

1029 – Moment Frame Design According to AISC

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

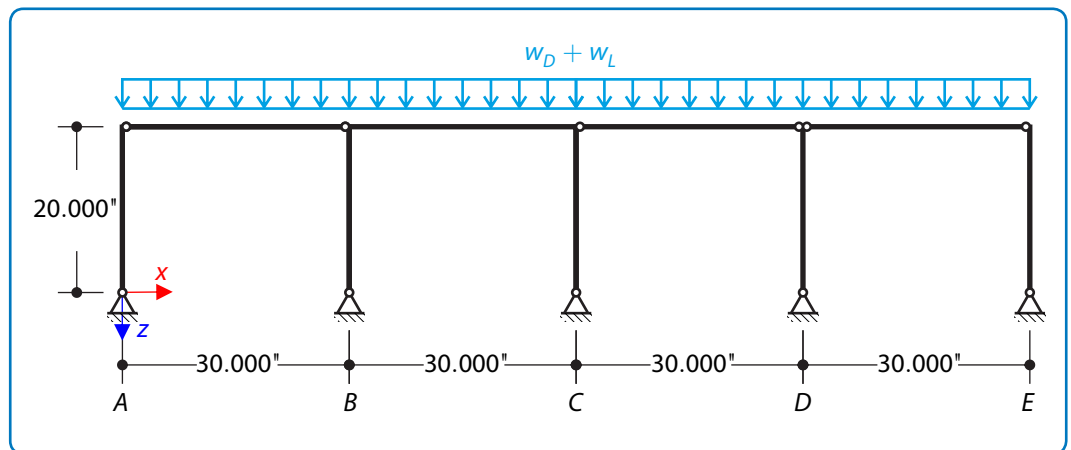


Figure 1: Moment Frame Elevation

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- Δ effects 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
$\omega_u = 1.2w_D + 1.6w_L = 1.600 \text{ kip·ft}$	$\omega_u = w_D + w_L = 1.600 \text{ kip·ft}$

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.

Verification Example: 1029 – Moment Frame Design According to AISC

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

LRFD	ASD
$\omega'_u = 2.400 \text{ kip}\cdot\text{ft}$	$\omega'_u = 2.560 \text{ kip}\cdot\text{ft}$

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
$P'_u = (\omega'_u \cdot l)/2 = 36.000 \text{ kips}$	$P'_a = (\omega'_a \cdot l)/2 = 38.400 \text{ kips}$

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
$\alpha = 1$ $Y_i = 288.000 \text{ kips}$ $N_i = 0.002 \cdot \alpha Y_i = 0.572 \text{ kips}$	$\alpha = 1.6$ $Y_i = 192.000 \text{ kips}$ $N_i = 0.002 \cdot \alpha Y_i = 0.614 \text{ kips}$

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 $P-\delta$ and $P-\Delta$ must be considered in the frame analysis.

RFEM 6 Settings

- Modeled in RFEM 6.08.0010
- 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]	RFEM Solution	AISC Solution	Ratio [-]
LRFD	B_{Fy} [kips]	71.612	71.600	1.000
	C_{Fy} [kips]	72.380	72.400	1.000
	B_{Fx} [kips]	5.639	5.640	1.000
	C_{Fx} [kips]	-6.215	-6.210	0.999
	B_{My} [kips·ft]	112.785	113.000	0.998
	C_{My} [kips·ft]	124.304	124.000	0.994
ASD	B_{Fy} [kips]	47.588	47.742	0.997
	C_{Fy} [kips]	48.407	48.407	1.000
	B_{Fx} [kips]	3.644	3.645	1.000
	C_{Fx} [kips]	-4.258	-4.259	1.000
	B_{My} [kips·ft]	75.888	72.890	1.000
	C_{My} [kips·ft]	85.168	85.170	1.000

2 Second-Order Analysis Results

Design	Joint [Units]	RFEM Solution	AISC Solution	Ratio [-]
LRFD	B_{Fy} [kips]	71.376	71.400	0.999
	C_{Fy} [kips]	72.617	72.600	1.000
	B_{Fx} [kips]	5.522	5.520	1.000
	C_{Fx} [kips]	-6.274	-6.260	0.998
	B_{My} [kips·ft]	108.644	109.000	0.997
	C_{My} [kips·ft]	127.256	127.270	1.000
ASD	B_{Fy} [kips]	47.450	47.600	0.997
	C_{Fy} [kips]	48.546	48.400	1.003
	B_{Fx} [kips]	3.580	3.680	0.973
	C_{Fx} [kips]	-4.180	-4.297	0.973
	B_{My} [kips·ft]	72.551	72.200	0.995
	C_{My} [kips·ft]	86.990	84.800	0.975

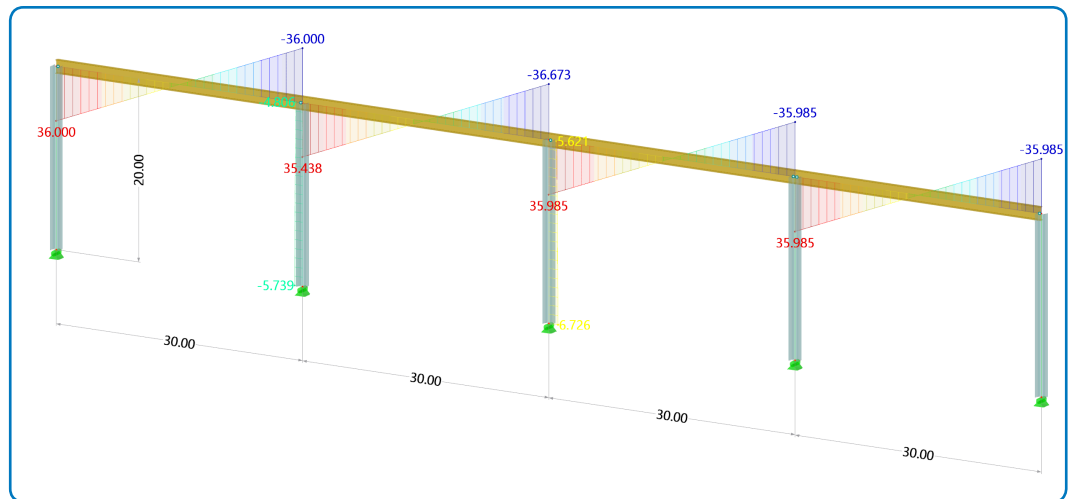


Figure 2: RFEM 6 results - Shear V_z in z-axis (2nd Order LRFD)

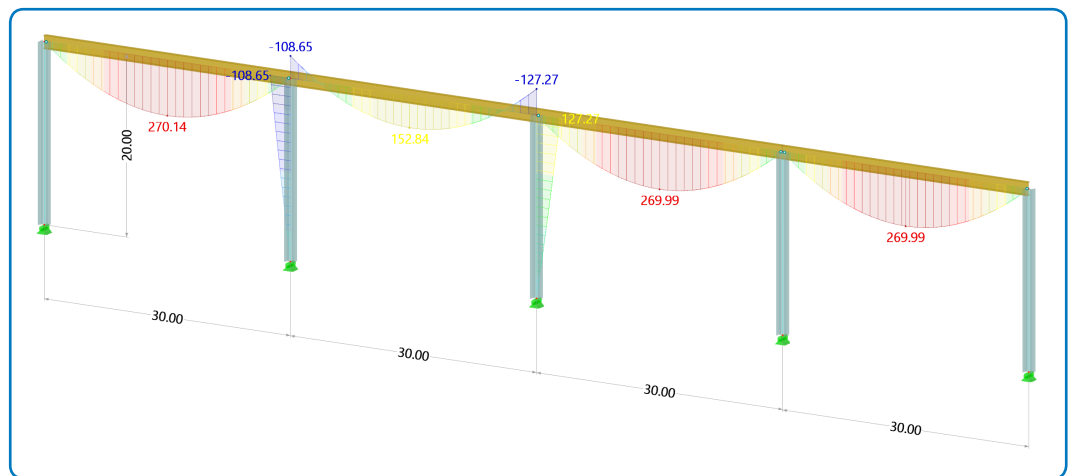


Figure 3: RFEM 6 results - Moment M_y about y-axis (2nd Order LRFD)

References

- [1] AMERICAN INSTITUTE OF STEEL CONSTRUCTION, *Design Examples V16 - Companion to the AISC Steel Construction Manual*.