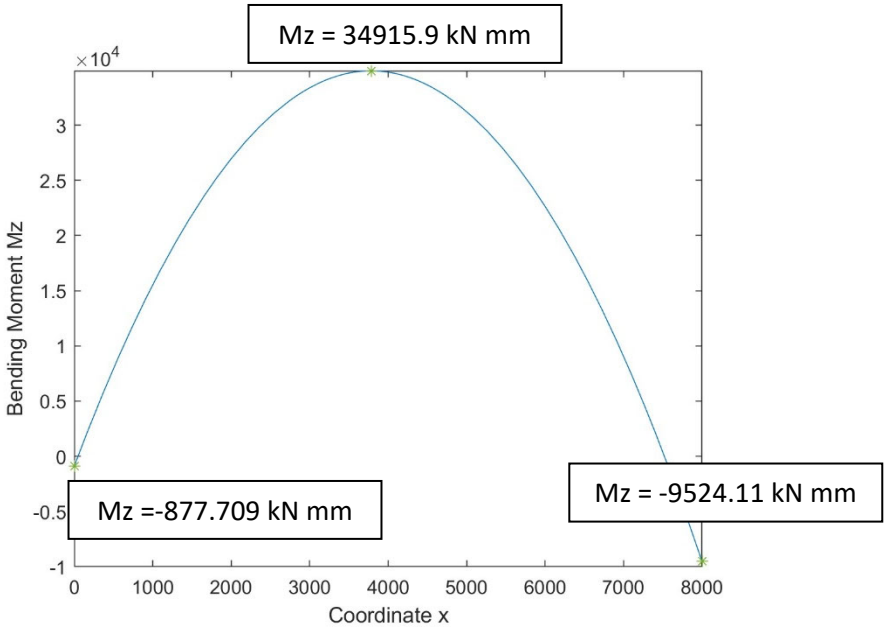
Member:	MASTAN results	your results
a-b	-877.709 kN mm	-877.7 kN mm

Sketch of bending moment diagram

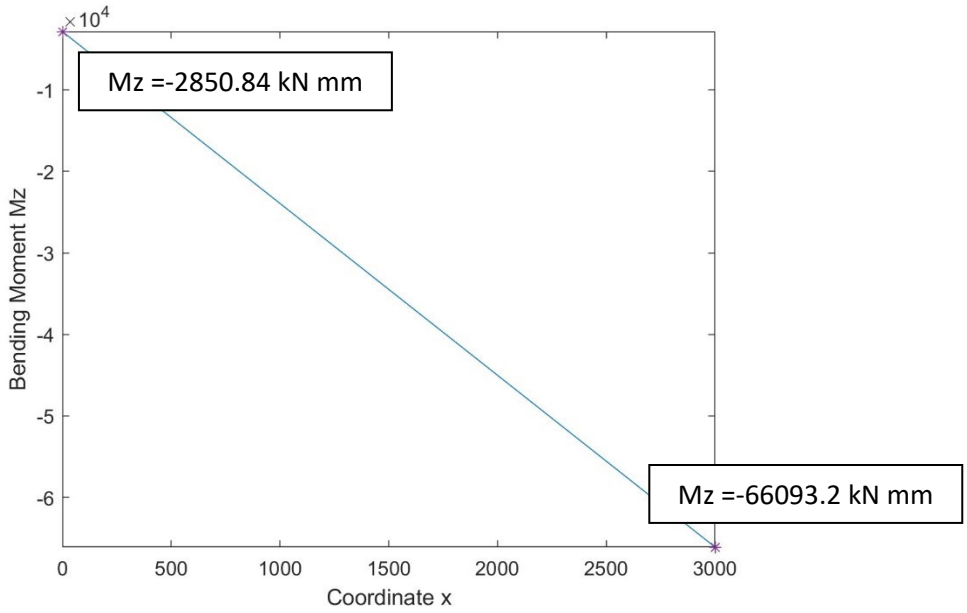
Member 1:



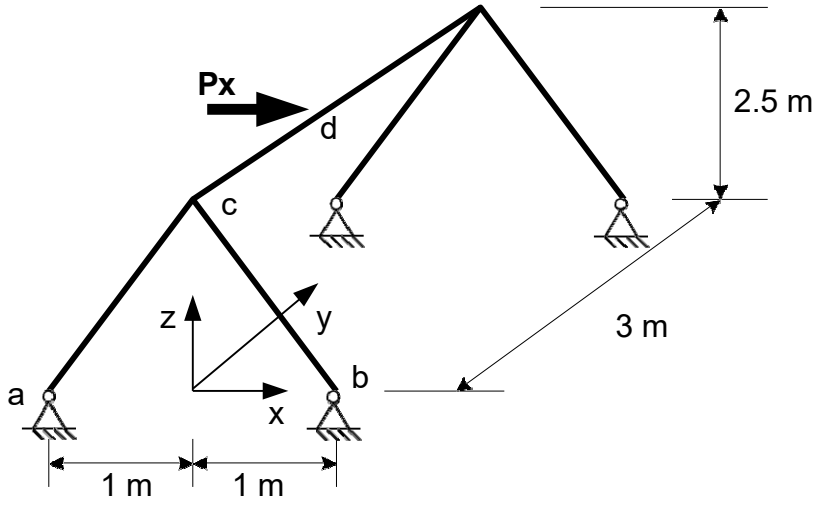
Member 2



Member 3


×10^4
Mz =-2850.84 kN mm
Mz =-66093.2 kN mm
Bending Moment Mz
Coordinate x
-1
-2
-3
-4
-5
-6
0
500
1000
1500
2000
2500
3000

Verification Problem 3 – Swing Set:



Notes:

1) The structure is built with round 75 mm diameter tubular members have the following properties: A = 1,430 mm^2, I = 1.26 x 10^6 mm^4, J = 2.52 x 10^6 mm^4
2) Members are steel with E = 200 kN/mm^2 and $\nu = 0.3$.
3) The load P_x = 4.5 kN at node d is applied in the global x direction at the mid-span of the horizontal member.

Report the following information:

- Deflections at point d (Δx, Δy, Δz, θz, θy, θz)
- Reactions at points a and b (Fx, Fy, Fz, Mx, My, Mz)
- Axial forces in members a-c, c-b, and c-d.

Solution

Deflections at point d

point d

	MASTAN results	your results
Δx	7.744 mm	7.74411 mm
Δy	-1.601e-32 mm	0.0000891948 mm
Δz	-1.426e-20 mm	0.0000535169 mm
θx	-1.608e-36 mm/mm	-3.56779e-8 mm
θy	2.648e-05 mm/mm	-0.0000239967 mm/mm
θz	-1.844e-19 mm/mm	-0.00687496 mm/mm

Reactions at points a and b

Mx, My, Mz correspond to free DOFs, hence reactions are zero.

point a

	MASTAN results	your results
Fx	-1.125 kN	-1.14504 kN
Fy	-0.2662 kN	-0.266247 kN
Fz	-2.813 kN	-2.80384 kN
Mx	--	--
My	--	--
Mz	--	--

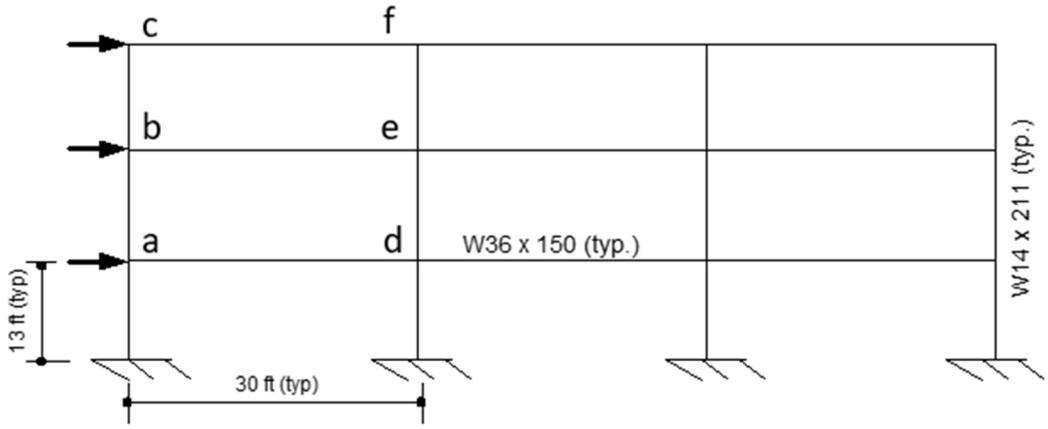
point b

	MASTAN results	your results
Fx	-1.125 kN	-1.14504 kN
Fy	0.2662 kN	0.266252 kN
Fz	2.813 kN	2.80374 kN
Mx	--	--
My	--	--
Mz	--	--

Axial forces

	MASTAN results	your results
a-c	3.029 kN	3.02856 kN
c-b	-3.029 kN	-3.02845 kN
c-d	-1.221e-17 kN	-5.87623e-8 kN

Verification Problem 4a:



Notes:

1) Since this is a 2D problem, you will have to restrain the structure in the out-of-plane direction. In other words, you will restrain translation in the global z-direction and rotation about the global x and y axes.
2) Members have the following properties:
   W36 x 150: A=44.2 in^2, I = 9,040 in^4, A_{web} = 22.4 in^2 W14 x 211: A=62.0 in^2, I = 2,660 in^4, A_{web} = 15.7 in^2
3) Members are steel with E = 30,000 k/in^2 and $\nu = 0.3$.
4) The applied lateral load at each floor is Px = 9.5 kips
5) Base your analysis on centerline dimensions (i.e., ignoring finite joint size effects).

Perform two lateral load analyses, one in which shear deformations are included and one in which they are excluded. Report the following information for each analysis

- Lateral deflections at each floor level (Δx_a, Δx_b, Δx_c)
- The maximum moments in column a-b and beam b-e.
- What is the percentage change in lateral deflections due to the shear deformations?
- What is the percentage change in the *maximum* beam and column moments due to shear deformations?

Solution:

Include shear deformation

Lateral deflections at each floor level

	MASTAN results	your results
Δx3 (Roof)	0.113 in	0.113034 in
Δx2 (3F)	0.09067 in	0.090669 in
Δx1 (2F)	0.04813 in	0.0481261 in

The maximum moments

	MASTAN results	your results
column a-b	324.7 kip-in	324.726 kip-in
beam b-e	429.7 kip-in	429.675 kip-in

Exclude shear deformation

Lateral deflections at each floor level

	MASTAN results	your results
Δx3 (Roof)	0.09695 in	0.096948 in
Δx2 (3F)	0.07769 in	0.0776854 in
Δx1 (2F)	0.0409 in	0.040904 in

The maximum moments

	MASTAN results	your results
column a-b	316.2 kip-in	316.205 kip-in
beam b-e	422.4 kip-in	422.441 kip-in

Comparison

The percentage change in lateral deflection change [= 100 * (Δx_include - Δx_exclude)/ Δx_include]

	your results
Δx3 (Roof)	14.23 %
Δx2 (3F)	14.32 %
Δx1 (2F)	15.01 %

The percentage change in the maximum moments [= 100 * (M_include - M_exclude)/ M_include]

	your results
column a-b	2.62 %
beam b-e	1.68 %

Verification Problem 4b (Extra Credit):

Repeat Verification Problem 4a for the case where both ends of beams a-d, b-e and c-f are flexurally released.
Verification Problem 4b

a) include shear deformation

Lateral deflections at each floor level

	MASTAN results	your results
Δx3 (Roof)	0.1507 in	0.15069 in
Δx2 (3F)	0.1168 in	0.116797 in
Δx1 (2F)	0.05722 in	0.0572165 in

The maximum moments

	MASTAN results	your results
column a-b	101.2 kip-in	101.227 kip-in
beam b-e	0 kip-in	0 kip-in

b) exclude shear deformation

Lateral deflections at each floor level

	MASTAN results	your results
Δx3 (Roof)	0.1305 in	0.130484 in
Δx2 (3F)	0.1013 in	0.101338 in
Δx1 (2F)	0.04921 in	0.0492134 in

The maximum moments

	MASTAN results	your results
column a-b	96.56 kip-in	96.56 kip-in
beam b-e	0 kip-in	0 kip-in

The percentage change in lateral deflection
change [= 100 * (Δx_include -
Δx_exclude)/ Δx_include]

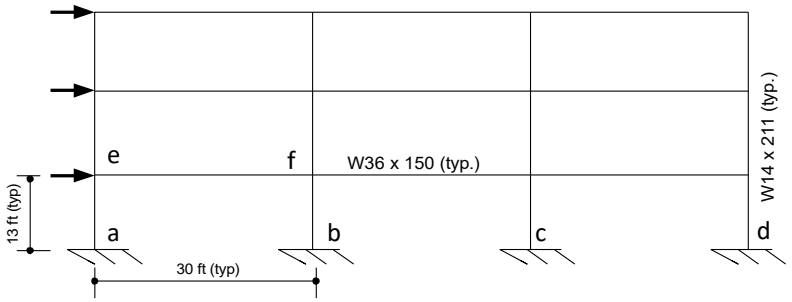
	your results
Δx3 (Roof)	10.52 %
Δx2 (3F)	11.49%
Δx1 (2F)	13.99%

The percentage change in the maximum
moments [= 100 * (M_include -
M_exclude)/ M_include]

	your results
column a-b	4.61%

am b-e	0 %

Verification Problem 5:



Notes:
1) This is the same structure as for Problem 4.
2) For this problem, do NOT include member shear deformations.

Perform an analysis where you apply a vertical settlement of Δ = -1 inch to the support at point b. Report the following information from this analysis.

- Base reactions at points a, b, c, and d (Fx, Fy, M)
- Shear and moments in beam e-f (V, Me, Mf).

Problem 5

Base reactions at points a, b, c and d

point a

	MASTAN results	your results
Fx	22.76 kips	22.7618 kips
Fy	125.1 kips	125.051 kips
Mz	-844.4 kip-in	-844.411 kip-in

point b

	MASTAN results	your results
Fx	-11.9 kips	-11.8976 kips
Fy	-285.2 kips	-285.2108 kips
Mz	982.2 kip-in	982.198 kip-in

point c

	MASTAN results	your results
Fx	-34.1 kips	-34.0952 kips
Fy	178.8 kips	178.769 kips
Mz	2160 kip-in	2160.23 kip-in

point d

	MASTAN results	your results
Fx	-5.269 kips	-5.26907 kips
Fy	-18.61 kips	-18.609 kips
Mz	653.9 kip-in	653.898 kip-in

Shear and moments in beam e-f

	MASTAN results	your results
V	43.17 kips	43.1716 kips
Me	6480 kips	6479.59 kips
Mf	9062 kip-in	9062.17 kip-in