1001 – AISC C.1A - Moment Frame Design

Description

Determine the required strengths and effective length factors for the ASTM A992 material columns in the moment frame shown in Figure 1 for the maximum gravity load combination, using LRFD and ASD, see [1]. The uniform load w_D includes beam self-weight and an allowance for column self-weight. Use the direct analysis method.

Material		Modulus of Elasticity	E	29000.000	ksi
Geometry	Structure	Length	L	30.000	ft
	Cross-section W 12×65	Gross Area	A_g	19.100	in^2
Load		Dead	w_D	0.400	kip · ft
		Live	w_L	1.200	kip · ft

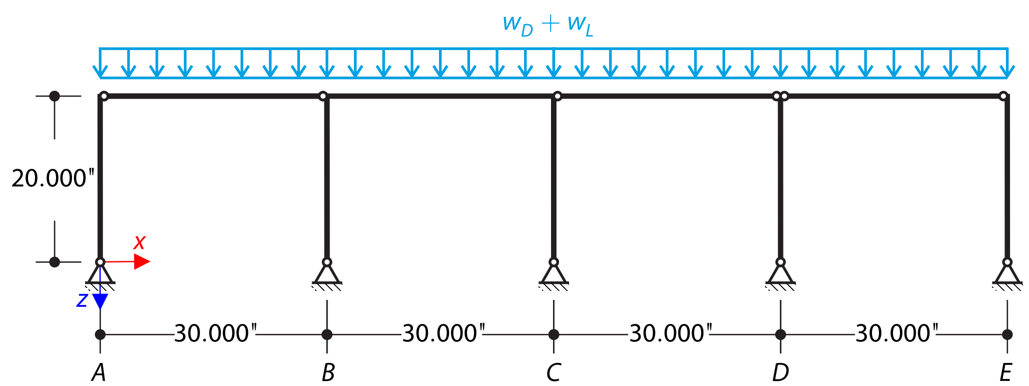

Figure 1: Moment Frame Elevation

AISC Solution

The beams from grid lines A to B and C to E and the columns at A, D, and E are pinned at both ends and do not contribute to the lateral stability of the frame. There are no P-Δeffects to consider in these members and they may be designed using $L_c = L$.

From Chapter 2 of ASCE/SEI 7, the maximum gravity load combinations are

LRFD	ASD
$\omega_u = 1.2w_D + 1.6w_L = 1.600$ kip · ft	$\omega_u = w_D + w_L = 1.600$ kip · ft

Per AISC Specification Section C2.1(d), for LRFD, perform a second-order analysis and member strength checks using the LRFD load combinations. For ASD, perform a second-order analysis using 1.6 times the ASD load combinations and divide the analysis results by 1.6 for the ASD member strength checks.

The uniform gravity loads to be considered in a second-order analysis on the beam from B to C are

LRFD	ASD
$\omega_u' = 2.400$ kip·ft	$\omega_u' = 2.560$ kip·ft

Concentrated gravity loads to be considered in a second-order analysis on the columns at B and C contributed by adjacent beams are

LRFD	ASD
$P_u' = (\omega_u' \cdot l)/2 = 36.000$ kips	$P_a' = (\omega_a' \cdot l)/2 = 38.400$ kips

Per AISC Specification Section C2.2, frame out-of-plumbness must be accounted for either by explicit modeling of the assumed out-of-plumbness or by the application of notional loads. Use notional loads.

Per AISC Specification Equation C2-1, the notional loads are

LRFD	ASD
$\alpha = 1$ $Y_i = 288.000$ kips $N_i = 0.002 \cdot \alpha Y_i = 0.572$ kips	$\alpha = 1.6$ $Y_i = 192.000$ kips $N_i = 0.002 \cdot \alpha Y_i = 0.614$ kips

Assume, subject to verification, that $(\alpha P_r)/P_{ns}$ is not greater than 0.500; therefore, no additional stiffness reduction is required

$$\tau_b = 1$$

Half of the gravity load is carried by the columns of the moment-resisting frame. Because the gravity load supported by the moment-resisting frame columns exceeds one-third of the total gravity load tributary to the frame, per AISC Specification Section C2.1, the effects of P-δ and P-Δ must be considered in the frame analysis.

RFEM 5 Settings

- Modeled in RFEM 5.14.03
- Isotropic linear elastic model is used
- Shear stiffness of members is activated

Results

Results from both a first-order and a second-order analysis are shown. (The first-order analysis is shown for reference only.) In each case, the drift is the average of drifts at grid lines B and C.

1 First-Order Analysis Results

Design	Joint [Units]	AISC Solution	RFEM Solution	Ratio [-]
LRFD	B_{Fy} [kips]	71.600	71.613	1.000
	C_{Fy} [kips]	72.400	72.318	0.999
	B_{Fx} [kips]	5.640	5.638	0.999
	C_{Fx} [kips]	-6.210	-6.214	1.001
	B_{My} [kips·ft]	113.000	112.763	0.998
	C_{My} [kips·ft]	124.000	124.283	1.002
ASD	B_{Fy} [kips]	47.700	47.742	1.001
	C_{Fy} [kips]	48.300	48.254	0.999
	B_{Fx} [kips]	3.760	3.759	0.999
	C_{Fx} [kips]	-4.140	-4.143	1.001
	B_{My} [kips·ft]	75.200	75.178	0.999
	C_{My} [kips·ft]	82.800	82.583	1.001

2 Second-Order Analysis Results

Design	Joint [Units]	AISC Solution	RFEM Solution	Ratio [-]
LRFD	B_{Fy} [kips]	71.400	71.376	0.999
	C_{Fy} [kips]	72.600	72.618	1.000
	B_{Fx} [kips]	5.520	5.520	1.000
	C_{Fx} [kips]	-6.260	-6.273	1.002
	B_{My} [kips·ft]	109.000	108.613	0.996
	C_{My} [kips·ft]	127.000	127.234	1.002
ASD	B_{Fy} [kips]	47.742	47.700	1.001
	C_{Fy} [kips]	48.400	48.429	1.001
	B_{Fx} [kips]	3.680	3.670	0.998
	C_{Fx} [kips]	-4.180	-4.188	1.002
	B_{My} [kips·ft]	72.200	72.113	0.999
	C_{My} [kips·ft]	84.800	85.062	1.003

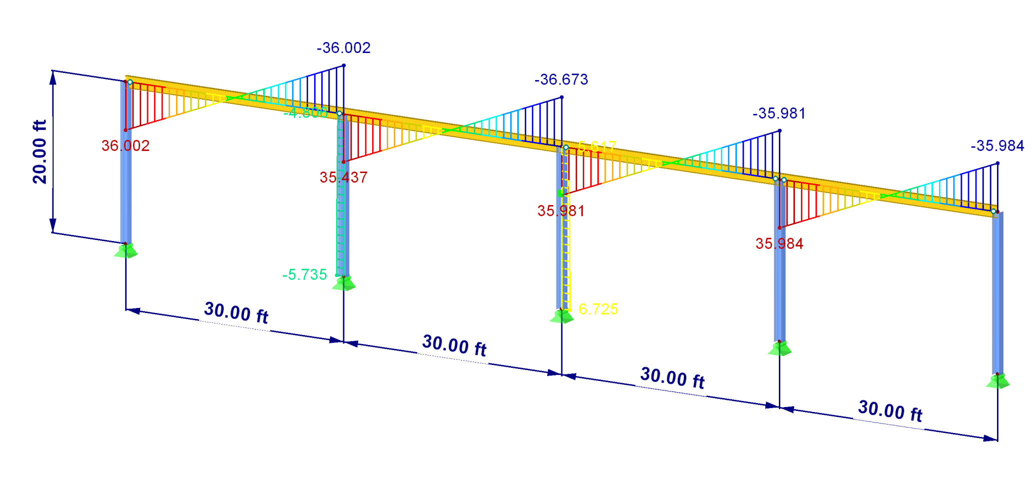

Figure 2: RFEM 5 results - Shear V_z in z-axis (2nd Order LRFD)

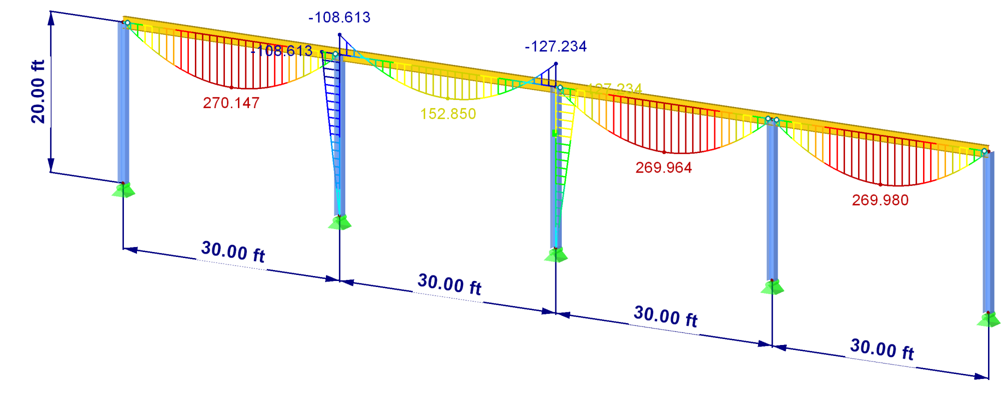

Figure 3: RFEM 5 results - Moment M_y about y-axis (2nd Order LRFD)

References

[1] AMERICAN INSTITUTE OF STEEL CONSTRUCTION, *Specification for Structural Steel Buildings*. 2015.