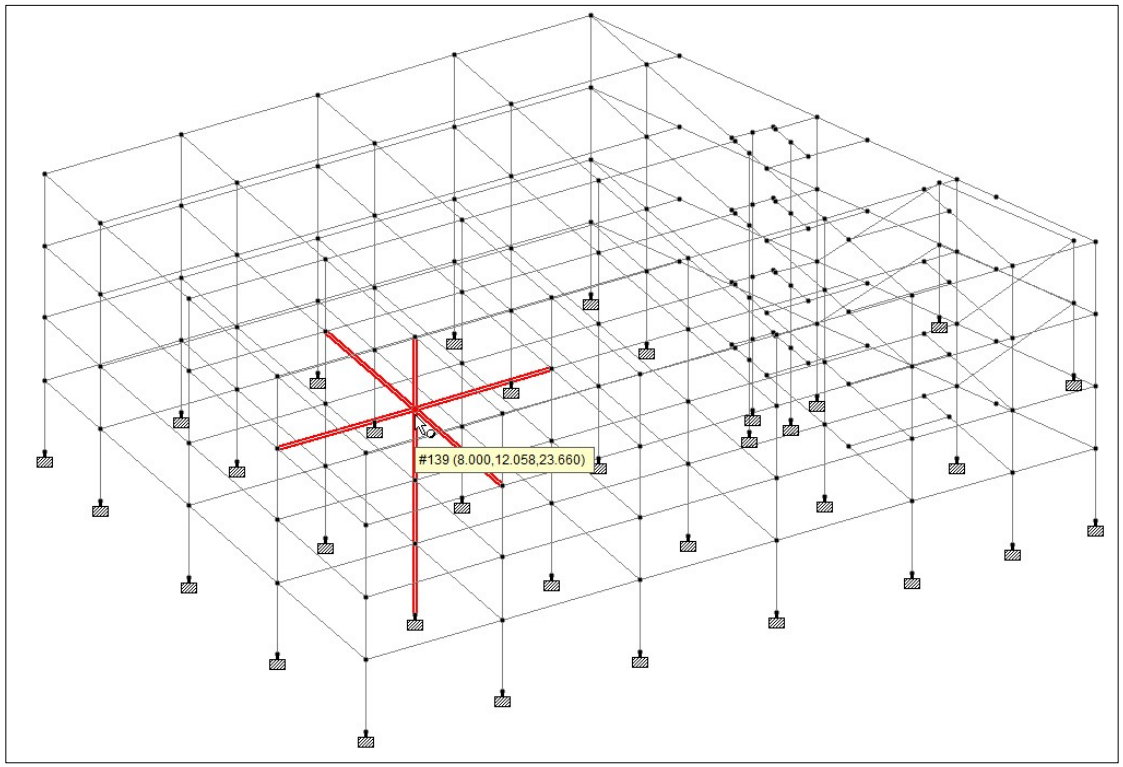
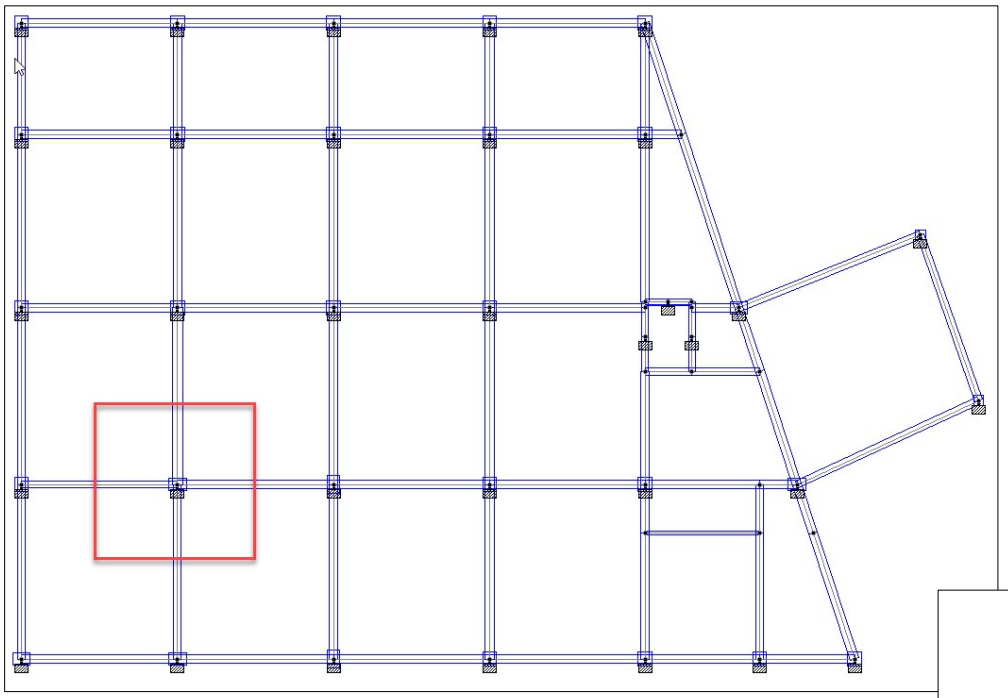
Validation Problem for Joint Checks as per ACI 318M-2014

Input Data:

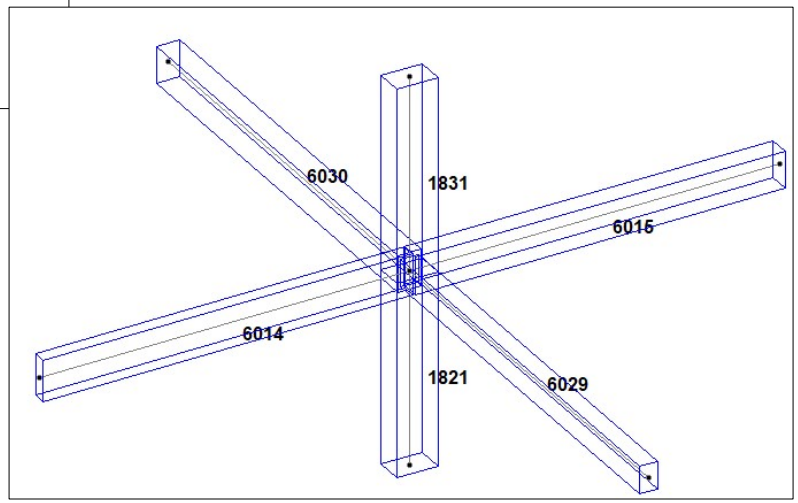
STAAD file	= RCDC-Staad-Demo -with RCC wall
Joint level	= 12.058 m
Column No. (RCDC)	= C22
Column Member no. (below joint)	= 1821
Column Member no.(above joint)	= 1831
Column Size	= 600 x 900
Height of column below Joint	= 4200 mm
Height of column Above Joint	= 4200 mm



3D View



Top View



Element Numbers at Joint at 12.058m level

Note: STAAD command file is available at end of this document

Relative Strength of Beams and Column at a Joint (Clause 18.7.3)

18.7.3.1 Columns shall satisfy 18.7.3.2 or 18.7.3.3.

18.7.3.2 The flexural strengths of the columns shall satisfy

$$\sum M_{nc} \geq (6/5)\sum M_{nb} \qquad (18.7.3.2)$$

where

$\sum M_{nc}$ is sum of nominal flexural strengths of columns framing into the joint, evaluated at the faces of the joint. Column flexural strength shall be calculated for the factored axial force, consistent with the direction of the lateral forces considered, resulting in the lowest flexural strength.

$\sum M_{nb}$ is sum of nominal flexural strengths of the beams framing into the joint, evaluated at the faces of the joint. In T-beam construction, where the slab is in tension under moments at the face of the joint, slab reinforcement within an effective slab width defined in accordance with 6.3.2 shall be assumed to contribute to M_{nb} if the slab reinforcement is developed at the critical section for flexure.

RCDC Report for Flexural strength of Joint

General Data:

Column No. : C22

Joint at Level : 12.058 m

	Column Below	Column Above
Member Number	1821	1831
Concrete Grade,fck (N/sqmm)	C25	C25
Steel Grade,fy (N/sqmm)	Fy420	Fy420
Column Size (mm)	600 X 900	600 X 900

Check At Beam-Column Joints:

1. Flexure Strength Of Joint:

Moment Capacity Calculations for Beam

Concrete Grade,fck = C25 N/sqmm

Steel Grade,fy = Fy420 N/sqmm

Beam Size	Beam angle w.r.t. column Ly	Torsion moment	Moment Capacity for Top Reinforcement				Moment Capacity for Bottom Reinforcement				Resultant Moment			
(mm)	(deg)	(kNm)	Mu (kNm)	Ast Req (sqmm)	Ast Pro (sqmm)	Mu Cap (kNm)	Mu (kNm)	Ast Req (sqmm)	Ast Pro (sqmm)	Mu Cap (kNm)	Top @ D (kNm)	Top @ B (kNm)	Bot @ D (kNm)	Bot @ B (kNm)
450 x 800	0	0	526.57	1986.13	2005.64	531.42	0	993.07	1013.44	277.05	531.42	0	277.05	0
500 x 800	90	0.69	622.63	2358.55	2382.72	628.58	0	1179.28	1266.8	345.01	0	628.58	0	345.01
300 x 900	180	0.48	464.11	1546.22	1588.48	475.96	0	773.11	886.76	273.66	475.96	0	273.66	0
400 x 600	270	0.46	562.24	3190.69	3546.97	613.22	0	1595.34	1626.2	310.84	0	613.22	0	310.84

Effective Moment for Beam

	Along D		Along B	
	Left	Right	Left	Right
Top (kNm)	475.96	531.42	613.22	628.58
Bottom (kNm)	273.66	277.05	310.84	345.01
Mnb (kNm)	MAX((Left Bottom + Right Top), (Left Top + Right		MAX((Left Top + Right Bottom), (Right Top + Left	
	805.07		958.23	

Check for Column Flexural Capacity

	Along D	Along B
Critical Load Combination Top	[11] : 0.9 (LOAD 1: LOAD CASE 1) -1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	[11] : 0.9 (LOAD 1: LOAD CASE 1) -1.4 (LOAD 4: LOAD CASE 4 EQ-Y)
Pu Top (kN)	587	587
Mnc Top (kNm)	1531.58	999.35
Critical Load Combination Bot	[11] : 0.9 (LOAD 1: LOAD CASE 1) -1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	[11] : 0.9 (LOAD 1: LOAD CASE 1) -1.4 (LOAD 4: LOAD CASE 4 EQ-Y)
Pu Bot (kN)	1103.74	1103.74
Mnc Bottom (kNm)	1166.72	767.91
Mnc (kNm)	2698.3	1767.26
	>= 1.2 x Mnb, Hence OK	>= 1.2 x Mnb, Hence OK

Where,

Mnb = Flexural Capacity of Beams in kN-m

Mnc Top = Flexural capacity of column above joint considered

Mnc Bottom = Flexural capacity of column below joint considered

Mnc = Mnc Top + Mnc Bottom, along D

Mnc = Mnc Top + Mnc Bottom, along B

Check for Column Flexural Capacity

Load Combination	Top Column	Bottom Column	Joint Flexure Check Along D				Joint Flexure Check Along B			
	Pu (kN)	Pu (kN)	Mnc Top (kNm)	Mnc Bottom (kNm)	Mnc Total (kNm)	Design Check Mnc Total/Mnb	Mnc Top (kNm)	Mnc Bottom (kNm)	Mnc Total (kNm)	Design Check Mnc Total/Mnb
4	893.72	1878.87	1609.89	1353.97	2963.86	3.68	1055.88	904.33	1960.22	2.05
5	901.66	1910.29	1611.92	1361.03	2972.95	3.69	1057.35	909.43	1966.78	2.05
6	903.14	1913.55	1612.3	1361.76	2974.06	3.69	1057.62	909.96	1967.58	2.05
7	892.24	1875.62	1609.51	1353.23	2962.75	3.68	1055.61	903.81	1959.41	2.04
8	588.49	1107	1531.96	1167.56	2699.53	3.35	999.62	768.51	1768.14	1.85
9	596.42	1138.42	1533.99	1175.72	2709.71	3.37	1001.08	774.34	1775.42	1.85
10	597.91	1141.68	1534.37	1176.57	2710.94	3.37	1001.36	774.94	1776.3	1.85
11	587	1103.74	1531.58	1166.72	**2698.3**	**3.35**	999.35	767.91	**1767.26**	**1.84**

Calculation of Column Capacity:

Column Above Joint at 12.058m level i.e. Bottom Node of Member 1831

Member force table from RCDC:

Columns	Level	Analysis No	Load Comb	Load Comb	Load Comb	Location	P	Mx	My	ShearX	ShearY
			Ref No	Analysis No	Description	(m)	(kN)	(kNm)	(kNm)	(kN)	(kN)
C22	16.258 m	1831	1		1.4 (LOAD 1: LOAD CASE 1)	0	921.59	3.05	7.71	-3.95	2.7
			1		1.4 (LOAD 1: LOAD CASE 1)	4.2	842.18	-8.3	-8.87	-3.95	2.7
			2		1.2 (LOAD 1: LOAD CASE 1) +1.6 (LOAD 2: LOAD CASE 2)	0	962.34	5.99	9.63	-4.64	4.06
			2		1.2 (LOAD 1: LOAD CASE 1) +1.6 (LOAD 2: LOAD CASE 2)	4.2	894.27	-11.05	-9.84	-4.64	4.06
			3		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2)	0	897.69	4.72	8.49	-4.17	3.4
			3		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2)	4.2	829.62	-9.57	-9	-4.17	3.4
			4		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) +1.4 (LOAD 3: LOAD CASE 3 EQ-X)	0	893.72	95.96	8.87	-4.38	60.01
			4		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) +1.4 (LOAD 3: LOAD CASE 3 EQ-X)	4.2	825.65	-156.04	-9.52	-4.38	60.01
			5		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) -1.4 (LOAD 3: LOAD CASE 3 EQ-X)	0	901.66	-86.51	8.11	-3.95	-53.21
			5		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) -1.4 (LOAD 3: LOAD CASE 3 EQ-X)	4.2	833.59	136.89	-8.48	-3.95	-53.21
			6		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) +1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	0	903.14	3.69	69.3	-40.82	2.83
			6		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) +1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	4.2	835.07	-8.21	-102.12	-40.82	2.83
			7		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) -1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	0	892.24	5.75	-52.32	32.49	3.97
			7		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) -1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	4.2	824.17	-10.93	84.11	32.49	3.97
			8		0.9 (LOAD 1: LOAD CASE 1) +1.4 (LOAD 3: LOAD CASE 3 EQ-X)	0	588.49	93.19	5.33	-2.75	58.35
			8		0.9 (LOAD 1: LOAD CASE 1) +1.4 (LOAD 3: LOAD CASE 3 EQ-X)	4.2	537.44	-151.8	-6.22	-2.75	58.35
			9		0.9 (LOAD 1: LOAD CASE 1) -1.4 (LOAD 3: LOAD CASE 3 EQ-X)	0	596.42	-89.27	4.57	-2.32	-54.87
			9		0.9 (LOAD 1: LOAD CASE 1) -1.4 (LOAD 3: LOAD CASE 3 EQ-X)	4.2	545.37	141.13	-5.18	-2.32	-54.87
			10		0.9 (LOAD 1: LOAD CASE 1) +1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	0	597.91	0.93	65.76	-39.19	1.17
			10		0.9 (LOAD 1: LOAD CASE 1) +1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	4.2	546.86	-3.98	-98.81	-39.19	1.17
			11		0.9 (LOAD 1: LOAD CASE 1) -1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	0	587	2.99	-55.86	34.12	2.31
			11		0.9 (LOAD 1: LOAD CASE 1) -1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	4.2	535.95	-6.69	87.41	34.12	2.31

Note:

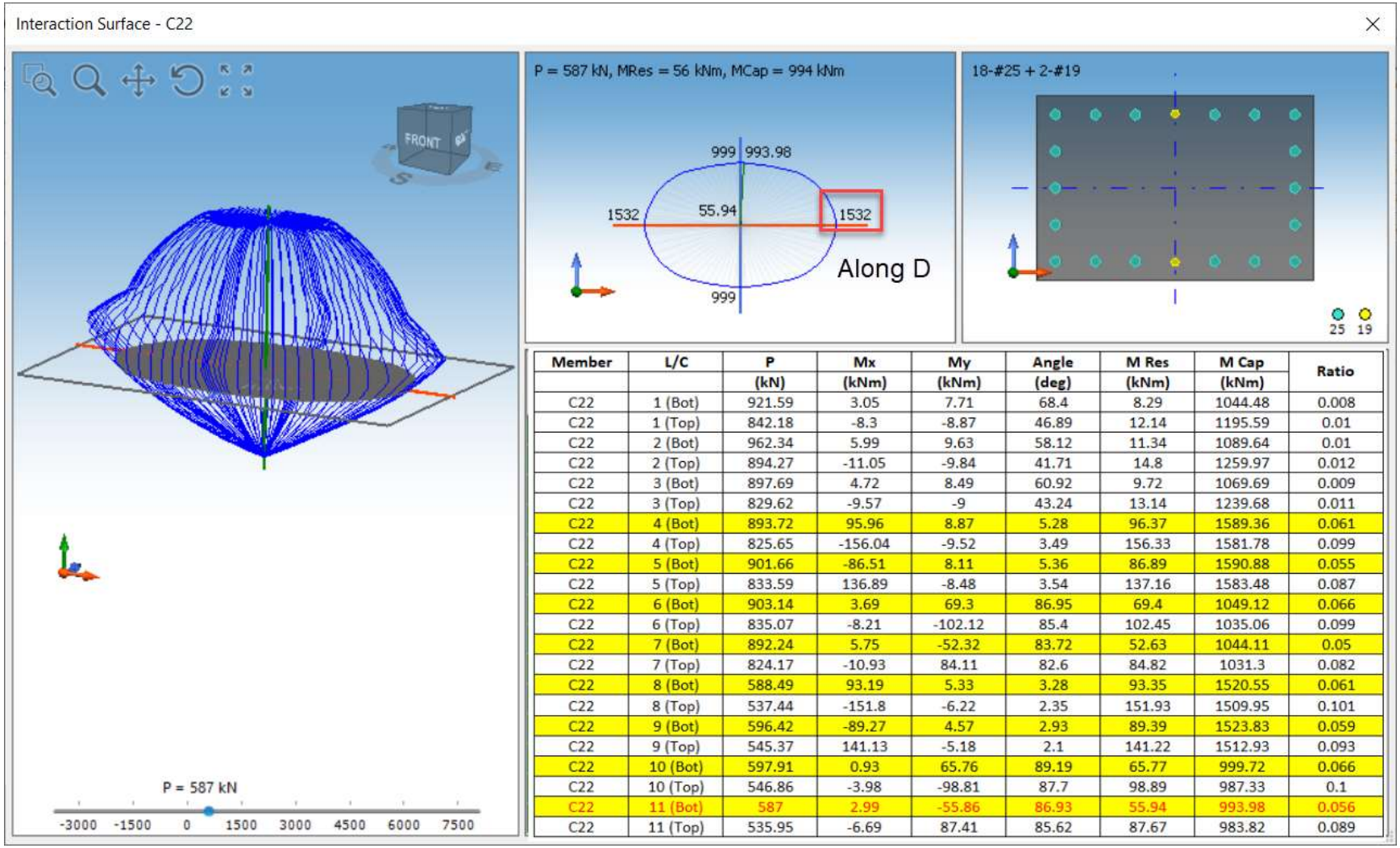
For column moment capacity calculation, load combinations contain Earthquake load case should be considered.

Pu from all Eq load combinations which gives minimum moment capacity should be considered.

Along D

Pu which gives Minimum Moment capacity — Pu = 587 kN

Moment Capacity, (Mnc top) — Mcap = 1531.58 kNm (refer below PM curve)

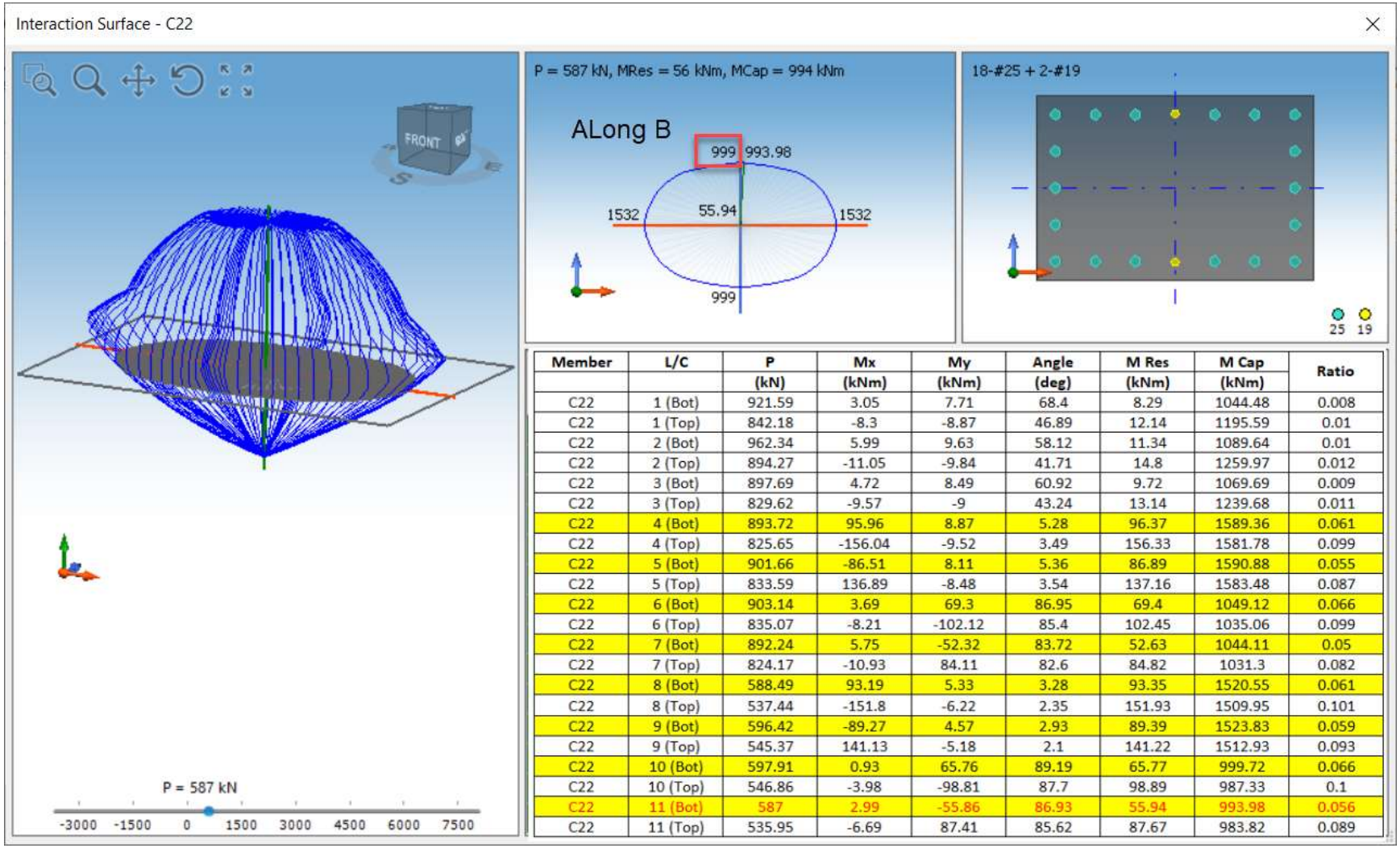


Member	L/C	P (kN)	Mx (kNm)	My (kNm)	Angle (deg)	M Res (kNm)	M Cap (kNm)	Ratio
C22	1 (Bot)	921.59	3.05	7.71	68.4	8.29	1044.48	0.008
C22	1 (Top)	842.18	-8.3	-8.87	46.89	12.14	1195.59	0.01
C22	2 (Bot)	962.34	5.99	9.63	58.12	11.34	1089.64	0.01
C22	2 (Top)	894.27	-11.05	-9.84	41.71	14.8	1259.97	0.012
C22	3 (Bot)	897.69	4.72	8.49	60.92	9.72	1069.69	0.009
C22	3 (Top)	829.62	-9.57	-9	43.24	13.14	1239.68	0.011
C22	4 (Bot)	893.72	95.96	8.87	5.28	96.37	1589.36	0.061
C22	4 (Top)	825.65	-156.04	-9.52	3.49	156.33	1581.78	0.099
C22	5 (Bot)	901.66	-86.51	8.11	5.36	86.89	1590.88	0.055
C22	5 (Top)	833.59	136.89	-8.48	3.54	137.16	1583.48	0.087
C22	6 (Bot)	903.14	3.69	69.3	86.95	69.4	1049.12	0.066
C22	6 (Top)	835.07	-8.21	-102.12	85.4	102.45	1035.06	0.099
C22	7 (Bot)	892.24	5.75	-52.32	83.72	52.63	1044.11	0.05
C22	7 (Top)	824.17	-10.93	84.11	82.6	84.82	1031.3	0.082
C22	8 (Bot)	588.49	93.19	5.33	3.28	93.35	1520.55	0.061
C22	8 (Top)	537.44	-151.8	-6.22	2.35	151.93	1509.95	0.101
C22	9 (Bot)	596.42	-89.27	4.57	2.93	89.39	1523.83	0.059
C22	9 (Top)	545.37	141.13	-5.18	2.1	141.22	1512.93	0.093
C22	10 (Bot)	597.91	0.93	65.76	89.19	65.77	999.72	0.066
C22	10 (Top)	546.86	-3.98	-98.81	87.7	98.89	987.33	0.1
C22	11 (Bot)	587	2.99	-55.86	86.93	55.94	993.98	0.056
C22	11 (Top)	535.95	-6.69	87.41	85.62	87.67	983.82	0.089

Along B

Pu which gives Minimum Moment capacity — Pu = 587 kN

Moment Capacity, (Mnc top) — Mcap = 999.35 kNm (refer below PM curve)



Member	L/C	P (kN)	Mx (kNm)	My (kNm)	Angle (deg)	M Res (kNm)	M Cap (kNm)	Ratio
C22	1 (Bot)	921.59	3.05	7.71	68.4	8.29	1044.48	0.008
C22	1 (Top)	842.18	-8.3	-8.87	46.89	12.14	1195.59	0.01
C22	2 (Bot)	962.34	5.99	9.63	58.12	11.34	1089.64	0.01
C22	2 (Top)	894.27	-11.05	-9.84	41.71	14.8	1259.97	0.012
C22	3 (Bot)	897.69	4.72	8.49	60.92	9.72	1069.69	0.009
C22	3 (Top)	829.62	-9.57	-9	43.24	13.14	1239.68	0.011
C22	4 (Bot)	893.72	95.96	8.87	5.28	96.37	1589.36	0.061
C22	4 (Top)	825.65	-156.04	-9.52	3.49	156.33	1581.78	0.099
C22	5 (Bot)	901.66	-86.51	8.11	5.36	86.89	1590.88	0.055
C22	5 (Top)	833.59	136.89	-8.48	3.54	137.16	1583.48	0.087
C22	6 (Bot)	903.14	3.69	69.3	86.95	69.4	1049.12	0.066
C22	6 (Top)	835.07	-8.21	-102.12	85.4	102.45	1035.06	0.099
C22	7 (Bot)	892.24	5.75	-52.32	83.72	52.63	1044.11	0.05
C22	7 (Top)	824.17	-10.93	84.11	82.6	84.82	1031.3	0.082
C22	8 (Bot)	588.49	93.19	5.33	3.28	93.35	1520.55	0.061
C22	8 (Top)	537.44	-151.8	-6.22	2.35	151.93	1509.95	0.101
C22	9 (Bot)	596.42	-89.27	4.57	2.93	89.39	1523.83	0.059
C22	9 (Top)	545.37	141.13	-5.18	2.1	141.22	1512.93	0.093
C22	10 (Bot)	597.91	0.93	65.76	89.19	65.77	999.72	0.066
C22	10 (Top)	546.86	-3.98	-98.81	87.7	98.89	987.33	0.1
C22	11 (Bot)	587	2.99	-55.86	86.93	55.94	993.98	0.056
C22	11 (Top)	535.95	-6.69	87.41	85.62	87.67	983.82	0.089

Column below Joint at 12.058m level i.e. top Node of Member 1821

Member force table from RCDC:

Columns	Level	Analysis No	Load Comb	Load Comb	Load Comb	Location	P	Mx	My	ShearX	ShearY
			Ref No	Analysis No	Description	(m)	(kN)	(kNm)	(kNm)	(kN)	(kN)
C22	12.058 m	1821	1		1.4 (LOAD 1: LOAD CASE 1)	0	1825.85	5.75	18.9	-10.92	-0.49
			1		1.4 (LOAD 1: LOAD CASE 1)	4.2	1746.44	7.8	-26.95	-10.92	-0.49
			2		1.2 (LOAD 1: LOAD CASE 1) +1.6 (LOAD 2: LOAD CASE 2)	0	2201.23	17.3	12.33	-7.8	4.71
			2		1.2 (LOAD 1: LOAD CASE 1) +1.6 (LOAD 2: LOAD CASE 2)	4.2	2133.17	-2.47	-20.42	-7.8	4.71
			3		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2)	0	1962.65	12.66	13.78	-8.38	2.79
			3		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2)	4.2	1894.58	0.96	-21.42	-8.38	2.79
			4		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) +1.4 (LOAD 3: LOAD CASE 3 EQ-X)	0	1946.94	170.52	14.14	-8.57	82.23
			4		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) +1.4 (LOAD 3: LOAD CASE 3 EQ-X)	4.2	1878.87	-174.77	-21.84	-8.57	82.23
			5		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) -1.4 (LOAD 3: LOAD CASE 3 EQ-X)	0	1978.36	-145.2	13.41	-8.2	-76.66
			5		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) -1.4 (LOAD 3: LOAD CASE 3 EQ-X)	4.2	1910.29	176.69	-21.01	-8.2	-76.66
			6		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) +1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	0	1981.62	10.84	110.14	-57.02	2.04
			6		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) +1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	4.2	1913.55	2.29	-129.28	-57.02	2.04
			7		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) -1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	0	1943.68	14.48	-82.58	40.25	3.54
			7		1.2 (LOAD 1: LOAD CASE 1) +(LOAD 2: LOAD CASE 2) -1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	4.2	1875.62	-0.37	86.43	40.25	3.54
			8		0.9 (LOAD 1: LOAD CASE 1) +1.4 (LOAD 3: LOAD CASE 3 EQ-X)	0	1158.05	161.56	12.51	-7.21	79.13
			8		0.9 (LOAD 1: LOAD CASE 1) +1.4 (LOAD 3: LOAD CASE 3 EQ-X)	4.2	1107	-170.71	-17.74	-7.21	79.13
			9		0.9 (LOAD 1: LOAD CASE 1) -1.4 (LOAD 3: LOAD CASE 3 EQ-X)	0	1189.47	-154.17	11.78	-6.83	-79.76
			9		0.9 (LOAD 1: LOAD CASE 1) -1.4 (LOAD 3: LOAD CASE 3 EQ-X)	4.2	1138.42	180.74	-16.91	-6.83	-79.76
			10		0.9 (LOAD 1: LOAD CASE 1) +1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	0	1192.73	1.88	108.51	-55.65	-1.06
			10		0.9 (LOAD 1: LOAD CASE 1) +1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	4.2	1141.68	6.34	-125.18	-55.65	-1.06
			11		0.9 (LOAD 1: LOAD CASE 1) -1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	0	1154.8	5.52	-84.21	41.62	0.44
			11		0.9 (LOAD 1: LOAD CASE 1) -1.4 (LOAD 4: LOAD CASE 4 EQ-Y)	4.2	1103.74	3.68	90.53	41.62	0.44

Note:

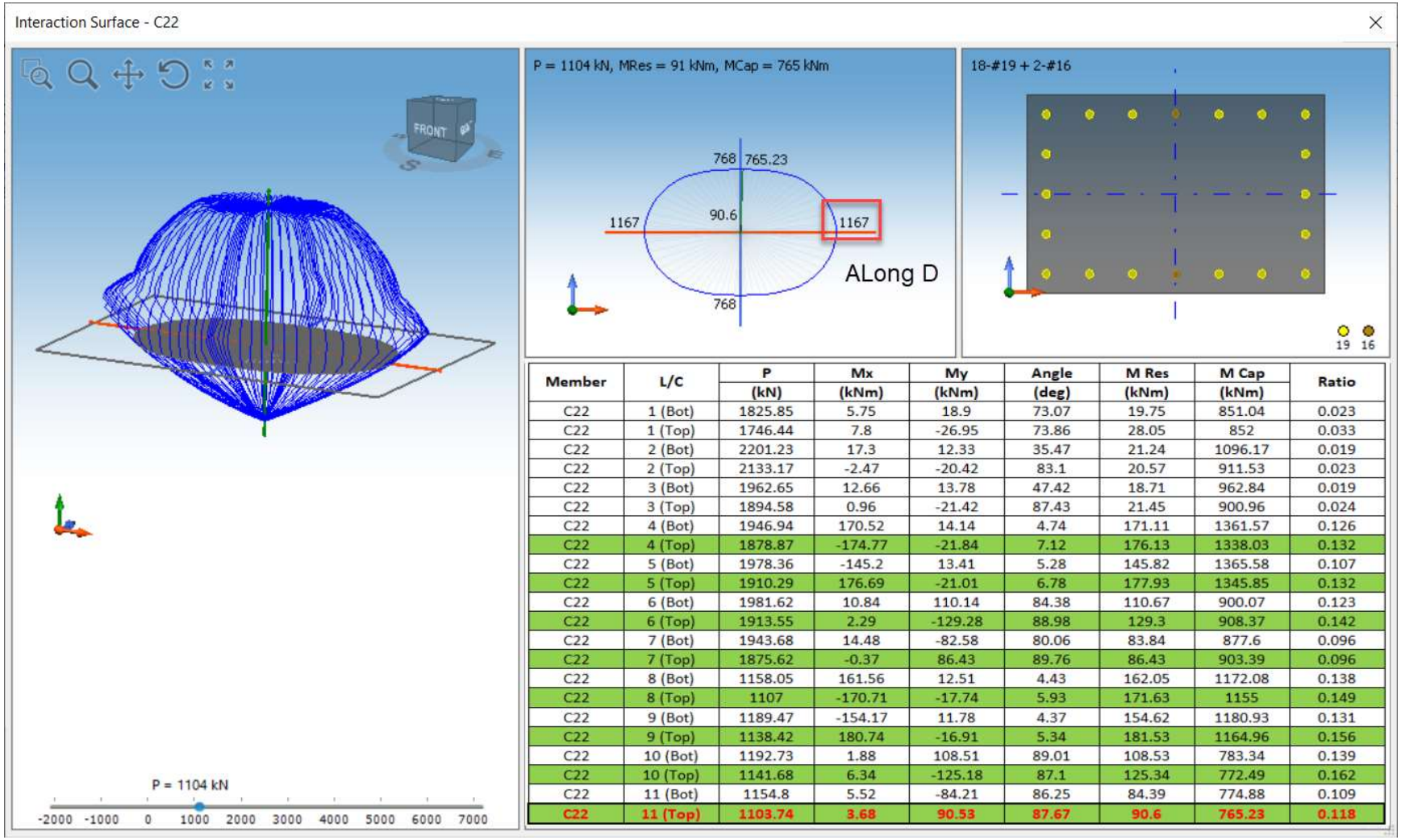
For column moment capacity calculation load combinations contains Earthquake load case should be considered.

Pu from all Eq load combinations which gives minimum moment capacity should be considered.

Along D

Pu which gives Minimum Moment capacity — Pu = 1103.74 kN

Moment Capacity, (Mnc top) — Mcap = 1166.72 kNm (refer below PM curve)

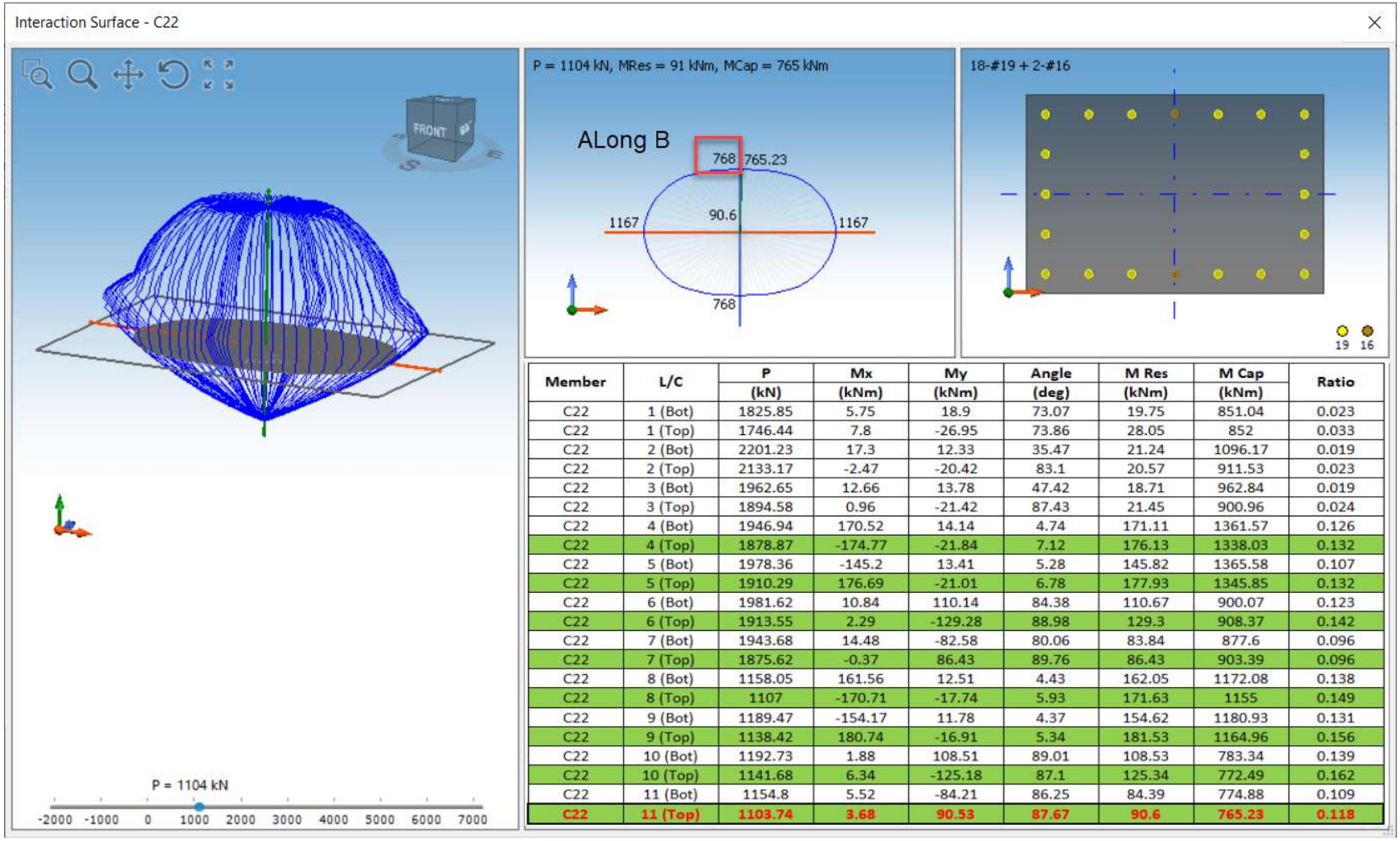


Member	L/C	P (kN)	Mx (kNm)	My (kNm)	Angle (deg)	M Res (kNm)	M Cap (kNm)	Ratio
C22	1 (Bot)	1825.85	5.75	18.9	73.07	19.75	851.04	0.023
C22	1 (Top)	1746.44	7.8	-26.95	73.86	28.05	852	0.033
C22	2 (Bot)	2201.23	17.3	12.33	35.47	21.24	1096.17	0.019
C22	2 (Top)	2133.17	-2.47	-20.42	83.1	20.57	911.53	0.023
C22	3 (Bot)	1962.65	12.66	13.78	47.42	18.71	962.84	0.019
C22	3 (Top)	1894.58	0.96	-21.42	87.43	21.45	900.96	0.024
C22	4 (Bot)	1946.94	170.52	14.14	4.74	171.11	1361.57	0.126
C22	4 (Top)	1878.87	-174.77	-21.84	7.12	176.13	1338.03	0.132
C22	5 (Bot)	1978.36	-145.2	13.41	5.28	145.82	1365.58	0.107
C22	5 (Top)	1910.29	176.69	-21.01	6.78	177.93	1345.85	0.132
C22	6 (Bot)	1981.62	10.84	110.14	84.38	110.67	900.07	0.123
C22	6 (Top)	1913.55	2.29	-129.28	88.98	129.3	908.37	0.142
C22	7 (Bot)	1943.68	14.48	-82.58	80.06	83.84	877.6	0.096
C22	7 (Top)	1875.62	-0.37	86.43	89.76	86.43	903.39	0.096
C22	8 (Bot)	1158.05	161.56	12.51	4.43	162.05	1172.08	0.138
C22	8 (Top)	1107	-170.71	-17.74	5.93	171.63	1155	0.149
C22	9 (Bot)	1189.47	-154.17	11.78	4.37	154.62	1180.93	0.131
C22	9 (Top)	1138.42	180.74	-16.91	5.34	181.53	1164.96	0.156
C22	10 (Bot)	1192.73	1.88	108.51	89.01	108.53	783.34	0.139
C22	10 (Top)	1141.68	6.34	-125.18	87.1	125.34	772.49	0.162
C22	11 (Bot)	1154.8	5.52	-84.21	86.25	84.39	774.88	0.109
C22	11 (Top)	1103.74	3.68	90.53	87.67	90.6	765.23	0.118

Along B

Pu which gives Minimum Moment capacity — Pu = 1103.74 kN

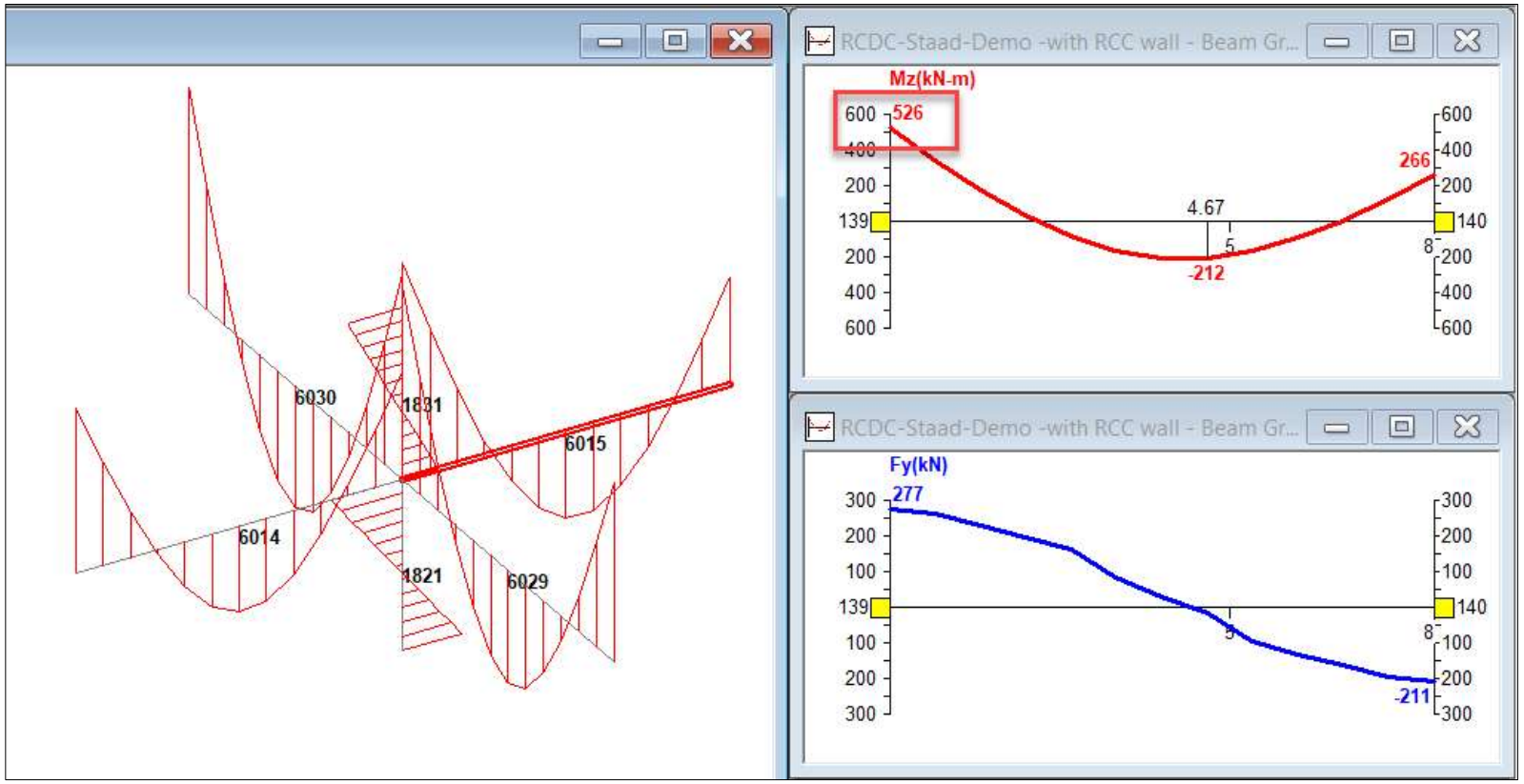
Moment Capacity, (Mnc top) — Mcap = 767.91 kNm (refer below PM curve)



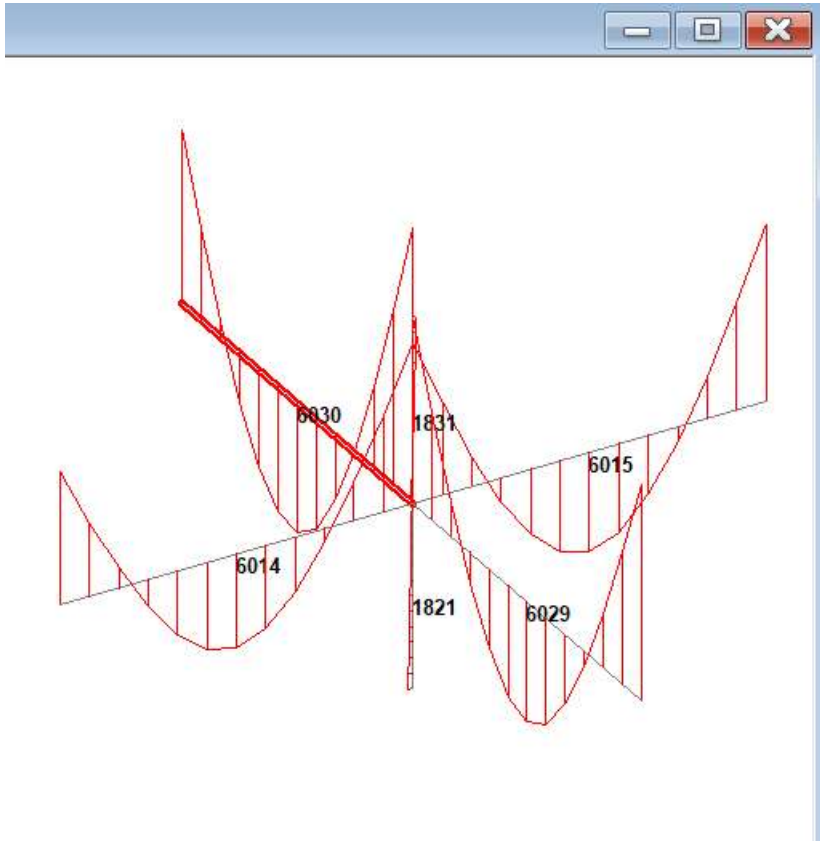
Member	L/C	P (kN)	Mx (kNm)	My (kNm)	Angle (deg)	M Res (kNm)	M Cap (kNm)	Ratio
C22	1 (Bot)	1825.85	5.75	18.9	73.07	19.75	851.04	0.023
C22	1 (Top)	1746.44	7.8	-26.95	73.86	28.05	852	0.033
C22	2 (Bot)	2201.23	17.3	12.33	35.47	21.24	1096.17	0.019
C22	2 (Top)	2133.17	-2.47	-20.42	83.1	20.57	911.53	0.023
C22	3 (Bot)	1962.65	12.66	13.78	47.42	18.71	962.84	0.019
C22	3 (Top)	1894.58	0.96	-21.42	87.43	21.45	900.96	0.024
C22	4 (Bot)	1946.94	170.52	14.14	4.74	171.11	1361.57	0.126
C22	4 (Top)	1878.87	-174.77	-21.84	7.12	176.13	1338.03	0.132
C22	5 (Bot)	1978.36	-145.2	13.41	5.28	145.82	1365.58	0.107
C22	5 (Top)	1910.29	176.69	-21.01	6.78	177.93	1345.85	0.132
C22	6 (Bot)	1981.62	10.84	110.14	84.38	110.67	900.07	0.123
C22	6 (Top)	1913.55	2.29	-129.28	88.98	129.3	908.37	0.142
C22	7 (Bot)	1943.68	14.48	-82.58	80.06	83.84	877.6	0.096
C22	7 (Top)	1875.62	-0.37	86.43	89.76	86.43	903.39	0.096
C22	8 (Bot)	1158.05	161.56	12.51	4.43	162.05	1172.08	0.138
C22	8 (Top)	1107	-170.71	-17.74	5.93	171.63	1155	0.149
C22	9 (Bot)	1189.47	-154.17	11.78	4.37	154.62	1180.93	0.131
C22	9 (Top)	1138.42	180.74	-16.91	5.34	181.53	1164.96	0.156
C22	10 (Bot)	1192.73	1.88	108.51	89.01	108.53	783.34	0.139
C22	10 (Top)	1141.68	6.34	-125.18	87.1	125.34	772.49	0.162
C22	11 (Bot)	1154.8	5.52	-84.21	86.25	84.39	774.88	0.109
C22	**11 (Top)**	**1103.74**	**3.68**	**90.53**	**87.67**	**90.6**	**765.23**	**0.118**

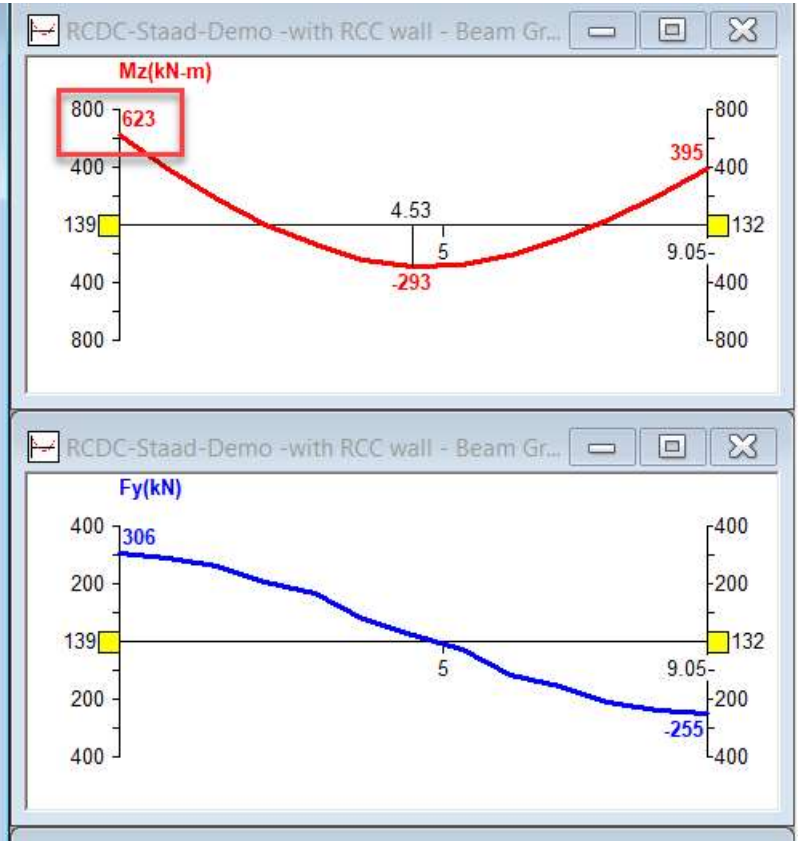
Calculation of Beam Capacity:

Beam @ 0 Location w.r.t. Colum Ly – Load Comb 15 – Maximum Bending Moment

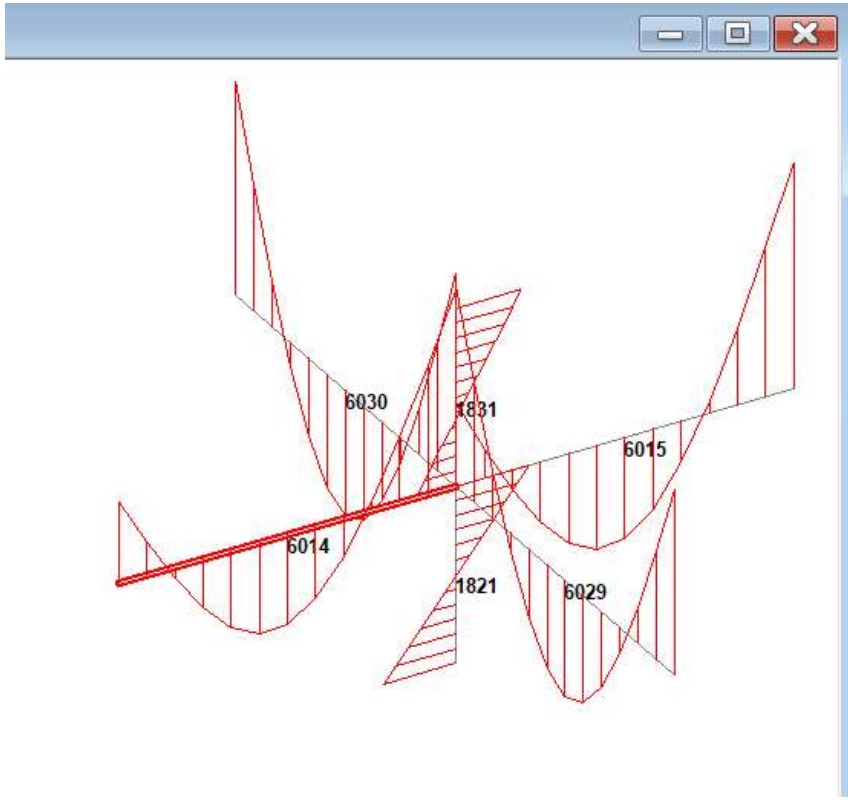


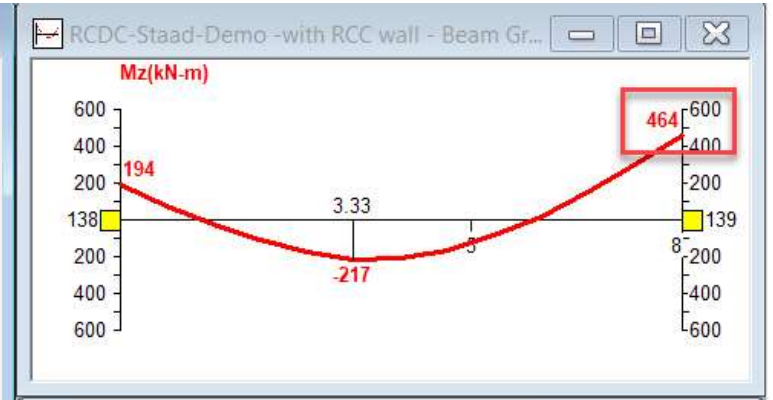
Beam @ 90 Location w.r.t. Colum Ly– Load Comb 16– Maximum Bending Moment

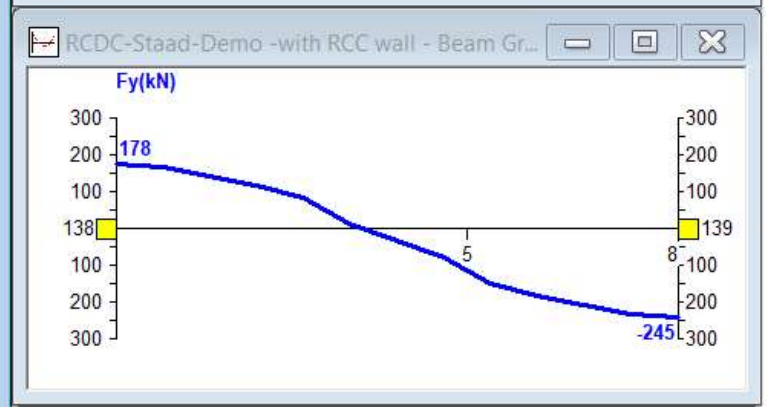




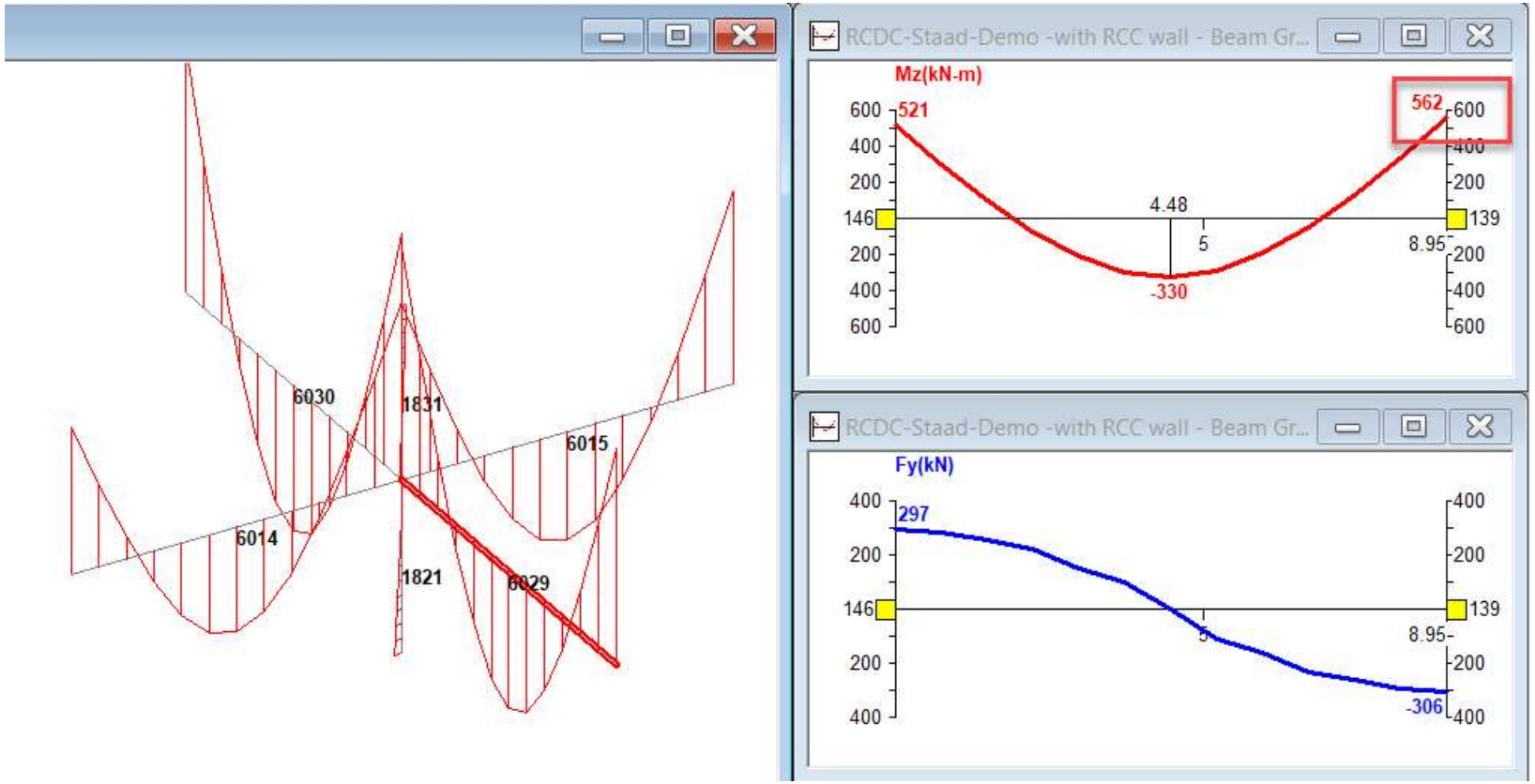
Beam @ 180 Location w.r.t. Colum Ly– Load Comb 14– Maximum Bending Moment







Beam @ 270 Location w.r.t. Colum Ly– Load Comb 13– Maximum Bending Moment



Steps to Calculate Mcap of Beam at Ends:

1. Identifying the angle of Beam in plan w.r.t. column Ly. (Ly= Major direction & Lx = minor direction)
2. Finding out the maximum moment at end of the beam which is supported on column. Calculating the area of reinforcement required in beam for Major direction moment and torsion if any.
3. Detailing the beam with actual rebar diameters and rebar arrangements.
4. Calculating the Mcap of the beam for provided reinforcement.
5. If the beam is not orthogonal to the column axis, resolving the Mcap of that beam along column direction.

6. Finding out the effective moments for column along Ly and Lx of the column.

Sample for calculation of Beam capacity:

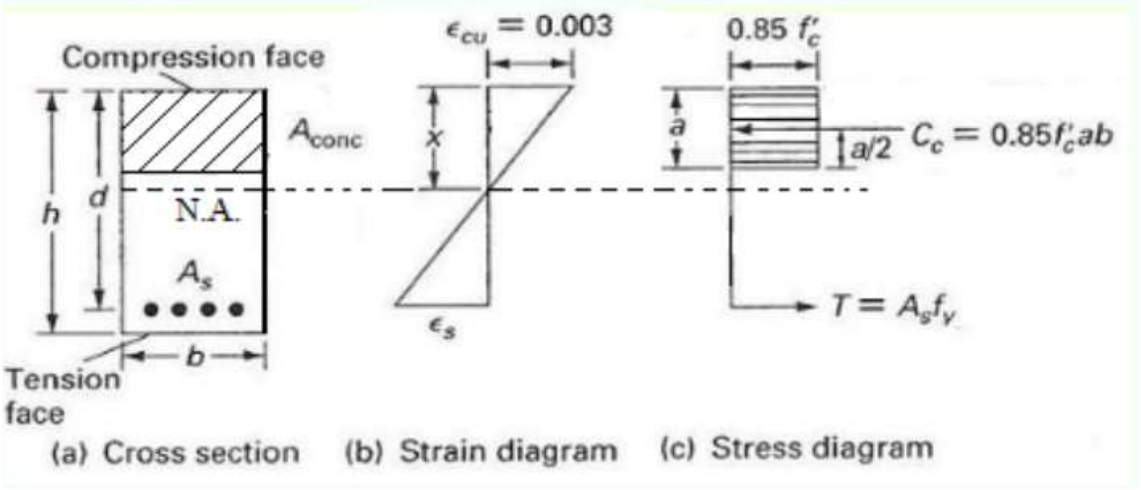
Beam @ 0 Location w.r.t. Colum Ly – Load Comb 15 – Maximum Bending Moment

Beam No	:	**B18**	
Analysis Reference (Member) 12.058 m	:	6015	
Beam Length	:	8000	mm
Breadth (B)	:	450	mm
Depth (D)	:	800	mm
Effective Depth (d)	:	745	mm
Design Code	:	ACI 318M - 2014	
Beam Type	:	Ductile Beam (Special Frame)	
Grade Of Concrete (f'c)	:	C25	N/sqmm
Grade Of Steel	:	Fy420	N/sqmm
Clear Cover (Cmin)	:	40	mm
Es	:	2x10^5	N/sqmm
Mubal	:	1518.23	kNm
As,min (flex) (B)	:	1095	sqmm
As,nominal (Bn)	:	427.05	sqmm
As,min(user input)(B')	:	427.05	sqmm

Calculation of Ast for Mu:

For Longitudinal Reinf						
	Beam Bottom			Beam Top		
	Left	Mid	Right	Left	Mid	Right
Critical L/C - RCDC	8	2	-	5	9	4
Mu (kNm)	80.73	264.03	-	526.57	59.05	538.79
As (flex) (sqmm) (C)	289.15	965.02	-	1986.13	210.99	2035.37
Asc (flex) (sqmm) (A)	-	-	-	-	-	-
Tu (kNm)	-	-	-	-	-	-
Tcr/4 (kNm)	-	-	-	-	-	-
Al, min(sqmm)(Tor.) (D)	-	-	-	-	-	-
Al (sqmm) (Tor.) (E)	-	-	-	-	-	-
Al (Dist) (sqmm) (D)	-	-	-	-	-	-
Ast (sqmm)	435.82	1117.5	1146.08	1986.13	435.82	2035.37
AstPrv (sqmm)	633.4	1140.12	1266.8	2005.64	506.72	2292.16
Reinforcement Provided	5-#13	5-#13 4-#13	5-#13 5-#13	4-#19 3-#19	4-#13	4-#19 4-#19

Calculation of Mcap for provided reinforcement:



Ast provided	=	2005.64 sqmm
Xu-max/Deff	=	0.003 / 0.007
	=	0.428571
Xu-max	=	319.2857 mm
Fc Max	=	Xu-max x 0.85 x f'c x B / 1000
	=	2595.194 kN
Mu-lim	=	Fc Max x (Deff – (0.85 x Xu-max)/2)
	=	1581.261 kN-m
Check		Mu-lim > Mu , Beam to be designed as Singly reinforced section
a	=	Ast provided x fy / (0.85 x f'c x B)
	=	88.09 mm
j	=	(Deff – (0.5 x a)) / Deff
	=	0.940879
c	=	a /0.85
	=	103.6363
Tensile force	=	Ast provided x x fy
	=	842.3688 kN
Xu-act	=	a / 0.85
	=	103.6363 mm
Mn	=	Tensile force x j x Deff
	=	590.462 kN-m
Mcap	=	Mn x 0.9
	=	531.42 kNm

Design of Beam Column Joint for Distortional Shear (Clause 9.1)

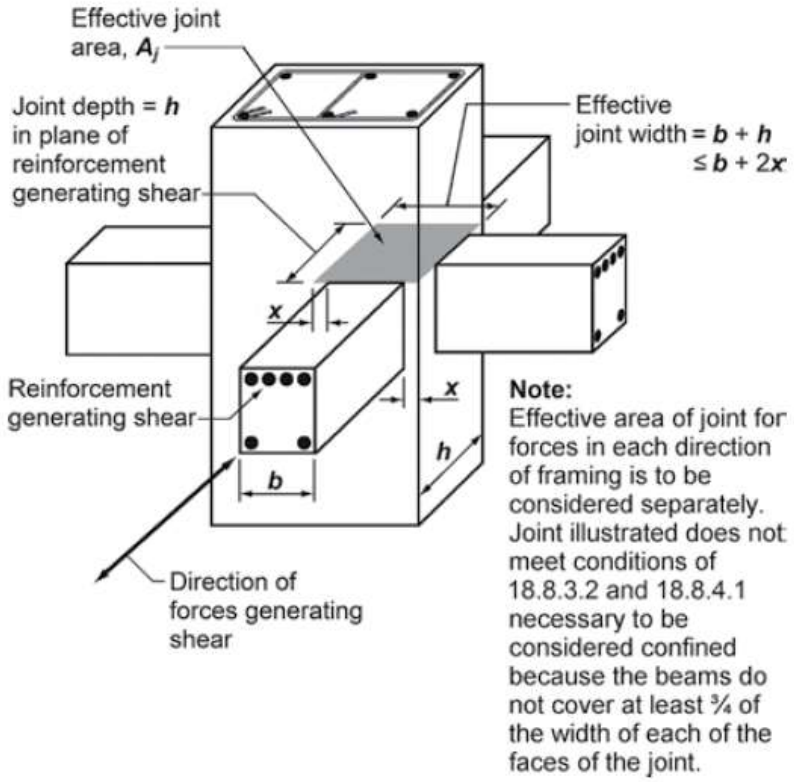


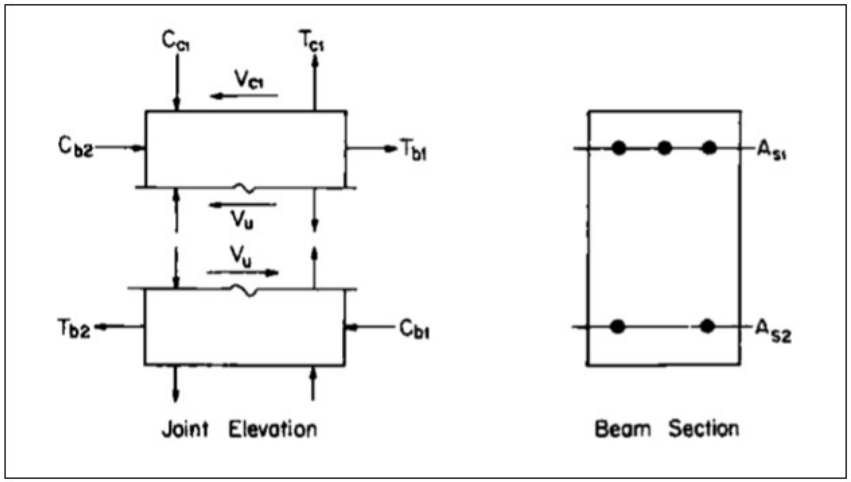
Fig. R18.8.4—Effective joint area.

18.8.4.1 V_n of the joint shall be in accordance with Table 18.8.4.1.

Table 18.8.4.1—Nominal joint shear strength V_n

Joint configuration	V_n
For joints confined by beams on all four faces[1]	$1.7\lambda\sqrt{f'_c}A_j$ [2]
For joints confined by beams on three faces or on two opposite faces[1]	$1.2\lambda\sqrt{f'_c}A_j$ [2]
For other cases	$1.0\lambda\sqrt{f'_c}A_j$ [2]

Below is the snap showing shear to be considered for Joint check.



Joint shear, $V_u = T_{b1} + C_{b2} - V_{c1}$

where,

$C_{b1} = T_{b1} = 1.25 f_y A_{s1}$

$T_{b2} = C_{b2} = 1.25 f_y A_{s2}$

V_{C1} is column shear

Output from RCDC

Beams Along D

Angle w.r.t Column Ly	Reference Location	Width	Depth	Ast Pro Top	Ast Pro Bot
(deg)		(mm)	(mm)	(sqmm)	(sqmm)
0	Right	450	800	2005.64	1013.44
180	Left	300	900	1588.48	886.76

Shear Checks

Conditions	AST-Total	V-Reinf	Vuy	Vj (Shear Demand)	B'	D'	Aj	Vn'	Vj < Vn'
	(sqmm)	(kN)	(kN)	(kN)	(mm)	(mm)	(sqmm)	(kN)	
Right Top + Left Bottom	2892.4	1518.51	805.07	713.44	600	900	540000	4590	OK
Left Top + Right Bottom	2601.92	1366.01	805.07	560.94	600	900	540000	4590	OK

Beams Along B

Angle w.r.t Column Ly	Reference Location	Width	Depth	Ast Pro Top	Ast Pro Bot
(deg)		(mm)	(mm)	(sqmm)	(sqmm)
90	Right	500	800	2382.72	1266.8
270	Left	400	600	3546.97	1626.2

Shear Checks

Conditions	AST-Total	V-Reinf	Vux	Vj (Shear Demand)	B'	D'	Aj	Vn'	Vj < Vn'
	(sqmm)	(kN)	(kN)	(kN)	(mm)	(mm)	(sqmm)	(kN)	
Right Top + Left Bottom	4008.92	2104.68	958.23	1146.46	900	600	540000	4590	OK
Left Top + Right Bottom	4813.77	2527.23	958.23	1569	900	600	540000	4590	OK

Example for calculation of effective width:

For Shear Along D of the Column

Beam Resting on the 0 degree w.r.t. Column Ly

Column Size = 600 x 900

Beam Size = 450 x 800

x = (600 – 450)/2

= 75 mm

Effective Width(B'1) = b + 2x

= 450+2x75

= 600 mm

Effective Width(B'2) = B+hc

= 450+800

= 1250 mm

Effective Width(B') = Min (600,1250)

= 600 mm

Effective Depth = D' (Column Depth)

= 900 mm

Effective area = 600 x 900

= 540000 sqmm

V-Reinf. calculation:

Right top + left Bottom = 2005.64 + 886.76

= 2892.4 Sqmm

V-reinf = 2892.4 x 420 x 1.25 x /1000

= 1518.51 kN

Note:

Beam capacity is calculated like explained in Flexural joint check.

Check At Beam-Column Joints:

1. Flexure Strength Of Joint:

Moment Capacity Calculations for Beam

Concrete Grade,fck = C25 N/sqmm

Steel Grade,fy = Fy420 N/sqmm

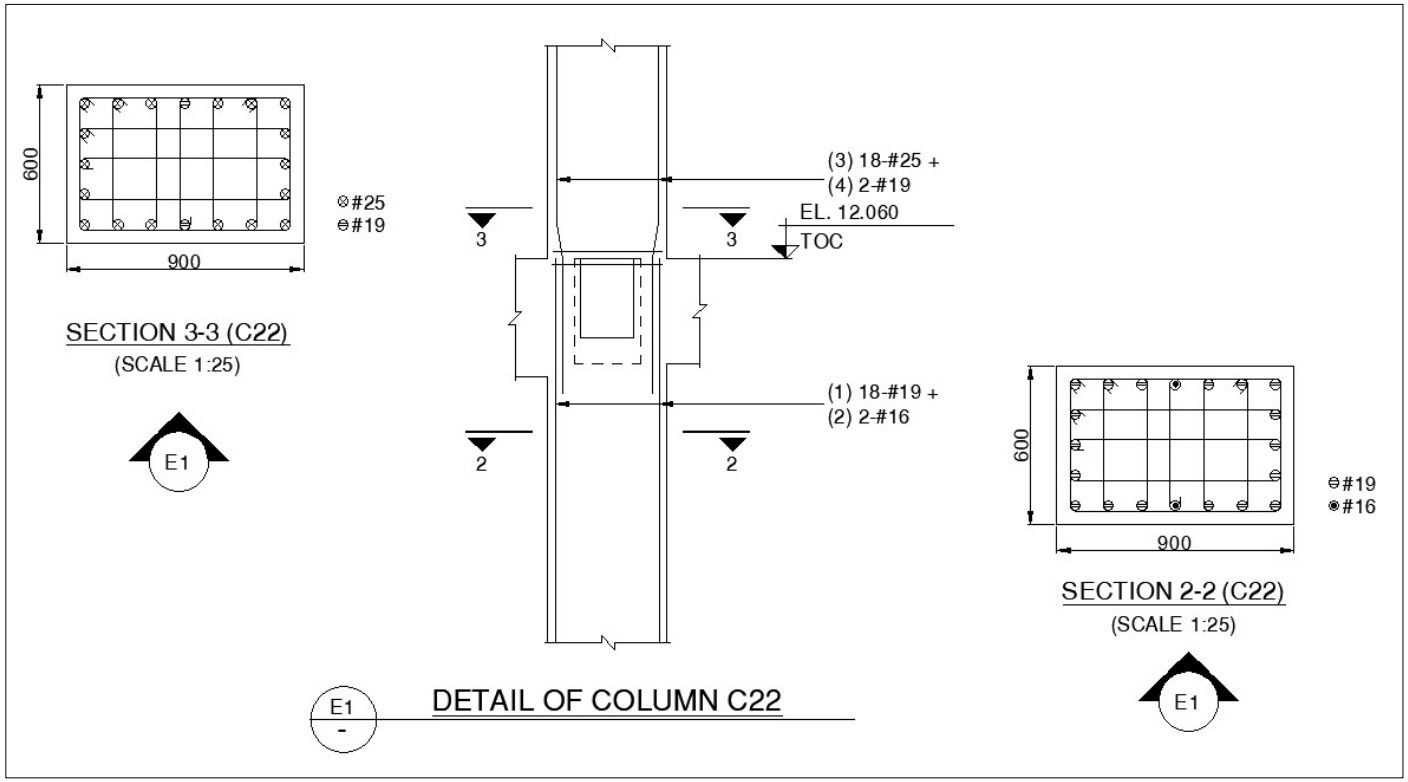
Beam Size	Beam angle w.r.t. column Ly	Torsion moment	Moment Capacity for Top Reinforcement				Moment Capacity for Bottom Reinforcement				Resultant Moment			
(mm)	(deg)	(kNm)	Mu (kNm)	Ast Req (sqmm)	Ast Pro (sqmm)	Mu Cap (kNm)	Mu (kNm)	Ast Req (sqmm)	Ast Pro (sqmm)	Mu Cap (kNm)	Top @ D (kNm)	Top @ B (kNm)	Bot @ D (kNm)	Bot @ B (kNm)
450 x 800	0	0	526.57	1986.13	2005.64	531.42	0	993.07	1013.44	277.05	531.42	0	277.05	0
500 x 800	90	0.69	622.63	2358.55	2382.72	628.58	0	1179.28	1266.8	345.01	0	628.58	0	345.01
300 x 900	180	0.48	464.11	1546.22	1588.48	475.96	0	773.11	886.76	273.66	475.96	0	273.66	0
400 x 600	270	0.46	562.24	3190.69	3546.97	613.22	0	1595.34	1626.2	310.84	0	613.22	0	310.84

Effective Moment for Beam

	Along D		Along B	
	Left	Right	Left	Right
Top (kNm)	475.96	531.42	613.22	628.58
Bottom (kNm)	273.66	277.05	310.84	345.01
Mnb (kNm)	MAX((Left Bottom + Right Top), (Left Top + Right		MAX((Left Top + Right Bottom), (Right Top + Left	
	805.07		958.23	

Vj (Shear Demand)	=1518.51 – 805.07	
	= 713.44 kN	
Vn'	= 1.7 x λ x Sqrt (f'c) x Aj	
	= 1.7 x 1 x Sqrt (25) x 540000	
	= 4590 kN	
Check	Vj < Vn'	Ok

RCDC DRAWING OUTPUT



STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 17-Apr-19
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
1 0 0 0; 2 8 0 0; 3 16 0 0; 4 24 0 0; 5 31.96 0 0; 6 0 0 5.71; 7 8 0 5.71;
8 16 0 5.71; 9 24 0 5.71; 10 31.96 0 5.71; 11 0 0 14.61; 12 8 0 14.61;
13 16 0 14.61; 14 24 0 14.61; 16 36.77 0 14.61; 17 46.08 0 10.87; 18 0 0 23.66;
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29 31.96 0 32.61; 30 37.83 0 32.61; 31 42.7 0 32.61; 41 0 4.2 0; 42 8 4.2 0;
43 16 4.2 0; 44 24 4.2 0; 45 31.96 4.2 0; 46 0 4.2 5.71; 47 8 4.2 5.71;
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112 33.8399 7.8576 5.71; 113 31.96 7.8576 17.86; 114 37.8402 7.8576 17.86;

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125 31.96 12.0576 0; 126 0 12.0576 5.71; 127 8 12.0576 5.71;
128 16 12.0576 5.71; 129 24 12.0576 5.71; 130 31.96 12.0576 5.71;
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168 16 16.2576 5.71; 169 24 16.2576 5.71; 170 31.96 16.2576 5.71;
171 0 16.2576 14.61; 172 8 16.2576 14.61; 173 16 16.2576 14.61;
174 24 16.2576 14.61; 175 31.96 16.2576 14.61; 176 36.77 16.2576 14.61;
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181 24 16.2576 23.66; 182 31.96 16.2576 23.66; 183 39.75 16.2576 23.66;
185 0 16.2576 32.61; 186 8 16.2576 32.61; 187 16 16.2576 32.61;
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7099 222 226; 7100 227 216; 7101 216 218; 7102 218 220; 7103 220 222;
7104 76 223; 7105 116 224; 7106 156 225; 7107 196 226;
DEFINE MATERIAL START
ISOTROPIC CONCRETE
E 2.5e+07
POISSON 0.17
DENSITY 25
ALPHA 1e-05
DAMP 0.05
ISOTROPIC CONCDUMMY
E 2.5e+07
POISSON 0.17
DENSITY 0
ALPHA 1e-05
DAMP 0.05
END DEFINE MATERIAL
MEMBER PROPERTY INDIAN
1 11 21 31 101 111 121 131 201 211 221 231 301 311 321 331 401 411 421 431 -
501 511 521 531 601 611 621 631 701 711 721 731 801 811 821 831 901 911 921 -
931 1001 1011 1021 1031 1101 1111 1121 1131 1201 1211 1221 1231 1301 1311 -
1321 1331 1701 1711 1721 1731 2001 2011 2021 2031 2101 2111 2121 2131 2701 -
2711 2721 2731 2801 2811 2821 2831 2901 2911 2921 2931 3001 3011 3021 -
3031 PRIS IX 1e-09 YD 0.7 ZD 0.7
1501 1511 1521 1531 2201 2211 2221 -
2231 PRIS AX 0.315 IX 1e-09 IY 0.00531562 IZ 0.0128625 YD 0.9 ZD 0.6
1601 1611 2301 -
2311 PRIS AX 0.2025 IX 1e-09 IY 0.00341719 IZ 0.00341719 YD 0.5 ZD 0.5
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MEMBER PROPERTY INDIAN
4001 TO 4004 4019 TO 4028 4041 4042 4044 4048 TO 4050 4054 4056 4059 4063 -
4064 5001 TO 5004 5019 TO 5028 5041 5042 5044 5048 TO 5050 5054 5056 5059 -
5063 5064 6001 TO 6004 6019 TO 6028 6041 6042 6044 6054 6056 6059 6063 6064 -
7001 TO 7004 7019 TO 7028 7041 7042 7044 7054 7056 7059 7063 7064 7088 7090 -
7092 7094 PRIS AX 0.315 IX 1e-09 IY 0.00321562 IZ 0.0212625 YD 0.8 ZD 0.4
4005 TO 4012 4015 TO 4018 4031 TO 4040 4045 TO 4047 4051 4052 4055 4057 4061 -
4062 5005 TO 5012 5015 TO 5018 5031 TO 5040 5045 TO 5047 5051 5052 5055 5057 -
5061 5062 6005 TO 6012 6015 TO 6018 6031 TO 6040 6045 TO 6047 6051 6052 6055 -
6057 6061 6062 7005 TO 7012 7015 TO 7018 7031 TO 7040 7045 TO 7047 7051 7052 -
7055 7057 7061 -
7062 PRIS AX 0.54 IX 1e-09 IY 0.0162 IZ 0.03645 YD 0.8 ZD 0.45
4060 5060 6060 -
7060 PRIS AX 0.1725 IX 1e-09 IY 0.000760437 IZ 0.00808594 YD 0.75 ZD 0.23
MEMBER PROPERTY INDIAN
7077 7079 TO 7083 7086 7087 PRIS YD 3.55 ZD 0.35
7100 TO 7103 PRIS YD 2.4 ZD 0.3
MEMBER PROPERTY INDIAN
4043 4053 4058 5043 5053 5058 6043 6053 6058 7043 7053 7058 7065 TO 7072 7089 -
7091 7093 7095 TO 7099 7104 TO 7107 PRIS YD 4.2 ZD 0.35
MEMBER PROPERTY INDIAN
1801 1811 1821 1831 1901 1911 1921 1931 2401 2411 2421 2431 2501 2511 2521 -
2531 2601 2611 2621 2631 PRIS YD 0.9 ZD 0.6
MEMBER PROPERTY
4029 5029 6029 7029 PRIS YD 0.6 ZD 0.4
4030 5030 6030 7030 PRIS YD 0.8 ZD 0.5
4014 5014 6014 7014 PRIS YD 0.9 ZD 0.3
SUPPORTS
1 TO 4 6 TO 9 11 TO 14 16 TO 21 23 TO 28 30 31 FIXED
5 10 22 29 213 214 227 FIXED
CONSTANTS
BETA 90 MEMB 1901 1911 1921 1931 2601 2611 2621 2631 7077 7079 TO 7083 7086 -
7087
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MATERIAL CONCRETE MEMB 1 11 21 31 101 111 121 131 201 211 221 231 301 311 -
321 331 401 411 421 431 501 511 521 531 601 611 621 631 701 711 721 731 801 -
811 821 831 901 911 921 931 1001 1011 1021 1031 1101 1111 1121 1131 1201 -
1211 1221 1231 1301 1311 1321 1331 1501 1511 1521 1531 1601 1611 1701 1711 -
1721 1731 1801 1811 1821 1831 1901 1911 1921 1931 2001 2011 2021 2031 2101 -
2111 2121 2131 2201 2211 2221 2231 2301 2311 2401 2411 2421 2431 2501 2511 -
2521 2531 2601 2611 2621 2631 2701 2711 2721 2731 2801 2811 2821 2831 2901 -
2911 2921 2931 3001 3011 3021 3031 4001 TO 4012 4014 TO 4042 4044 TO 4052 -
4054 TO 4057 4059 TO 4064 5001 TO 5012 5014 TO 5042 5044 TO 5052 -
5054 TO 5057 5059 TO 5064 6001 TO 6012 6014 TO 6042 6044 TO 6047 6051 6052 -
6054 TO 6057 6059 TO 6064 7001 TO 7012 7014 TO 7042 7044 TO 7047 7051 7052 -
7054 TO 7057 7059 TO 7064 7077 7079 TO 7083 7086 TO 7088 7090 7092 7094 7100 -
7101 TO 7103
MATERIAL CONCDUMMY MEMB 4043 4053 4058 5043 5053 5058 6043 6053 6058 7043 -
7053 7058 7065 TO 7072 7089 7091 7093 7095 TO 7099 7104 TO 7107
LOAD 1 LOADTYPE Dead  TITLE LOAD CASE 1
SELFWEIGHT Y -1
MEMBER LOAD
4001 TO 4004 4019 TO 4028 4041 4042 4053 4059 4060 4063 4064 5001 TO 5004 -
5019 TO 5028 5041 5042 5053 5059 5060 5063 5064 6001 TO 6004 6019 TO 6028 -
6041 6042 6053 6059 6060 6063 6064 7065 7067 7069 UNI GY -14.285
7001 TO 7004 7019 TO 7028 7041 7042 7053 7059 7060 7063 7064 7071 UNI GY -5
FLOOR LOAD
YRANGE 7 16 FLOAD -6 XRANGE 0 33  ZRANGE 0 33  GY
YRANGE 7 16 FLOAD -6 XRANGE 31.96 36.77  ZRANGE 0 14.61  GY
YRANGE 7 16 FLOAD -6 XRANGE 31.96 42.7  ZRANGE 23.66 32.61  GY
YRANGE 7 16 FLOAD -6 XRANGE 31.96 39.75  ZRANGE 17.86 23.66  GY
YRANGE 7 16 FLOAD -6 XRANGE 34.36 37.84  ZRANGE 14.61 17.86  GY
YRANGE 7 10 FLOAD -6 XRANGE 36.77 49.06  ZRANGE 10.87 23.66  GY
YRANGE 15 17 FLOAD -6 XRANGE 0 33  ZRANGE 0 33  GY
YRANGE 15 17 FLOAD -6 XRANGE 31.96 36.77  ZRANGE 0 14.61  GY
YRANGE 15 17 FLOAD -6 XRANGE 31.96 42.7  ZRANGE 23.66 32.61  GY
YRANGE 15 17 FLOAD -6 XRANGE 31.96 39.75  ZRANGE 17.86 23.66  GY
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YRANGE 15 17 FLOAD -6 XRANGE 34.36 37.84 ZRANGE 14.61 17.86 GY
LOAD 2 LOADTYPE Live TITLE LOAD CASE 2
FLOOR LOAD
YRANGE 7 16 FLOAD -4 XRANGE 0 33 ZRANGE 0 33 GY
YRANGE 7 16 FLOAD -4 XRANGE 31.96 36.77 ZRANGE 0 14.61 GY
YRANGE 7 16 FLOAD -4 XRANGE 31.96 42.7 ZRANGE 23.66 32.61 GY
YRANGE 7 16 FLOAD -4 XRANGE 31.96 39.75 ZRANGE 17.86 23.66 GY
YRANGE 7 16 FLOAD -4 XRANGE 34.36 37.84 ZRANGE 14.61 17.86 GY
YRANGE 7 10 FLOAD -2 XRANGE 36.77 49.06 ZRANGE 10.87 23.66 GY
YRANGE 15 17 FLOAD -1.5 XRANGE 0 33 ZRANGE 0 33 GY
YRANGE 15 17 FLOAD -1.5 XRANGE 31.96 36.77 ZRANGE 0 14.61 GY
YRANGE 15 17 FLOAD -1.5 XRANGE 31.96 42.7 ZRANGE 23.66 32.61 GY
YRANGE 15 17 FLOAD -1.5 XRANGE 31.96 39.75 ZRANGE 17.86 23.66 GY
YRANGE 15 17 FLOAD -1.5 XRANGE 34.36 37.84 ZRANGE 14.61 17.86 GY
LOAD 3 LOADTYPE None TITLE LOAD CASE 3 EQ-X
JOINT LOAD
161 TO 176 178 TO 183 185 TO 191 221 FX 35
121 TO 136 138 TO 143 145 TO 151 219 FX 15
81 TO 111 217 FX 7.5
41 TO 71 215 FX 2
LOAD 4 LOADTYPE None TITLE LOAD CASE 4 EQ-Y
JOINT LOAD
161 TO 176 178 TO 183 185 TO 191 221 FZ 35
121 TO 136 138 TO 143 145 TO 151 219 FZ 15
81 TO 111 217 FZ 7.5
41 TO 71 215 FZ 2
LOAD COMBINATION 11
1 1.4
LOAD COMBINATION 12
1 1.2 2 1.0
LOAD COMBINATION 13
1 1.2 2 1.6
LOAD COMBINATION 14

1 1.2 2 1.0 3 1.4
LOAD COMBINATION 15
1 1.2 2 1.0 3 -1.4
LOAD COMBINATION 16
1 1.2 2 1.0 4 1.4
LOAD COMBINATION 17
1 1.2 2 1.0 4 -1.4
LOAD COMBINATION 18
1 0.9 3 1.4
LOAD COMBINATION 19
1 0.9 3 -1.4
LOAD COMBINATION 20
1 0.9 4 1.4
LOAD COMBINATION 21
1 0.9 4 -1.4
PERFORM ANALYSIS
FINISH