Graphical Design Aid for Beam-Columns (LRFD)

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The AISC load and resistance factor design (LRFD) procedure for the design of a beam-column uses the following interaction equations.

$$\frac{P_u}{\phi_c P_n} + \left(\frac{8}{9}\right)\left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right) \le 1.0 \text{ for } \frac{P_u}{(\phi_c P_n)} \ge 0.20 \quad (1)$$

and

$$\frac{P_u}{2\phi_c P_n} + \left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right) \le 1.0 \text{ for } \frac{P_u}{(\phi_c P_n)} < 0.20 \quad (2)$$

where

P_u = required axial strength
M_u = required flexural strength
$\phi_c P_n$ = axial design strength
$\phi_b M_n$ = flexural design strength

These equations are taken from the *Load and Resistance Factor Design Specification for Structural Steel Buildings* (AISC, 1999), hereafter referred to as the AISC LRFD Specification. Aminmansour (2004), has rewritten the interaction equations as

$$bP_u + m\,M_{ux} + n\,M_{uy} \le 1.0 \text{ for } bP_u \ge 0.2 \quad (3)$$

$$0.50\,bP_u + (9/8)\{m\,M_{ux} + n\,M_{uy}\} \le 1.0 \text{ for } bP_u \ge 0.2 \quad (4)$$

with b, m, and n replacing $(1/\phi_c P_n)$, $(1/\phi_b M_{nx})$, and $(1/\phi_b M_{ny})$, respectively. He suggested that the smaller b, m, and n values are more effective and therefore desirable. Also in the case of relatively large axial load, a section with a smaller b-value may be more effective, although it may have a larger m-value. Similarly in the case of a member subjected to relatively large bending moment about the x-axis, a section with a smaller m value may be more effective and desirable though b may be larger.

Keil (2000) developed graphical design aids for beam-columns per the AISC LRFD Specification. The design aids are presented as interaction curves for W-sections with the conservative and simplifying assumption of $C_b = 1$, a factor accounting for moment gradient.

Zuraski (1992) elaborated upon the significance and application of C_b in beam design to account for moment gradient. The magnitude of compressive force within a beam can be determined by the inspection of moment diagram. Because the resistance to bending is composed of an internal compressive force, C, and tensile force, T, couple, the magnitude of C at any location along the span equals the bending moment divided by the internal moment arm. Thus the variation of the force within the compression flange has the same shape as the moment diagram.

In light of Zuraski's observations and the importance of the C_b factor, Keil's graphical design aids can be improved by considering the actual C_b value instead of a conservative value of $C_b = 1$, as the value of C_b varies from 1.0 to 2.3, which is quite significant.

DERIVATION OF THE DESIGN PROCEDURE

The design procedure is developed taking into consideration the equivalent uniform moment factor, C_b, unbraced length, L_b, for the flexural design strength and effective length, KL, for the axial compressive design strength. Although the design aids are developed for beam-columns, the same curves can be used for beams and columns with $P_u = 0$ and $M_u = 0$, respectively.

The interaction curves are derived with $K = 1$ and $C_b = 1.0$. Therefore, the following conversion factors are defined to account for KL in axial load and L_b in bending moment.

$$\alpha_{(\text{at } KL)} = \frac{\phi_c \bar{P}_n}{\phi_c P_n} \ge 1.0 \quad (5)$$

$$\beta_{(\text{at } L_b)} = \frac{\phi_b \bar{M}_n}{\phi_b M_{n(\text{at } L_b \text{ and } C_b = 1)}} \ge 1.0 \quad (6)$$

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where

$\phi_c \bar{P}_n$ = maximum axial compressive design strength

$\phi_b \bar{M}_n$ = maximum flexural design strength (plastic moment capacity) of the section

The axial load and bending moments are transformed as $P_u' = \alpha P_u$ and $M_u' = (\beta/C_b)M_u$ for use in the interaction equations, where P_u and M_u are the required axial compressive strength and required flexural strength, respectively. The interaction equations are rewritten for the convenience of preparing design aids as

$$\frac{P_u'}{\phi_c \bar{P}_n} + \left(\frac{8}{9}\right)\left(\frac{M_u'}{\phi_b \bar{M}_n}\right) \le 1.0 \text{ for } \frac{P_u'}{\left(\phi_c \bar{P}_n\right)} \ge 0.20 \tag{7}$$

and

$$\frac{P_u'}{2\phi_c \bar{P}_n} + \left(\frac{M_u'}{\phi_b \bar{M}_n}\right) \le 1.0 \text{ for } \frac{P_u'}{\left(\phi_c \bar{P}_n\right)} < 0.20 \tag{8}$$

The equivalence of $P_u'/\phi_c \bar{P}_n$ and $P_u/\phi_c P_n$ and also the equivalence of $M_u'/\phi_b M_n$ and $M_u/\phi_b \bar{M}_n$ are established here:

$$\frac{P_u'}{\phi_c \bar{P}_n} = \frac{\alpha P_u}{\phi_c \bar{P}_n}, \text{ substituting for } \alpha$$

$$= \frac{\left[\dfrac{\phi_c \bar{P}_n}{\phi_c P_n}(\text{at } KL)\right] P_u}{\phi_c \bar{P}_n}$$

$$= \frac{P_u}{\phi_c \bar{P}_n (\text{at } KL)}$$

$$\frac{M_u'}{\phi_b \bar{M}_n} = \frac{\left(\dfrac{\beta}{C_b}\right) M_u}{\phi_b \bar{M}_n}, \text{ substituting for } \beta$$

$$= \frac{\left[\dfrac{\phi_b \bar{M}_n}{\phi_b M_n}\left(\text{at } L_b \text{ and } C_b = 1\right)\right]\left(\dfrac{1}{C_b}\right) M_u}{\phi_b \bar{M}_n}$$

$$= \frac{M_u}{C_b \phi_b M_n \left(\text{at } L_b \text{ and } C_b = 1\right)}$$

To ensure $P_u \le \phi_c P_n$ and $M_u \le \phi_b M_n$, the conditions $\alpha \ge 1.0$ and $(\beta/C_b) \ge 1.0$ are to be imposed.

Based on the definitions of α and β the design tables for α and β (Appendix C) are prepared for different sections.

THE USE OF DESIGN AIDS

The proposed design aids can be used for beam-columns, beams, and columns.

Selection of a Beam-Column

1. For the member under consideration, effective length factor, K, unsupported length, L_b, factored moment, M_u, and factored axial load, P_u, are to be computed.
2. Compute C_b for the given moment distribution.
3. Compute the conversion factor, α, for axial load and β for bending moment (or find α and β from the table in Appendix C for the appropriate values of KL and L_b).
4. In the tables for values of α and β values shown in bold letters are for spans having slenderness ratio, $KL/r > 200$. So check for slenderness limits.
5. Find the ratio β/C_b. If this ratio is less than 1.0, the ratio is to be taken equal to 1.0, because $\beta/C_b \ge 1.0$.
6. Compute transformed axial load and bending moment as $P_u' = \alpha . P_u$ and $M_u' = (\beta/C_b)M_u$.
7. Enter the design curves with P_u' and M_u' to select the section.

An efficient section for the beam-column can be selected following Aminmansour's (2004) recommendations. Namely, for a beam-column with relatively large axial loads, a section having a smaller α is to be selected. Similarly, for a beam-column with a relatively large bending moment, a section having a smaller β is to be selected.

Use of Design Aid for a Beam

1. For the member with given unbraced length, L_b, and factored moment, M_u, C_b is to be computed.
2. For a given L_b, compute β or determine the value from the table in Appendix C.
3. Find the ratio β/C_b. If this ratio is less than 1.0, the ratio is to be taken equal to 1.0, because $\beta/C_b \ge 1.0$.
4. Compute the transformed moment, $M_u' = (\beta/C_b)M_u$.
5. Enter the design curves with M_u' and $P_u' = 0$, to select the section. Check $M_u' \le \bar{M}_n$ (plastic moment capacity).
6. If condition 5 is satisfied, then the section selected is satisfactory. Otherwise Steps 2 to 5 are to be repeated. However, the iteration converges quickly.

Use of Design Aid for a Column

1. For the member with given effective length, KL, and factored axial load, P_u, compute α or determine the value from tables in Appendix C.

2. Compute the transformed axial load, $P_u' = \alpha P_u$.

3. Check $P_u' \le \bar{P}_n$ (squash load).

If condition 3 is satisfied, then the section selected is satisfactory, otherwise, steps 2 and 3 are to be repeated. However, the iteration converges quickly.

ILLUSTRATIVE EXAMPLES

The following examples from the references as indicated are used to demonstrate the applicability of the proposed method.

Example 1 (Smith, 1996)

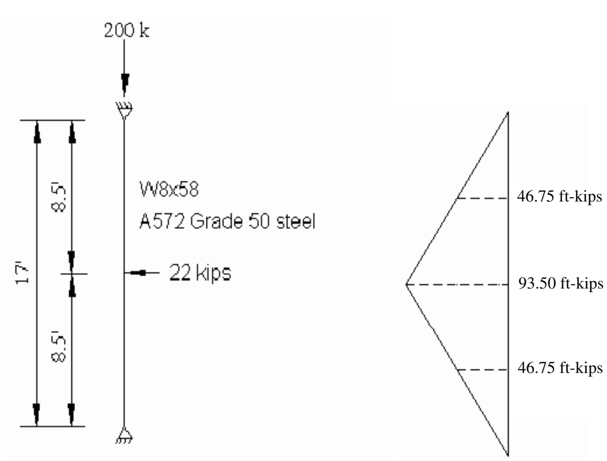
Given

The beam-column shown in Figure 1 is pinned at both ends and is subjected to the factored loads shown. Bending is about the strong axis. Determine whether this member satisfies the appropriate AISC LRFD Specification interaction equation.

Solution

From the AISC column load tables, for W8×58 with $F_y = 50$ ksi and an effective length $K_yL = 1.0 \times 17 = 17$ ft, $\phi_c P_n = 365$ kips (AISC, 1998). (Note: This value was taken from the 2nd Ed. AISC LRFD Manual because the W8×58 was not tabulated in the 3rd Ed. AISC LRFD Manual.)

From the AISC beam design charts (AISC, 1999), for $L_b = 17$ ft and $C_b = 1.0$, $\phi_b M_n = 202$ ft-kips.



(a) Beam-column *(b) Bending moment*

Fig. 1. Beam-column configuration and factored loading.

$$C_b = \frac{12.5M_{max}}{2.5M_{max} + 3M_A + 4M_B + 3M_C} = 1.32 \le 2.3$$

where

$M_{max} = M_B = 93.5$ ft-kips, $M_A = M_C = 46.75$ ft-kips

$\phi_b M_n = 1.32 \times 202 = 267$ ft-kips (for $C_b = 1.32$)

But $\phi_b M_p = 224$ ft-kips, therefore use $\phi_b M_n = 224$ ft-kips

$$\frac{P_u}{\phi_c P_n} = \frac{200}{365} = 0.5479 > 0.2$$

$$\frac{P_u}{\phi_c P_n} + \frac{8}{9}\left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right)$$

$$\frac{200}{365} + \frac{8}{9}\left(\frac{93.5}{224} + 0\right) = 0.919 < 1.0 \ \textbf{o.k.}$$

<u>Calculation Using Proposed Method</u>

For

M_u	=	93.5 ft-kips
P_u	=	200 kips
C_b	=	1.32
KL	=	17 ft = L_b
α	=	2.01 and $\beta = 1.11$ (interpolating from Appendix B, Table 1)
β/C_b	=	1.11/ 1.32 < 1.0, use $(\beta/C_b) = 1.0$.

Therefore, $P_u' = \alpha P_u = 2.01 \times 200 = 402$ kips and $M_u' = (\beta/C_b) M_u = 1.0 \times 93.5 = 93.5$ ft-kips.

From Chart 1, W8×58 satisfies the requirements.

Example 2 (Smith, 1996)

Given

A W12×65, of ASTM A572 Grade 50 steel, 15 ft long, is to be investigated for use as a column in an unbraced frame. The axial load and end moments obtained from a first order analysis of the gravity loads (dead and live load) are shown in Figure 2(a). The frame is symmetrical and the gravity loads are symmetrically placed. Figure 2(b) shows the wind load moments obtained from a first-order analysis. All bending moments are about the strong axis. Effective length factors are $K_x = 1.2$ for the sway case, $K_x = 1.0$ for the nonsway case, and $K_y = 1.0$. Determine whether this member is in compliance with the AISC Specification. Check the following load combinations.

$$1.2D + 1.6L \quad \text{(i)}$$

$$1.2D + 0.5L + 1.3W \quad \text{(ii)}$$

Solution

Figures 2(c) and 2(d) show the axial loads and bending moments calculated for these two combinations. The critical axis for axial compressive strength is determined as follows.

$$K_yL = 15 \text{ ft}$$

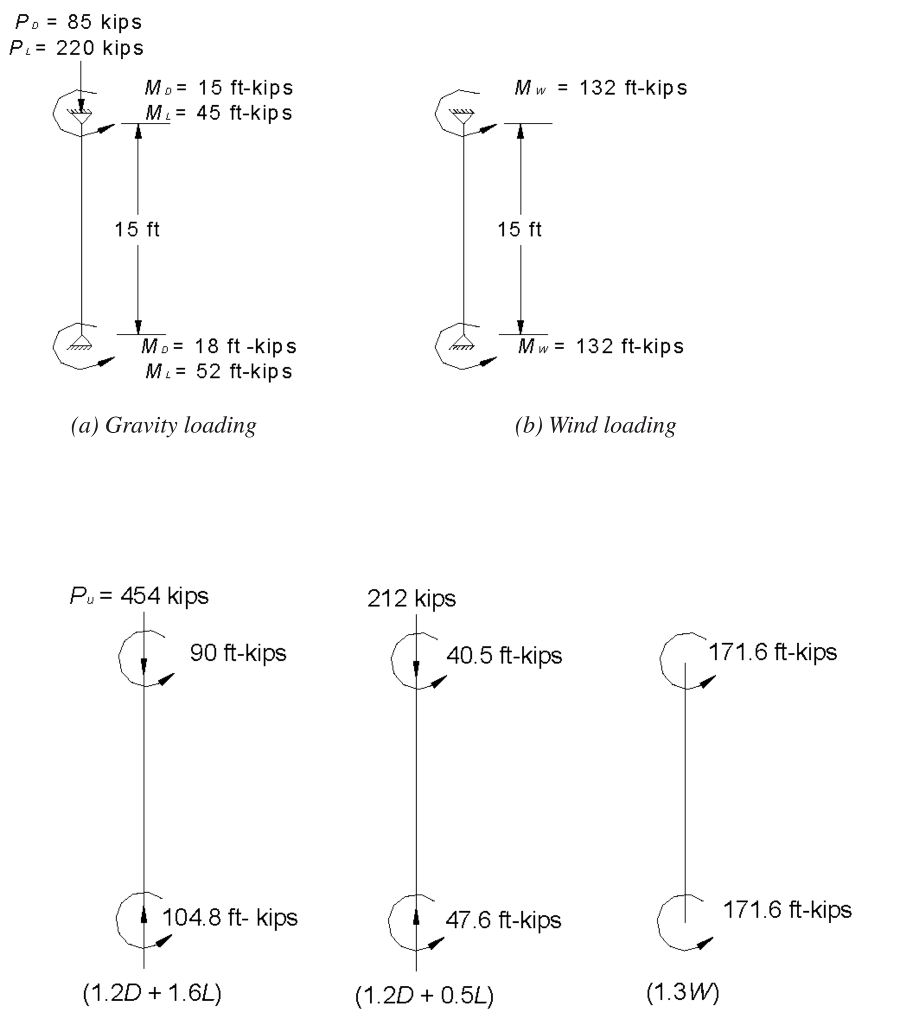
$$\frac{K_xL}{r_x / r_y} = \frac{1.2 \times 15}{1.75} = 10.29 < 15, \text{ therefore use } KL = 15 \text{ ft}$$

For Load Combination i:

From the column load tables (AISC, 2001) for KL = 15 ft, $\phi_c P_n$ = 626 kips.

M_{lt} = 0 (no sidesway because of symmetry)

C_m = 0.6 – 0.4 (M_1/M_2)
= 0.6 – 0.4 (90/104.8)
= 0.2565 [Eqn. C1-3 of AISC (1999)]



(a) Gravity loading

(b) Wind loading

(c) Load combination i

*(d) Load combination ii (1.2*D *+ 0.5*L *+ 1.3*W*)*

Fig. 2. Example 2 loading.

For the axis of bending:

$KL/r = K_xL/r_x = 1 \times 15 \times 12/5.28 = 34.09$ ($K_x = 1.0$ for no sidesway is used).

$$P_{e1} = \frac{\pi^2 EA_g}{(KL/r)^2} = \frac{\pi^2 \times 29{,}000 \times 19.1}{(34.09)^2} = 4{,}704 \text{ kips}$$

The amplification factor for nonsway moment is

$$B_1 = \frac{C_m}{1-(P_u/P_{e1})} \quad \text{[Eqn. C1-2 of AISC (1999)]}$$

$$= \frac{0.2565}{1-(454/4{,}704)} = 0.284$$

$$< 1.0, \text{ therefore use } B_1 = 1.0$$

$M_u = B_1M_{nt} + B_2M_{lt} = (1.0 \times 104.8) + 0 = 104.8$ kip-ft

From the beam design charts, with $L_b = 15$ ft,

$\phi_bM_n = 343$ kip-ft (for $C_b = 1.0$)

$\phi_bM_p = 358$ kip-ft

$$C_b = \frac{12.5M_{max}}{2.5M_{max} + 3M_A + 4M_B + 3M_C} \quad \text{[Eqn. F1-3 of AISC (1999)]}$$

$$= 2.24 \le 2.3$$

where

M_{max} = 104.8 kip-ft

M_A = 41.3 kip-ft

M_B = 7.4 kip-ft

M_c = 56.1 kip-ft

For $C_b = 2.24$, $\phi_bM_n = 2.24 \times 343 > \phi_bM_p = 358$ kip-ft, therefore use $\phi_bM_n = 358$ kip-ft.

$$\frac{P_u}{\phi_cP_n} = \frac{454}{626} = 0.725 > 0.2$$

$$\frac{P_u}{\phi_cP_n} + \frac{8}{9}\left(\frac{M_{ux}}{\phi M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right) \quad \text{[Eqn. H1-1a of AISC (1999)]}$$

$$\frac{454}{626} + \frac{8}{9}\left(\frac{104.8}{358} + 0\right) = 0.985 < 1.0 \quad \textbf{o.k.}$$

Calculation Using Proposed Method (for load combination i)

For $K = 1.0$, $L = 15$ ft, $C_b = 2.24$, $M_u = 104.8$ kip-ft, and $P_u = 454$ kips.

For W12×65, $KL = 15$ ft, $\alpha = 1.30$ and for $L_b = 15$ ft, $\beta = 1.044$ (interpolating from Appendix B, Table 1).

P_u' = 454 × 1.30 = 590.20 kips

β/C_b = 1.044/ 2.24 < 1.0, therefore $\beta/C_b = 1.0$ is used and $M_u' = 1 \times 104.8 = 104.8$ kip-ft.

From Chart 1, W12×65 satisfies the requirements as the coordinate (104.8, 590.2) lies below the curve for W12×65.

For Load Combination ii:

$P_u = 212$ kips, $M_{nt} = 47.6$ kip-ft (for $1.2D + 0.5L$), $M_{lt} = 171.6$ kip-ft (for $1.3W$)

For the braced condition,

C_m = 0.6 – 0.4 (40.5 / 47.6) = 0.2597

P_{e1} = 4,704 kips

$$B_1 = \frac{C_m}{1-\left(\frac{P_u}{P_{e1}}\right)} = \frac{0.2597}{1-\left(\frac{212}{4{,}704}\right)} = 0.272 < 1.0, \text{ use } B_1 = 1.0$$

Using K_x corresponding to unbraced condition for calculation of P_{e2},

$$P_{e2} = \frac{\pi^2 EA_g}{(KL/r)^2} = \frac{\pi^2 \times 29{,}000 \times 19.1}{(40.9)^2} = 3{,}268 \text{ kips}$$

where $KL_x/r_x = 1.2 \times 15 \times 12/5.28 = 40.9$

Assuming the ratio of P_u/P_e is the same for all the columns in the story, as for the column under consideration,

$$B_2 = \frac{1}{1-\left(\frac{\Sigma P_u}{\Sigma P_{e2}}\right)} \quad \text{[Eqn. C1-5 of AISC (1999)]}$$

$$\approx \frac{1}{1-\left(\frac{P_u}{P_{e2}}\right)} = \frac{1}{1-\left(\frac{212}{3{,}266}\right)} = 1.069$$

The total amplified moment is

M_u = $B_1M_{nt} + B_2M_{lt}$ = 1.0 × 47.6 + 1.069 × 171.6

= 231.0 kip-ft

$$C_b = \frac{12.5M_{max}}{2.5M_{max} + 3M_A + 4M_B + 3M_C} = 2.2867 \le 2.3$$

where

M_{max} = 219.2 kip-ft

M_A = 107.87 kip-ft

M_B = 3.45 kip-ft

M_c = 104.27 kip-ft

For $C_b = 2.2867$, $\phi_bM_n = 2.2867 \times 343 > \phi_bM_p = 358$ kip-ft, therefore use $\phi_bM_n = 358$ kip-ft

$$\frac{P_u}{\phi_c P_n} = \frac{212}{626} = 0.338 > 0.2$$

$$\frac{P_u}{\phi_c P_n} + \frac{8}{9}\left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right)$$

$$\frac{212}{626} + \frac{8}{9}\left(\frac{231.0}{358} + 0\right) = 0.912 < 1.0 \quad \textbf{o.k.}$$

Calculation Using Proposed Method (for load combination ii)

For P_u = 212 kips, M_u = 231.0 kip-ft, KL = 15 ft, L_b = 15 ft and C_b = 2.2867

For W12×65, KL = 15 ft, α = 1.30 and for L_b = 15 ft, β = 1.0645 (interpolating from Appendix B, Table 1)

β/C_b = 1.0645/ 2.2867 < 1.0, therefore use 1.0

M_u' = 1.0 × 231 = 231 kip-ft

P_u' = 1.30 × 212 = 275.6 kips

From Chart 1, W12×65 satisfies the requirements as the coordinates (231, 275.6) lie below the curve for W12×65.

Example 3 (Aminmansour, 2004)

Given

W24×131, ASTM A992 steel, L_b = 16 ft, C_b = 1.67

Determine $\phi_b M_{nx}$.

Solution

Referring to the AISC *LRFD Manual of Steel Construction* (Table 6-2) (AISC, 2001), $m = 0.700 \times 10^{-3}$ (kip-ft)$^{-1}$; $\phi_b M_p$ = 1,390 kip-ft; and L_p = 10.5 ft.

L_b = 16 ft > L_p = 10.5 ft

$\phi_b M_{nx}$ = $8/(9m) = 8/(9 \times 0.700 \times 10^{-3})$

= 1,270 kip-ft for C_b = 1.0

For C_b = 1.67, $\phi_b M_{nx} = (C_b)[\phi_b M_{nx}$ for $C_b = 1]$

= (1.67)(1,270 kip-ft)

= 2,120 kip-ft > $\phi_b M_p$ = 1,390 kip-ft

Therefore, $\phi_b M_{nx} = \phi_b M_p$ = 1,390 kip-ft.

Calculation Using Proposed Method

For L_b = 16 ft, β = 1.093 (from Appendix B, Table 1)

β/C_b = 1.093/1.67 < 1.0, therefore use 1.0

$\phi_b M_p$ = 1,390 (Chart 1), value of x-coordinate where curve for W24×131 meets the x-axis

Therefore, $\phi_b M_{nx} = (\phi_b M_p)/\ \beta/C_b$ = 1,390 kip-ft.

Example 4 (Keil, 2000)

Given

Given the following loading, select the lightest W14 using ASTM A992 steel.

Solution

P_u = 3,400 kips; M_u = 650 kip-ft; K = 1.0; L = 16 ft; F_y = 50 ksi

Try W14×398

$\phi_c P_n$ = 4,300 kips from the column tables of AISC (2001), Part 3.

$\phi_b M_n$ = 2,997 kip-ft from Chapter F of the AISC LRFD Specification.

$$\frac{P_u}{\phi_c P_n} = \frac{3,400}{4,300} = 0.7906 > 0.2, \text{ therefore,}$$

$$\frac{P_u}{\phi_c P_n} + \frac{8}{9}\left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right)$$

$$\frac{3,400}{4,300} + \frac{8}{9}\left(\frac{650}{2,997} + 0\right) = 0.983 < 1.0 \quad \textbf{o.k.}$$

Calculation Using Proposed Method

For P_u = 3,400 kips, M_u = 650 kip-ft, KL = 16 ft, L_b = 16 ft, and C_b = 1.0.

For W14×398, for KL = 15 ft, α = 1.157 and for L_b = 15 ft, β = 1.0019 (interpolating from Appendix B, Table 1).

β/C_b = 1.0019/1 = 1.0019

M_u' = 1.0019 × 650 = 651.235 kip-ft

P_u' = 1.157 × 3,400 = 3,933.8 kips

From Chart 1, W14×398 satisfies the requirements as the coordinates (651.235, 3,933.8) lie below the curve for W14×398.

CONCLUSION

The proposed graphical design aid and design procedure is an improvement over the design aid proposed by Keil (2000) as it includes the actual value of C_b in the computation of $\phi_b M_n$ as opposed to the conservative value of C_b = 1. The same set of design charts can be used for computing the capacity of columns, beams and beam-columns, which is illustrated in Examples 1 to 4. This method reduces the number of iterations and simplifies the tedious computation of beam-column strength and provides ready-to-use charts for design engineers. Selection of an efficient section is possible through the use of Aminmansour's approach (Aminmansour, 2004).

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APPENDIX A
LIST OF NOTATIONS

B_1, B_2 = Factors used in determining M_u for combined bending and axial forces when first-order analysis is used.

B_{kL} and B_{LM} = Axial conversion and moment capacity conversion factors defined for Keil's graphical design aids (Keil, 2000).

C_b = Modification factor for nonuniform moment.

C_m = Coefficient applied to bending term in interaction formula for prismatic members and dependent on column curvature caused by applied moment.

D = Dead load due to weight of structural elements and permanent features on the structure.

E = Modulus of elasticity of steel.

F_y = Specified minimum yield stress of steel.

K = Effective length factor.

L = Length of member.

L_p = Limiting laterally unbraced length for full plastic bending capacity, uniform moment case.

L_r = Limiting laterally unbraced length for inelastic lateral-torsional buckling.

M_A = Absolute value of moment at quarter point of the unbraced beam segment.

M_B = Absolute value of moment at center point of the unbraced beam segment

M_C = Absolute value of moment at three-quarter point of the unbraced beam segment.

M_{lt} = Required flexural strength in member due to lateral frame translation only.

M_{max} = Absolute value of maximum moment in the unbraced beam segment.

M_n = Nominal flexural strength.

M_{nt} = Required flexural strength in member assuming there is no lateral translation of the frame.

M_p = Plastic bending moment.

M_u = Required flexural strength.

M_1 = Smaller moment at end of unbraced length of beam or beam-column.

M_2 = Larger moment at end of unbraced length of beam or beam-column.

P_{e1}, P_{e2} = Elastic Euler buckling load for braced and unbraced frame, respectively.

P_n = Nominal axial strength (tension or compression).

P_u = Required axial strength (tension or compression).

r_x, r_y = Radius of gyration about respective axis.

α and β = Axial and moment capacity conversion factors for proposed method for AISC-LRFD.

ϕ_c = Resistance factor for compression.

ϕ_b = Resistance factor for flexure.

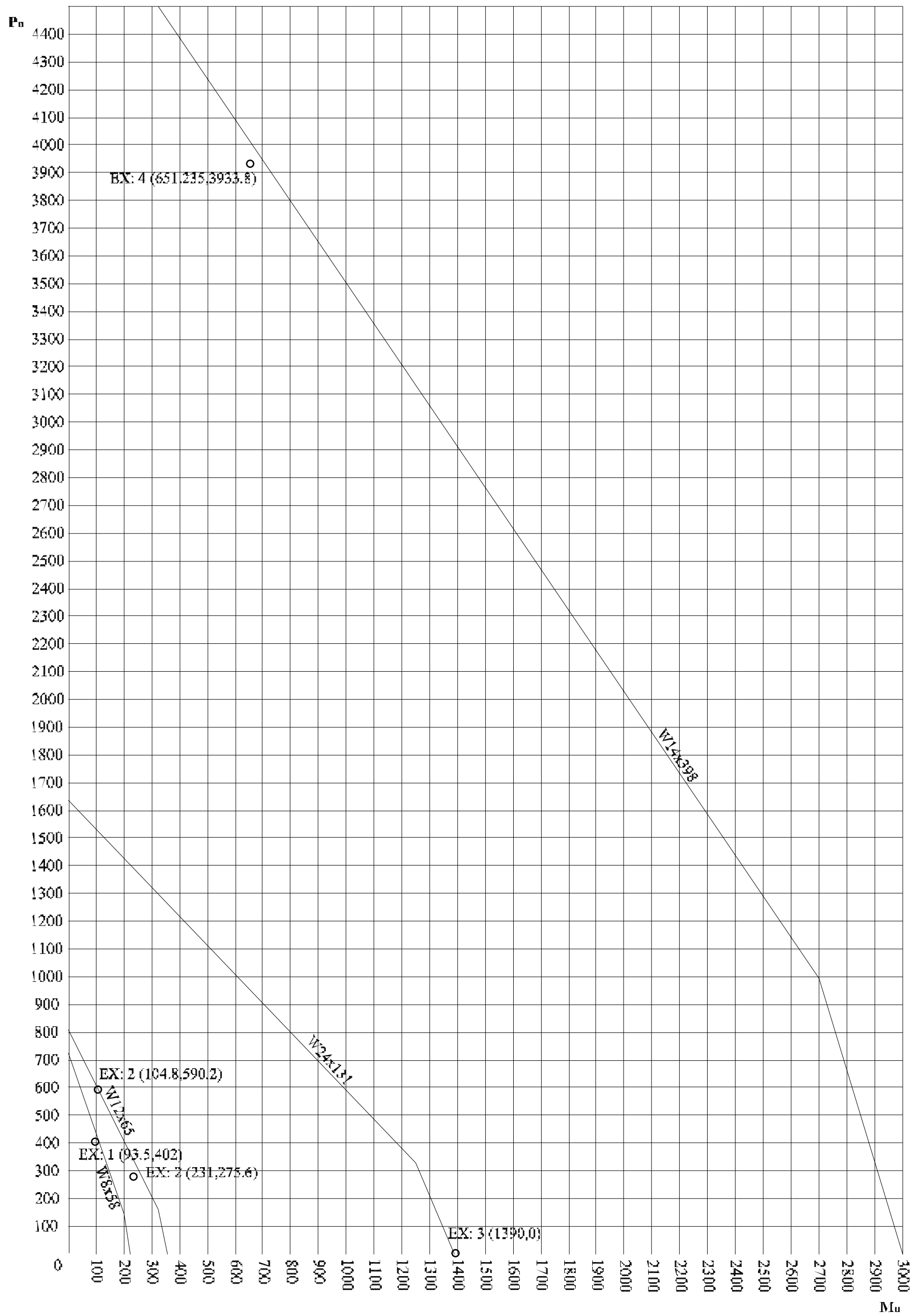
$\phi_b \bar{M}_n$ = Maximum moment capacity (plastic capacity).

$\phi_c \bar{P}_n$ = Maximum axial capacity of the section.

APPENDIX B

α and β Values for Sections Used in Illustrative Examples								
***KL* (ft) or *L_b* (ft)**	**W8×58**		**W12×65**		**W24×131**		**W14×398**	
	α	β	α	β	α	β	α	β
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	1.010	1.000	1.005	1.000	1.005	1.000	1.002	1.000
4	1.039	1.000	1.019	1.000	1.019	1.000	1.009	1.000
6	1.090	1.000	1.042	1.000	1.044	1.000	1.021	1.000
8	1.165	1.006	1.077	1.000	1.079	1.000	1.037	1.000
10	1.270	1.028	1.123	1.000	1.126	1.000	1.058	1.000
12	1.411	1.050	1.181	1.003	1.186	1.024	1.085	1.000
14	1.597	1.073	1.254	1.030	1.262	1.057	1.118	1.000
16	1.844	1.098	1.344	1.059	1.355	1.093	1.157	1.002
18	2.169	1.123	1.454	1.089	1.469	1.131	1.202	1.007
20	2.604	1.150	1.588	1.121	1.608	1.172	1.255	1.012
22	3.151	1.178	1.749	1.155	1.776	1.216	1.317	1.017
24	3.750	1.208	1.946	1.192	1.981	1.264	1.387	1.022
26	4.401	1.239	2.184	1.230	2.231	1.315	1.468	1.028
28	5.104	1.271	2.474	1.272	2.536	1.371	1.561	1.033
30	5.860	1.306	2.833	1.316	2.910	1.336	1.668	1.038
32	6.667	1.342	3.224	1.239	3.311	1.471	1.789	1.044
34	7.527	1.380	3.639	1.341	3.738	1.606	1.929	1.049
36	**8.438**	**1.421**	4.080	1.442	4.190	1.742	2.089	1.055
38	**9.402**	**1.339**	4.546	1.544	4.669	1.879	2.272	1.060
Note: Values where *KL*/*r* > 200 are shown in bold letters.								

Chart 1. Design Curves for Interaction Equation for Sections Used in Illustrative Examples (P_u in kips and M_u in kip-ft)



APPENDIX C

Tables of α and β Values

***KL* (ft) or L_b (ft)**	**W6×20**		**W6×25**		**W8×21**		**W8×24**		**W8×28**	
	α	β	α	β	α	β	α	β	α	β
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	1.019	1.000	1.018	1.000	1.027	1.000	1.016	1.000	1.016	1.000
4	1.078	1.000	1.076	1.000	1.112	1.000	1.067	1.000	1.066	1.000
6	1.184	1.016	1.178	1.011	1.270	1.051	1.158	1.007	1.156	1.007
8	1.350	1.065	1.339	1.051	1.529	1.127	1.297	1.059	1.293	1.053
10	1.597	1.120	1.578	1.094	1.942	1.216	1.502	1.116	1.494	1.103
12	1.963	1.180	1.929	1.141	2.604	1.320	1.796	1.180	1.783	1.159
14	2.505	1.246	2.445	1.192	3.545	1.347	2.219	1.252	2.197	1.220
16	3.267	1.321	3.181	1.248	4.630	1.603	2.836	1.333	2.801	1.289
18	4.135	1.278	4.027	1.310	5.860	1.857	3.589	1.328	3.545	1.366
20	5.104	1.448	4.971	1.377	7.234	2.110	4.431	1.518	4.376	1.353
22	6.176	1.618	6.015	1.338	**8.753**	**2.361**	5.361	1.707	5.295	1.515
24	7.350	1.786	7.158	1.472	**10.417**	**2.611**	6.380	1.895	6.302	1.677
26	**8.627**	**1.953**	**8.401**	**1.605**	**12.226**	**2.859**	7.488	2.081	7.396	1.837
28	**10.005**	**2.119**	**9.743**	**1.738**	**14.179**	**3.105**	**8.684**	**2.267**	**8.578**	**1.997**
30	**11.485**	**2.285**	**11.185**	**1.871**	**16.277**	**3.351**	**9.969**	**2.452**	**9.847**	**2.155**
32	**13.068**	**2.450**	**12.726**	**2.003**	**18.520**	**3.595**	**11.343**	**2.635**	**11.203**	**2.313**
34	**14.752**	**2.614**	**14.366**	**2.134**	**20.907**	**3.839**	**12.805**	**2.819**	**12.647**	**2.471**
36	**16.539**	**2.778**	**16.106**	**2.266**	**23.439**	**4.082**	**14.356**	**3.001**	**14.179**	**2.628**
38	**18.427**	**2.942**	**17.946**	**2.397**	**26.116**	**4.324**	**15.995**	**3.183**	**15.798**	**2.784**

Note: Values where KL/r > 200 are shown in bold letters.

Tables of α and β Values (continued)

***KL* (ft) or L_b (ft)**	**W8×31**		**W8×35**		**W8×40**		**W8×48**		**W8×58**	
	α	β	α	β	α	β	α	β	α	β
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	1.010	1.000	1.010	1.000	1.010	1.000	1.010	1.000	1.010	1.000
4	1.042	1.000	1.042	1.000	1.041	1.000	1.040	1.000	1.039	1.000
6	1.097	1.000	1.096	1.000	1.095	1.000	1.092	1.000	1.090	1.000
8	1.180	1.017	1.178	1.013	1.176	1.012	1.169	1.007	1.165	1.006
10	1.295	1.056	1.291	1.049	1.288	1.044	1.276	1.033	1.270	1.028
12	1.451	1.098	1.445	1.087	1.440	1.077	1.420	1.060	1.411	1.050
14	1.659	1.143	1.651	1.127	1.643	1.113	1.612	1.089	1.597	1.073
16	1.937	1.193	1.925	1.171	1.912	1.151	1.866	1.119	1.844	1.098
18	2.309	1.247	2.290	1.219	2.272	1.192	2.202	1.150	2.169	1.123
20	2.815	1.306	2.787	1.270	2.760	1.236	2.655	1.184	2.604	1.150
22	3.406	1.371	3.372	1.326	3.339	1.283	3.212	1.220	3.151	1.178
24	4.053	1.363	4.013	1.387	3.974	1.334	3.823	1.258	3.750	1.208
26	4.757	1.503	4.710	1.365	4.664	1.389	4.486	1.298	4.401	1.239
28	5.517	1.642	5.463	1.488	5.409	1.337	5.203	1.341	5.104	1.271
30	6.333	1.780	6.271	1.610	6.210	1.444	5.973	1.387	5.860	1.306
32	7.206	1.917	7.135	1.732	7.065	1.551	6.796	1.318	6.667	1.342
34	**8.134**	**2.054**	**8.055**	**1.853**	**7.976**	**1.658**	7.672	1.407	7.527	1.380
36	**9.120**	**2.191**	**9.030**	**1.974**	**8.942**	**1.764**	**8.601**	**1.495**	**8.438**	**1.421**
38	**10.161**	**2.327**	**10.061**	**2.094**	**9.963**	**1.870**	**9.583**	**1.583**	**9.402**	**1.339**

Note: Values where KL/r > 200 are shown in bold letters.

APPENDIX C (continued)

KL (ft) or L_b (ft)	W8×67		W10×22		W10×26		W10×30		W10×33	
	α	β	α	β	α	β	α	β	α	β
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	1.009	1.000	1.024	1.000	1.023	1.000	1.023	1.000	1.011	1.000
4	1.038	1.000	1.100	1.000	1.095	1.000	1.094	1.000	1.046	1.000
6	1.088	1.000	1.239	1.049	1.228	1.041	1.224	1.038	1.106	1.000
8	1.162	1.005	1.464	1.134	1.440	1.118	1.432	1.107	1.196	1.024
10	1.264	1.023	1.815	1.235	1.768	1.206	1.753	1.186	1.323	1.072
12	1.402	1.042	2.358	1.355	2.272	1.310	2.245	1.277	1.497	1.124
14	1.583	1.062	3.181	1.472	3.043	1.315	2.998	1.384	1.731	1.181
16	1.823	1.083	4.155	1.792	3.974	1.587	3.916	1.433	2.048	1.244
18	2.138	1.105	5.259	2.117	5.030	1.860	4.957	1.669	2.478	1.315
20	2.555	1.128	6.493	2.443	6.210	2.133	6.119	1.903	3.052	1.273
22	3.092	1.151	7.856	2.769	7.514	2.404	7.404	2.136	3.692	1.449
24	3.680	1.176	**9.350**	**3.095**	**8.942**	**2.675**	**8.812**	**2.368**	4.394	1.624
26	4.319	1.201	**10.973**	**3.420**	**10.494**	**2.944**	**10.341**	**2.599**	5.157	1.800
28	5.009	1.228	**12.726**	**3.743**	**12.171**	**3.211**	**11.994**	**2.828**	5.981	1.974
30	5.750	1.256	**14.609**	**4.064**	**13.971**	**3.477**	**13.768**	**3.055**	6.866	2.148
32	6.542	1.285	**16.622**	**4.385**	**15.896**	**3.742**	**15.665**	**3.282**	7.812	2.321
34	7.385	1.315	**18.764**	**4.703**	**17.946**	**4.006**	**17.684**	**3.508**	**8.819**	**2.493**
36	**8.280**	**1.348**	**21.037**	**5.021**	**20.119**	**4.268**	**19.826**	**3.733**	**9.887**	**2.665**
38	**9.225**	**1.381**	**23.439**	**5.337**	**22.416**	**4.530**	**22.090**	**3.958**	**11.016**	**2.836**

Tables of α and β Values (continued)

Note: Values where KL/r > 200 are shown in bold letters.

KL (ft) or L_b (ft)	W10×39		W10×45		W10×49		W10×54		W10×60	
	α	β	α	β	α	β	α	β	α	β
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	1.011	1.000	1.010	1.000	1.007	1.000	1.006	1.000	1.006	1.000
4	1.044	1.000	1.043	1.000	1.026	1.000	1.026	1.000	1.026	1.000
6	1.102	1.000	1.098	1.000	1.061	1.000	1.060	1.000	1.059	1.000
8	1.188	1.019	1.182	1.015	1.110	1.000	1.108	1.000	1.108	1.000
10	1.308	1.060	1.298	1.051	1.177	1.015	1.174	1.012	1.173	1.011
12	1.473	1.104	1.456	1.089	1.265	1.045	1.261	1.040	1.258	1.036
14	1.694	1.152	1.667	1.131	1.377	1.077	1.371	1.069	1.367	1.063
16	1.990	1.204	1.950	1.175	1.519	1.111	1.509	1.100	1.505	1.091
18	2.389	1.262	2.329	1.223	1.698	1.148	1.684	1.133	1.677	1.120
20	2.930	1.325	2.843	1.276	1.922	1.187	1.903	1.168	1.893	1.152
22	3.545	1.267	3.440	1.333	2.205	1.229	2.178	1.205	2.165	1.184
24	4.219	1.413	4.094	1.395	2.562	1.273	2.525	1.245	2.507	1.219
26	4.951	1.559	4.804	1.381	3.009	1.322	2.962	1.287	2.939	1.256
28	5.742	1.703	5.572	1.505	3.489	1.374	3.435	1.332	3.408	1.296
30	6.592	1.847	6.396	1.628	4.005	1.337	3.943	1.381	3.912	1.337
32	7.500	1.991	7.278	1.751	4.557	1.446	4.486	1.346	4.452	1.382
34	**8.466**	**2.133**	**8.216**	**1.874**	5.145	1.555	5.065	1.445	5.025	1.324
36	**9.492**	**2.275**	**9.211**	**1.996**	5.768	1.663	5.678	1.544	5.634	1.413
38	**10.576**	**2.417**	**10.262**	**2.117**	6.427	1.771	6.326	1.642	6.277	1.501

Note: Values where KL/r > 200 are shown in bold letters.

APPENDIX C (continued)

Tables of α and β Values (continued)

KL (ft) or L_b (ft)	W10×68		W10×77		W10×88		W10×100		W10×112	
	α	β	α	β	α	β	α	β	α	β
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	1.006	1.000	1.006	1.000	1.006	1.000	1.006	1.000	1.006	1.000
4	1.025	1.000	1.025	1.000	1.025	1.000	1.024	1.000	1.024	1.000
6	1.058	1.000	1.058	1.000	1.056	1.000	1.056	1.000	1.054	1.000
8	1.106	1.000	1.105	1.000	1.102	1.000	1.101	1.000	1.098	1.000
10	1.170	1.009	1.169	1.008	1.165	1.006	1.162	1.005	1.158	1.003
12	1.254	1.031	1.252	1.028	1.245	1.023	1.241	1.020	1.235	1.017
14	1.361	1.055	1.357	1.049	1.348	1.041	1.342	1.036	1.333	1.031
16	1.495	1.079	1.491	1.070	1.477	1.060	1.468	1.052	1.456	1.045
18	1.664	1.105	1.657	1.093	1.638	1.079	1.626	1.069	1.609	1.060
20	1.875	1.132	1.866	1.116	1.840	1.099	1.823	1.086	1.799	1.075
22	2.139	1.161	2.127	1.141	2.091	1.120	2.068	1.104	2.034	1.091
24	2.472	1.191	2.455	1.167	2.405	1.142	2.374	1.123	2.329	1.107
26	2.893	1.222	2.871	1.193	2.806	1.164	2.764	1.142	2.702	1.124
28	3.356	1.255	3.330	1.221	3.254	1.187	3.206	1.162	3.134	1.141
30	3.852	1.290	3.823	1.251	3.736	1.212	3.680	1.183	3.598	1.159
32	4.383	1.327	4.349	1.282	4.251	1.237	4.187	1.204	4.094	1.177
34	4.948	1.366	4.910	1.314	4.799	1.264	4.727	1.226	4.621	1.196
36	5.547	1.269	5.505	1.349	5.380	1.291	5.299	1.249	5.181	1.215
38	6.181	1.347	6.133	1.385	5.994	1.320	5.904	1.273	5.773	1.235

Tables of α and β Values (continued)

KL (ft) or L_b (ft)	W12×22		W12×26		W12×30		W12×35		W12×40	
	α	β	α	β	α	β	α	β	α	β
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	1.061	1.000	1.019	1.000	1.018	1.000	1.018	1.000	1.011	1.000
4	1.265	1.060	1.077	1.000	1.076	1.000	1.074	1.000	1.046	1.000
6	1.697	1.205	1.181	1.024	1.178	1.019	1.173	1.018	1.107	1.000
8	2.561	1.396	1.344	1.098	1.339	1.089	1.329	1.083	1.199	1.028
10	4.002	1.701	1.588	1.185	1.578	1.169	1.560	1.157	1.327	1.077
12	5.763	2.219	1.946	1.285	1.929	1.262	1.896	1.242	1.503	1.131
14	7.844	2.742	2.474	1.301	2.445	1.371	2.389	1.340	1.741	1.191
16	**10.246**	**3.266**	3.224	1.615	3.181	1.495	3.099	1.360	2.063	1.258
18	**12.967**	**3.788**	4.080	1.939	4.027	1.782	3.923	1.608	2.501	1.333
20	**16.009**	**4.306**	5.037	2.271	4.971	2.073	4.843	1.857	3.083	1.314
22	**19.371**	**4.821**	6.095	2.607	6.015	2.366	5.860	2.107	3.731	1.498
24	**23.053**	**5.333**	7.253	2.946	7.158	2.660	6.974	2.357	4.440	1.683
26	**27.055**	**5.842**	**8.513**	**3.286**	**8.401**	**2.953**	**8.184**	**2.605**	5.211	1.868
28	**31.378**	**6.348**	**9.873**	**3.627**	**9.743**	**3.246**	**9.492**	**2.852**	6.043	2.052
30	**36.021**	**6.852**	**11.334**	**3.967**	**11.185**	**3.538**	**10.896**	**3.099**	6.938	2.236
32	**40.983**	**7.353**	**12.895**	**4.306**	**12.726**	**3.829**	**12.398**	**3.344**	7.893	2.418
34	**46.266**	**7.853**	**14.557**	**4.645**	**14.366**	**4.119**	**13.996**	**3.588**	**8.911**	**2.601**
36	**51.870**	**8.351**	**16.320**	**4.982**	**16.106**	**4.407**	**15.691**	**3.831**	**9.990**	**2.782**
38	**57.793**	**8.848**	**18.184**	**5.318**	**17.946**	**4.695**	**17.482**	**4.073**	**11.131**	**2.963**

Note: Values where $KL/r > 200$ are shown in bold letters.

APPENDIX C (continued)

Tables of α and β Values (continued)										
***KL* (ft) or L_b (ft)**	**W12×45**		**W12×50**		**W12×53**		**W12×58**		**W12×65**	
	α	β	α	β	α	β	α	β	α	β
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	1.011	1.000	1.011	1.000	1.007	1.000	1.007	1.000	1.005	1.000
4	1.046	1.000	1.045	1.000	1.028	1.000	1.027	1.000	1.019	1.000
6	1.106	1.000	1.104	1.000	1.064	1.000	1.062	1.000	1.042	1.000
8	1.196	1.023	1.192	1.022	1.116	1.000	1.113	1.000	1.077	1.000
10	1.323	1.069	1.316	1.064	1.187	1.020	1.182	1.017	1.123	1.000
12	1.497	1.119	1.484	1.109	1.280	1.055	1.272	1.050	1.181	1.003
14	1.731	1.174	1.712	1.159	1.399	1.093	1.388	1.085	1.254	1.030
16	2.048	1.234	2.018	1.213	1.551	1.133	1.535	1.122	1.344	1.059
18	2.478	1.301	2.432	1.273	1.742	1.177	1.719	1.162	1.454	1.089
20	3.052	1.376	2.990	1.338	1.985	1.224	1.953	1.205	1.588	1.121
22	3.692	1.390	3.618	1.292	2.292	1.275	2.247	1.251	1.749	1.155
24	4.394	1.557	4.305	1.442	2.689	1.330	2.625	1.301	1.946	1.192
26	5.157	1.722	5.053	1.591	3.156	1.272	3.081	1.355	2.184	1.230
28	5.981	1.887	5.860	1.739	3.660	1.403	3.573	1.309	2.474	1.272
30	6.866	2.052	6.727	1.887	4.202	1.535	4.102	1.428	2.833	1.316
32	7.812	2.215	7.654	2.034	4.780	1.666	4.667	1.547	3.224	1.239
34	**8.819**	**2.378**	**8.640**	**2.181**	5.397	1.796	5.268	1.665	3.639	1.341
36	**9.887**	**2.540**	**9.687**	**2.327**	6.050	1.927	5.907	1.783	4.080	1.442
38	**11.016**	**2.702**	**10.793**	**2.472**	6.741	2.056	6.581	1.901	4.546	1.544

Note: Values where KL/r > 200 are shown in bold letters.

Tables of α and β Values (continued)										
***KL* (ft) or L_b (ft)**	**W12×72**		**W12×79**		**W12×87**		**W12×96**		**W12×106**	
	α	β	α	β	α	β	α	β	α	β
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	1.005	1.000	1.005	1.000	1.004	1.000	1.004	1.000	1.004	1.000
4	1.018	1.000	1.018	1.000	1.018	1.000	1.018	1.000	1.018	1.000
6	1.042	1.000	1.042	1.000	1.041	1.000	1.041	1.000	1.040	1.000
8	1.076	1.000	1.075	1.000	1.074	1.000	1.073	1.000	1.072	1.000
10	1.121	1.000	1.120	1.000	1.118	1.000	1.117	1.000	1.115	1.000
12	1.178	1.016	1.177	1.014	1.175	1.012	1.172	1.010	1.170	1.009
14	1.250	1.042	1.249	1.037	1.245	1.033	1.242	1.030	1.238	1.027
16	1.339	1.069	1.336	1.062	1.331	1.056	1.327	1.051	1.322	1.045
18	1.447	1.098	1.444	1.088	1.437	1.079	1.430	1.072	1.423	1.064
20	1.578	1.128	1.573	1.116	1.564	1.104	1.555	1.094	1.546	1.084
22	1.737	1.159	1.730	1.145	1.718	1.130	1.706	1.117	1.695	1.105
24	1.929	1.193	1.921	1.175	1.904	1.157	1.889	1.141	1.873	1.127
26	2.162	1.229	2.151	1.207	2.130	1.185	2.109	1.166	2.089	1.149
28	2.445	1.267	2.431	1.241	2.403	1.215	2.376	1.192	2.350	1.172
30	2.796	1.307	2.778	1.276	2.742	1.246	2.706	1.220	2.672	1.197
32	3.181	1.350	3.161	1.314	3.120	1.279	3.079	1.249	3.040	1.222
34	3.592	1.265	3.568	1.354	3.522	1.314	3.476	1.279	3.432	1.248
36	4.027	1.359	4.000	1.263	3.948	1.351	3.897	1.310	3.847	1.276
38	4.486	1.452	4.457	1.348	4.399	1.389	4.342	1.344	4.287	1.305

APPENDIX C (continued)

Tables of α and β Values (continued)

***KL* (ft) or *L_b* (ft)**	**W12×120**		**W14×22**		**W14×26**		**W14×30**		**W14×34**	
	α	β	α	β	α	β	α	β	α	β
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	1.004	1.000	1.040	1.000	1.037	1.000	1.019	1.000	1.018	1.000
4	1.017	1.000	1.169	1.015	1.156	1.009	1.079	1.000	1.075	1.000
6	1.039	1.000	1.420	1.130	1.384	1.113	1.186	1.025	1.176	1.020
8	1.071	1.000	1.866	1.274	1.783	1.240	1.355	1.102	1.334	1.091
10	1.114	1.000	2.655	1.373	2.468	1.400	1.608	1.192	1.569	1.173
12	1.168	1.007	3.823	1.868	3.545	1.667	1.981	1.298	1.912	1.269
14	1.235	1.023	5.203	2.395	4.825	2.115	2.536	1.310	2.417	1.381
16	1.317	1.039	6.796	2.942	6.302	2.574	3.311	1.632	3.140	1.510
18	1.417	1.056	**8.601**	**3.502**	**7.976**	**3.038**	4.190	1.969	3.974	1.810
20	1.538	1.073	**10.619**	**4.069**	**9.847**	**3.505**	5.173	2.314	4.906	2.115
22	1.683	1.091	**12.849**	**4.639**	**11.914**	**3.972**	6.260	2.666	5.937	2.424
24	1.858	1.110	**15.291**	**5.210**	**14.179**	**4.438**	7.449	3.021	7.065	2.735
26	2.069	1.129	**17.946**	**5.781**	**16.641**	**4.902**	**8.743**	**3.379**	**8.292**	**3.047**
28	2.324	1.149	**20.813**	**6.350**	**19.299**	**5.364**	**10.140**	**3.739**	**9.616**	**3.358**
30	2.638	1.170	**23.892**	**6.917**	**22.155**	**5.823**	**11.640**	**4.098**	**11.039**	**3.669**
32	3.001	1.191	**27.184**	**7.482**	**25.207**	**6.281**	**13.244**	**4.457**	**12.560**	**3.979**
34	3.388	1.213	**30.688**	**8.045**	**28.457**	**6.736**	**14.951**	**4.815**	**14.179**	**4.288**
36	3.798	1.236	**34.404**	**8.605**	**31.903**	**7.190**	**16.761**	**5.173**	**15.896**	**4.597**
38	4.232	1.260	**38.333**	**9.164**	**35.546**	**7.642**	**18.675**	**5.529**	**17.712**	**4.904**

Note: Values where KL/r > 200 are shown in bold letters.

Tables of α and β Values (continued)

***KL* (ft) or *L_b* (ft)**	**W14×38**		**W14×43**		**W14×48**		**W14×53**		**W14×61**	
	α	β	α	β	α	β	α	β	α	β
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	1.018	1.000	1.012	1.000	1.012	1.000	1.012	1.000	1.007	1.000
4	1.073	1.000	1.048	1.000	1.047	1.000	1.047	1.000	1.028	1.000
6	1.171	1.016	1.112	1.000	1.110	1.000	1.108	1.000	1.065	1.000
8	1.324	1.083	1.208	1.033	1.203	1.028	1.201	1.026	1.119	1.000
10	1.551	1.160	1.343	1.087	1.335	1.079	1.331	1.074	1.192	1.023
12	1.881	1.248	1.529	1.147	1.516	1.134	1.509	1.126	1.288	1.059
14	2.363	1.352	1.783	1.215	1.762	1.196	1.751	1.183	1.411	1.099
16	3.060	1.416	2.128	1.291	2.095	1.265	2.079	1.246	1.568	1.142
18	3.872	1.687	2.604	1.377	2.550	1.343	2.525	1.317	1.766	1.188
20	4.780	1.962	3.215	1.428	3.148	1.333	3.116	1.395	2.018	1.238
22	5.784	2.238	3.890	1.636	3.809	1.520	3.770	1.422	2.339	1.292
24	6.884	2.515	4.630	1.846	4.533	1.708	4.486	1.594	2.755	1.351
26	**8.079**	**2.792**	5.434	2.055	5.321	1.896	5.265	1.764	3.234	1.322
28	**9.370**	**3.068**	6.302	2.265	6.171	2.084	6.106	1.934	3.750	1.460
30	**10.756**	**3.343**	7.234	2.475	7.084	2.270	7.010	2.104	4.305	1.598
32	**12.238**	**3.617**	**8.231**	**2.684**	**8.060**	**2.456**	**7.976**	**2.272**	4.898	1.736
34	**13.816**	**3.890**	**9.292**	**2.892**	**9.098**	**2.642**	**9.004**	**2.440**	5.530	1.874
36	**15.489**	**4.162**	**10.417**	**3.099**	**10.200**	**2.826**	**10.094**	**2.607**	6.199	2.011
38	**17.258**	**4.433**	**11.607**	**3.306**	**11.365**	**3.010**	**11.247**	**2.774**	6.907	2.148

Note: Values where KL/r > 200 are shown in bold letters.

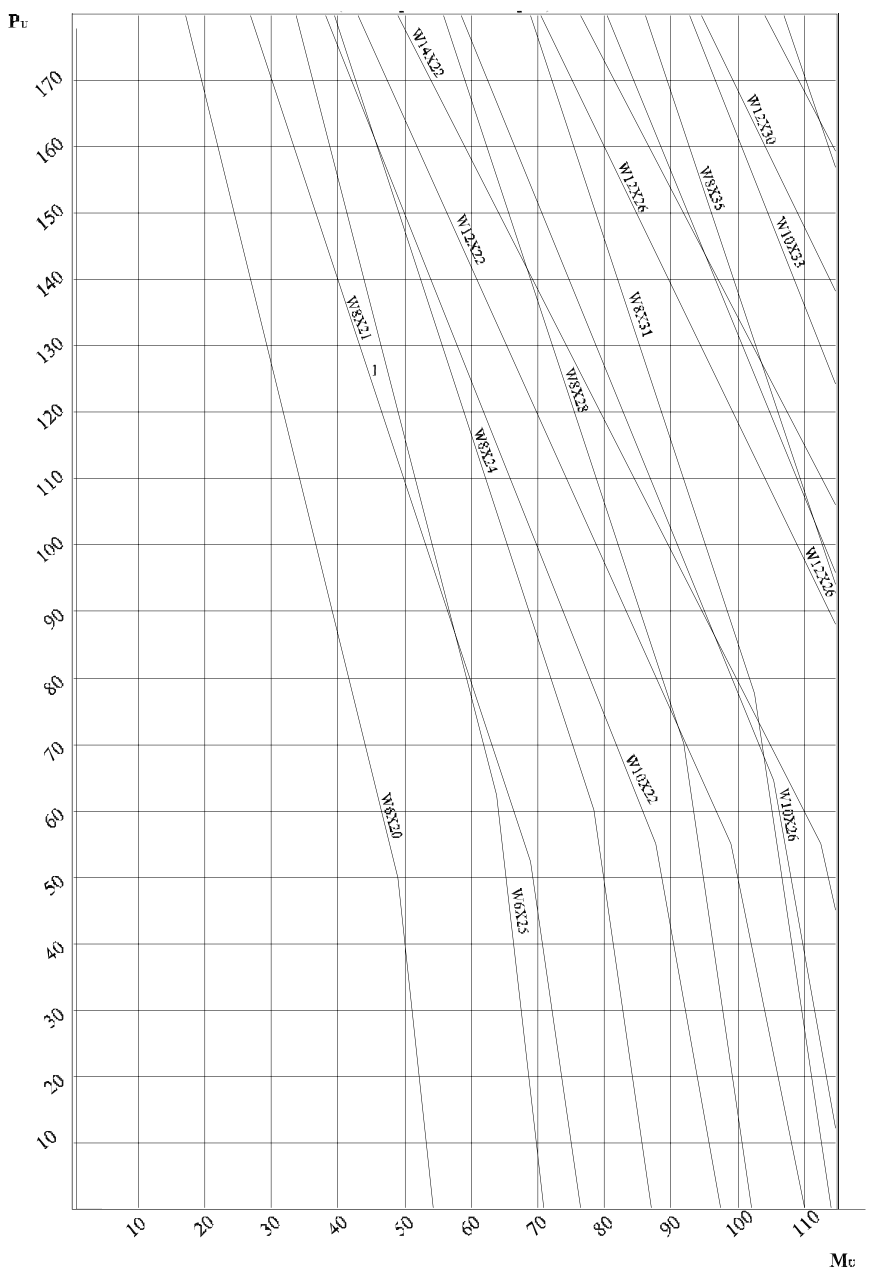
APPENDIX C (continued)

Tables of α and β Values (continued)										
KL (ft) or L_b (ft)	W14×68		W14×74		W14×82		W14×90		W14×99	
	α	β	α	β	α	β	α	β	α	β
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	1.007	1.000	1.007	1.000	1.007	1.000	1.003	1.000	1.003	1.000
4	1.028	1.000	1.028	1.000	1.028	1.000	1.012	1.000	1.012	1.000
6	1.065	1.000	1.064	1.000	1.064	1.000	1.028	1.000	1.028	1.000
8	1.118	1.000	1.116	1.000	1.116	1.000	1.051	1.000	1.050	1.000
10	1.190	1.021	1.187	1.018	1.187	1.017	1.080	1.000	1.080	1.000
12	1.285	1.056	1.280	1.051	1.280	1.047	1.117	1.000	1.117	1.000
14	1.407	1.093	1.399	1.085	1.399	1.079	1.163	1.000	1.162	1.006
16	1.562	1.133	1.551	1.122	1.551	1.112	1.218	1.011	1.217	1.027
18	1.758	1.175	1.742	1.161	1.742	1.148	1.283	1.034	1.282	1.048
20	2.007	1.221	1.985	1.203	1.985	1.186	1.361	1.058	1.358	1.071
22	2.323	1.271	2.292	1.248	2.292	1.227	1.452	1.083	1.449	1.094
24	2.733	1.325	2.689	1.297	2.689	1.271	1.558	1.109	1.554	1.118
26	3.207	1.384	3.156	1.349	3.156	1.318	1.683	1.137	1.678	1.144
28	3.720	1.356	3.660	1.272	3.660	1.369	1.829	1.166	1.823	1.171
30	4.270	1.481	4.202	1.387	4.202	1.292	1.999	1.196	1.992	1.199
32	4.859	1.605	4.780	1.500	4.780	1.396	2.200	1.228	2.190	1.228
34	5.485	1.729	5.397	1.614	5.397	1.499	2.435	1.262	2.423	1.259
36	6.149	1.852	6.050	1.727	6.050	1.602	2.718	1.298	2.704	1.291
38	6.851	1.975	6.741	1.839	6.741	1.704	3.029	1.336	3.012	1.326

Tables of α and β Values (continued)				
KL (ft) or L_b (ft)	W14×109		W14×120	
	α	β	α	β
0	1.000	1.000	1.000	1.000
2	1.003	1.000	1.003	1.000
4	1.012	1.000	1.012	1.000
6	1.028	1.000	1.027	1.000
8	1.050	1.000	1.049	1.000
10	1.079	1.000	1.078	1.000
12	1.115	1.000	1.115	1.000
14	1.160	1.008	1.159	1.007
16	1.214	1.027	1.213	1.025
18	1.278	1.047	1.277	1.043
20	1.354	1.068	1.352	1.062
22	1.443	1.089	1.440	1.082
24	1.547	1.112	1.543	1.102
26	1.669	1.135	1.664	1.123
28	1.811	1.160	1.805	1.145
30	1.977	1.185	1.970	1.168
32	2.172	1.212	2.163	1.192
34	2.401	1.240	2.389	1.217
36	2.675	1.269	2.660	1.243
38	2.980	1.300	2.964	1.270

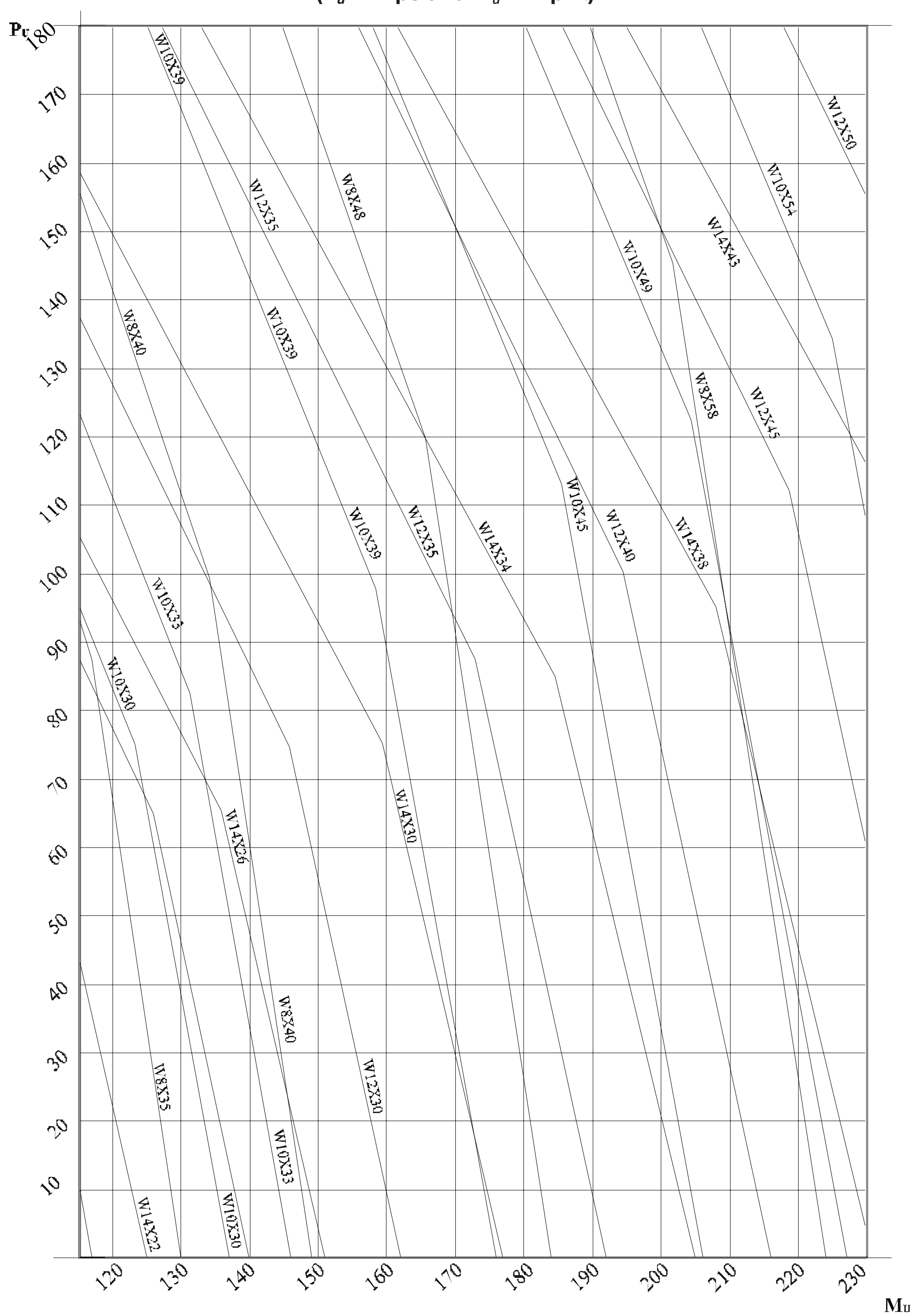
APPENDIX D

Chart D1. Design Curves for Interaction Equation (P_u in kips and M_u in kip-ft)



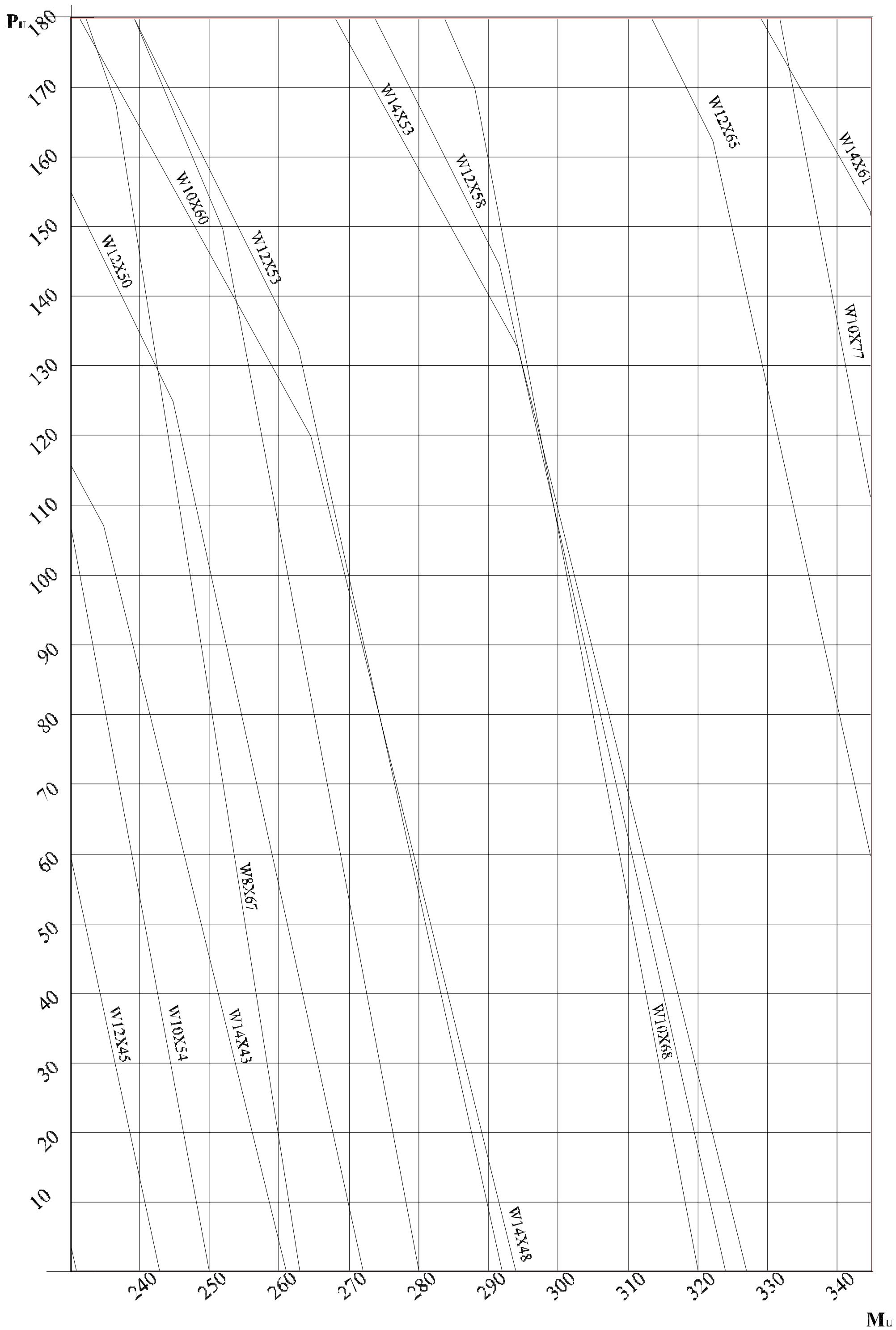
APPENDIX D (continued)

Chart D2. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



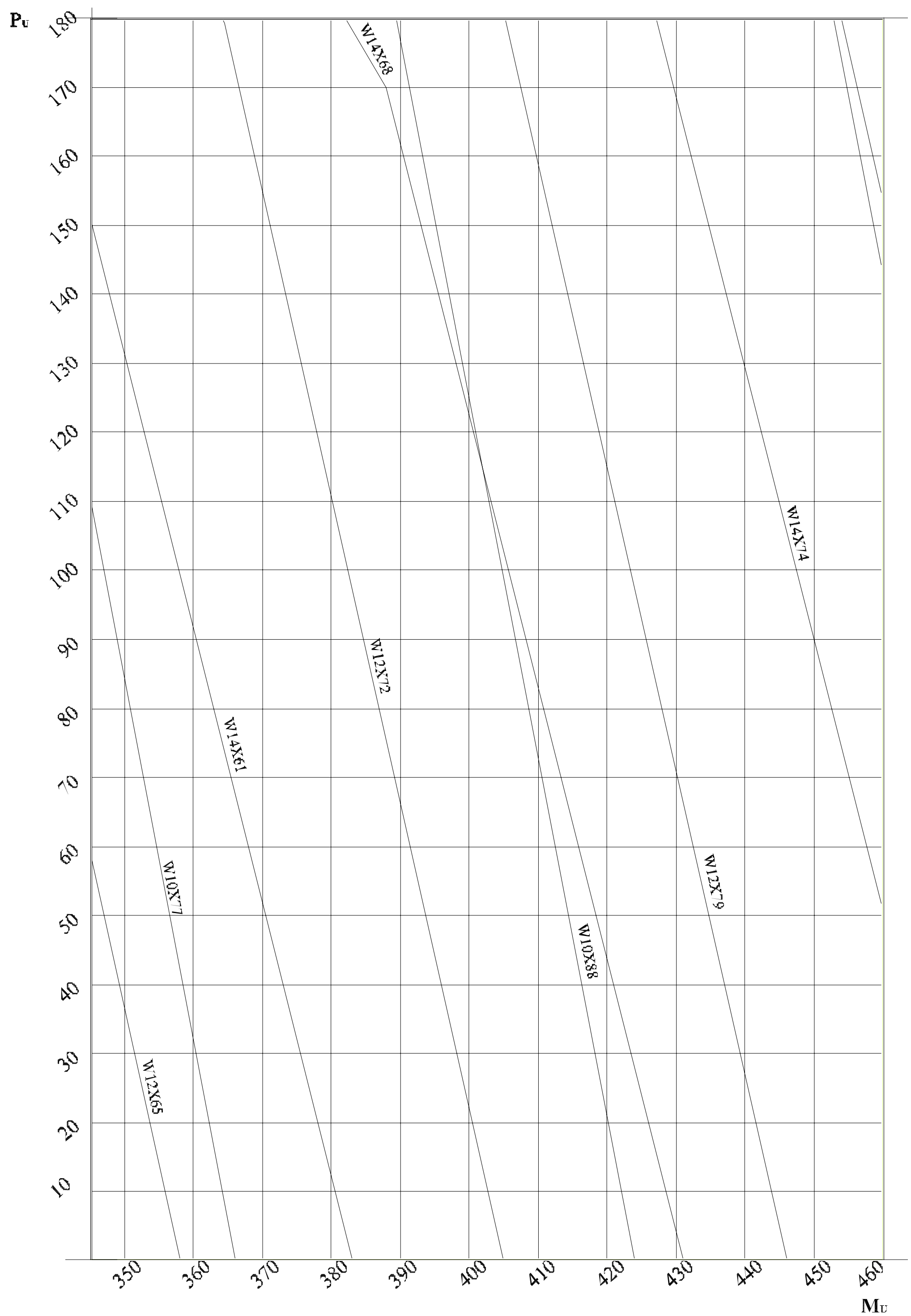
APPENDIX D (continued)

Chart D3. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



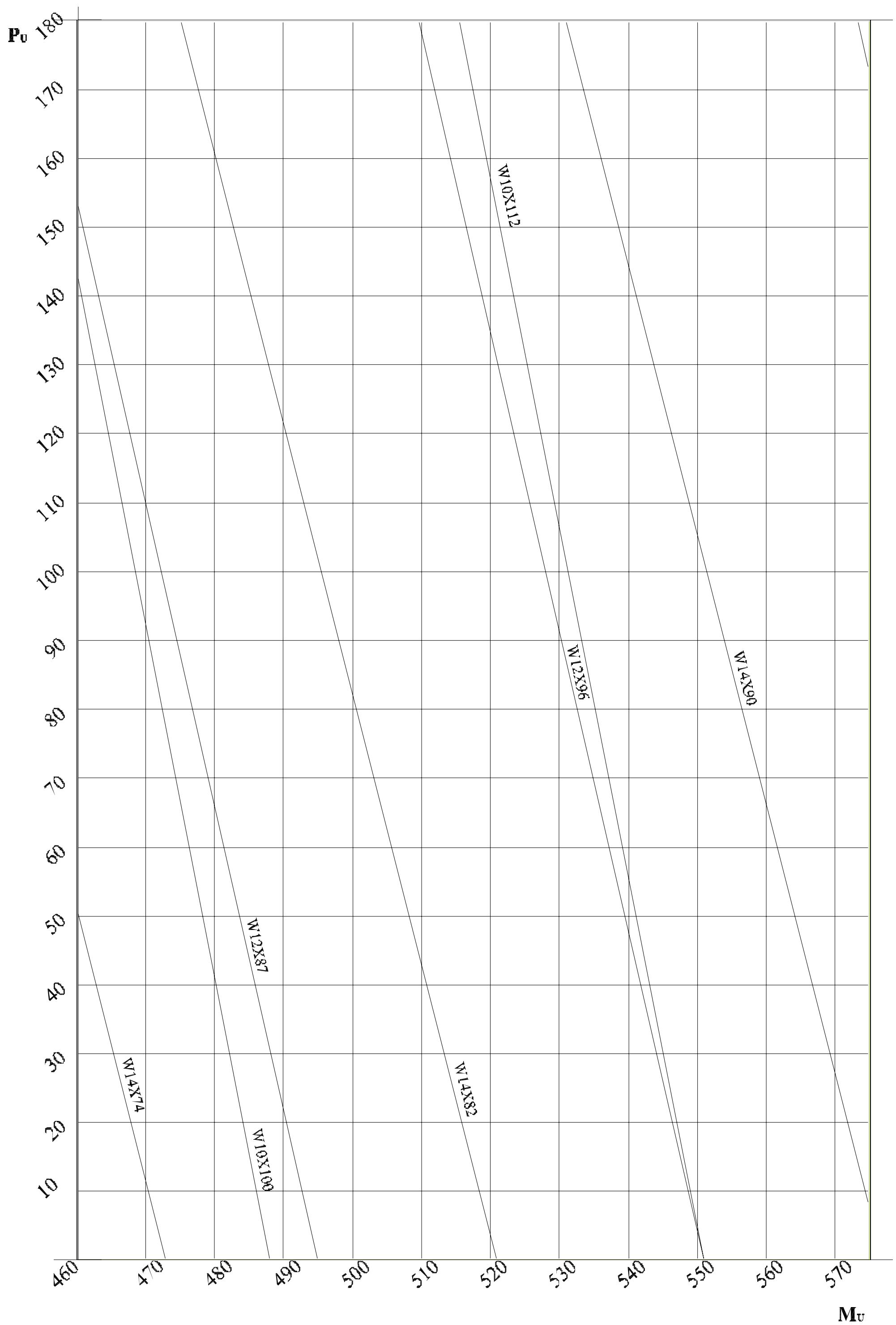
APPENDIX D (continued)

Chart D4. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



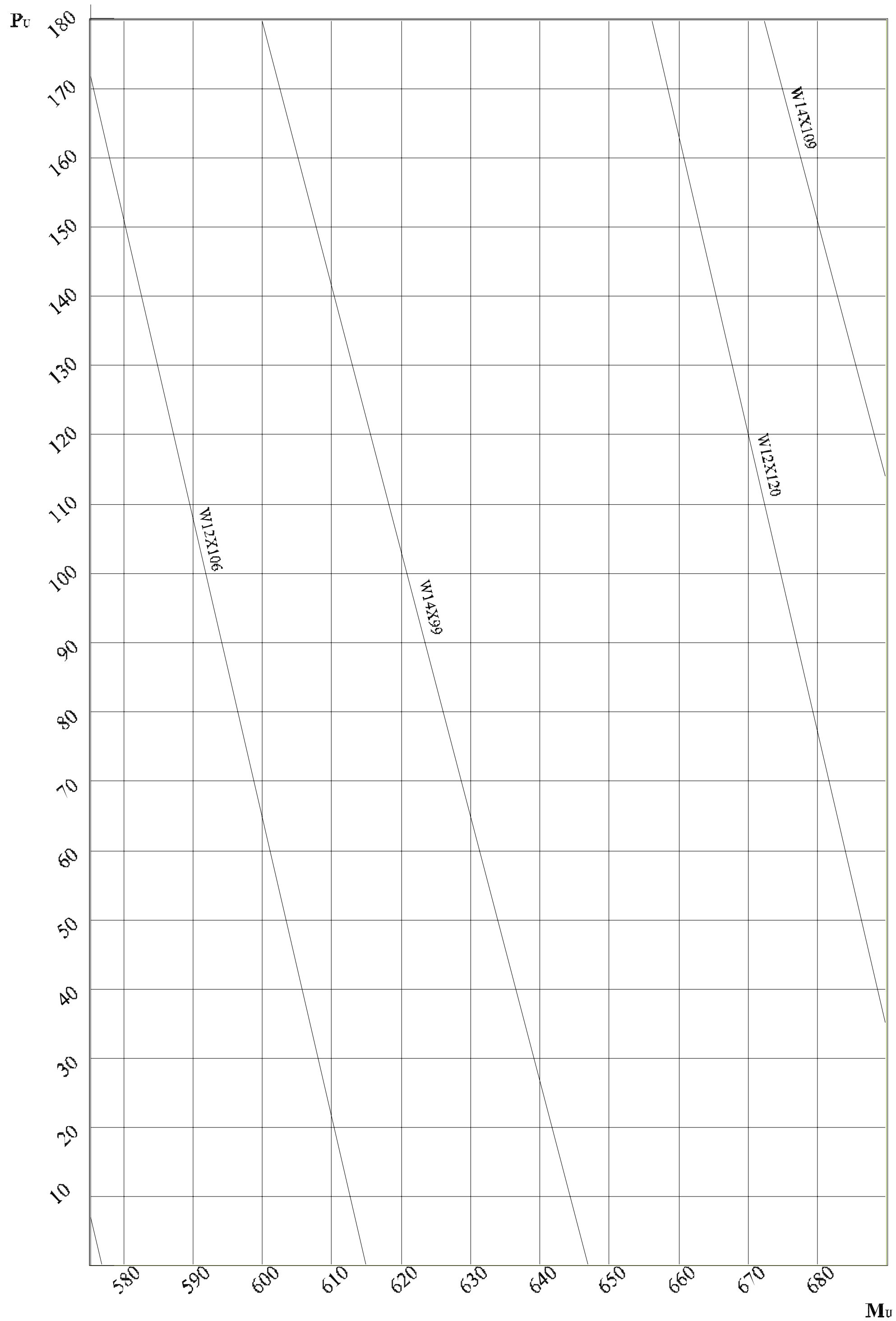
APPENDIX D (continued)

Chart D5. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



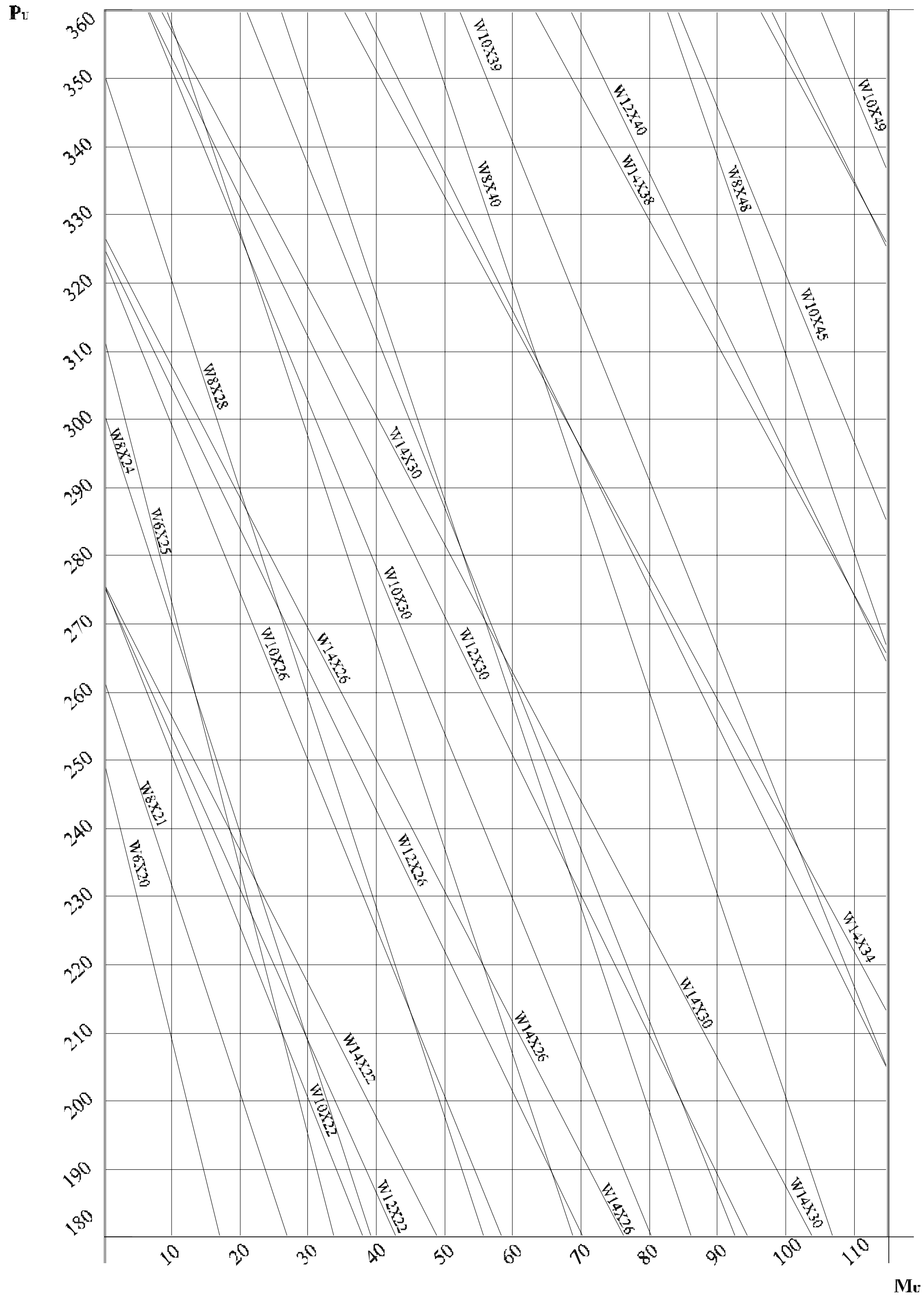
APPENDIX D (continued)

Chart D6. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



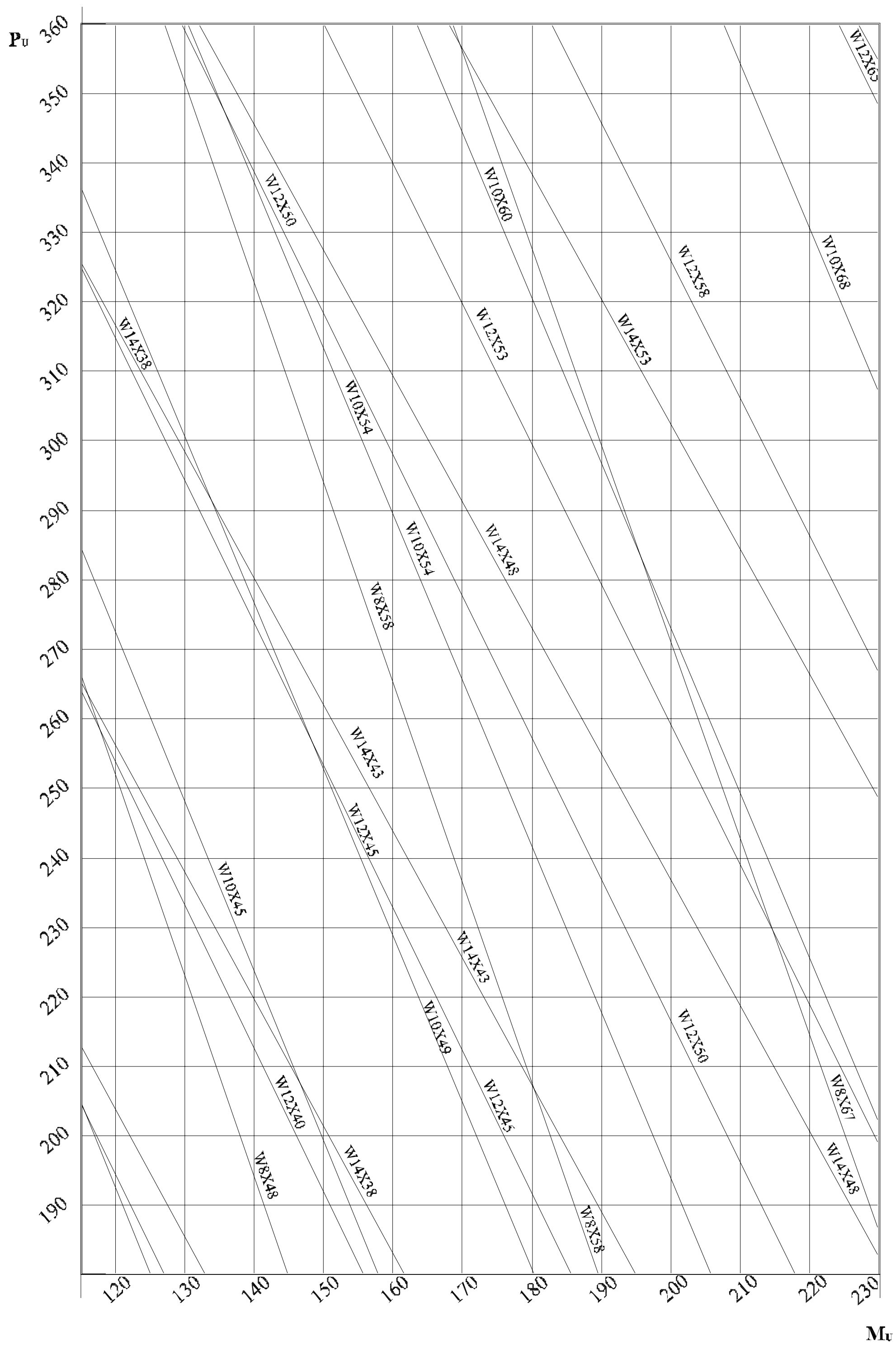
APPENDIX D (continued)

Chart D7. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



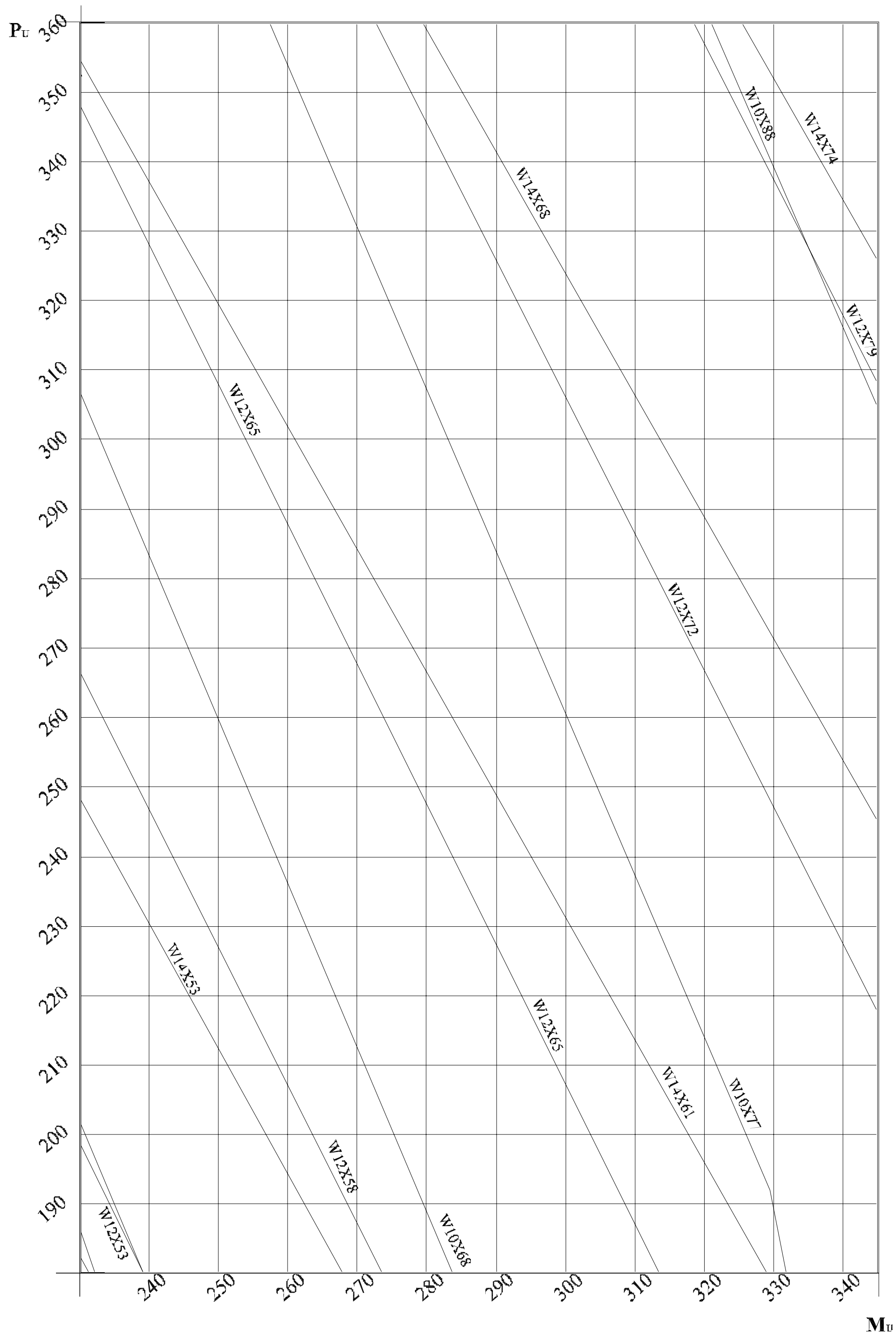
APPENDIX D (continued)

Chart D8. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



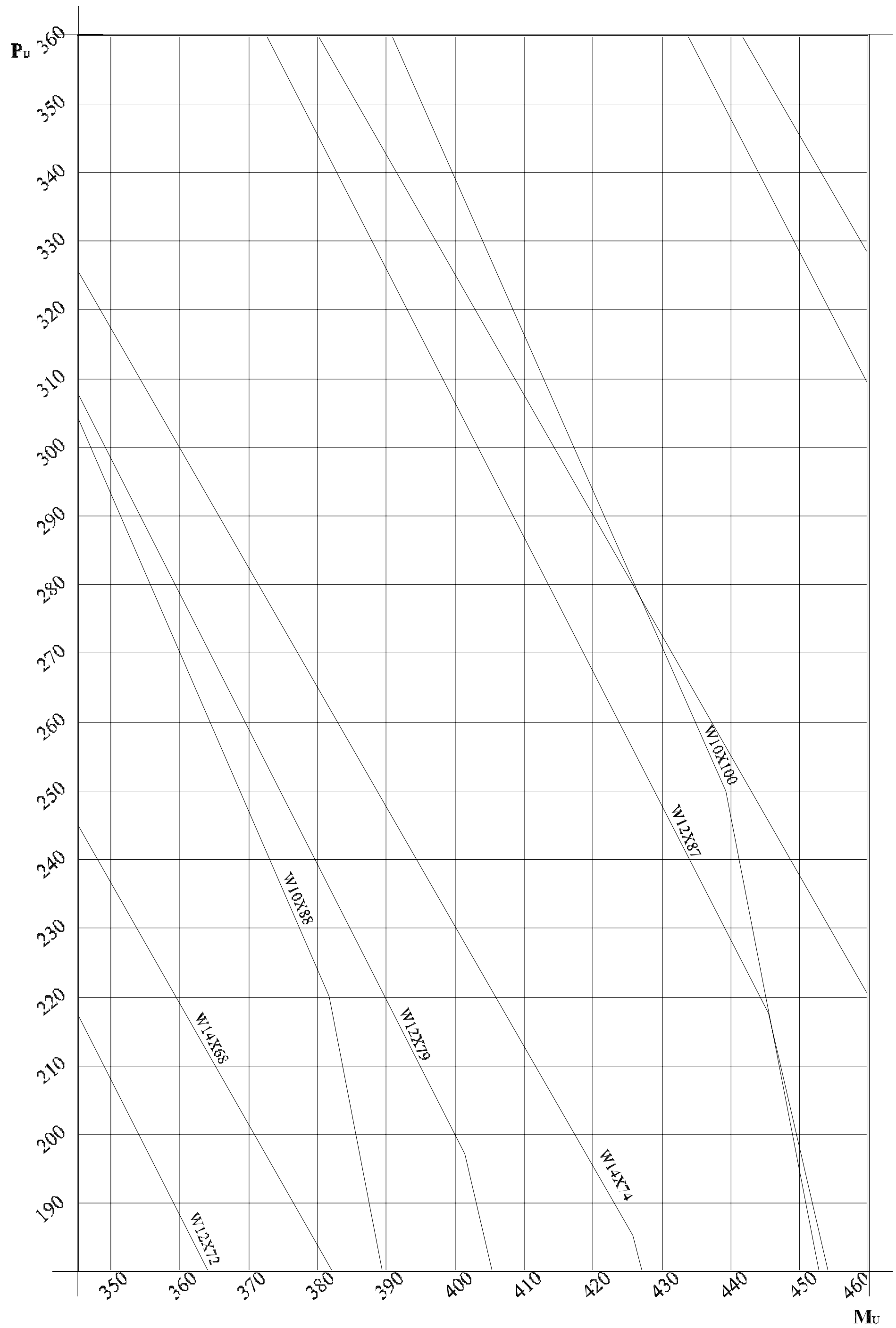
APPENDIX D (continued)

Chart D9. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



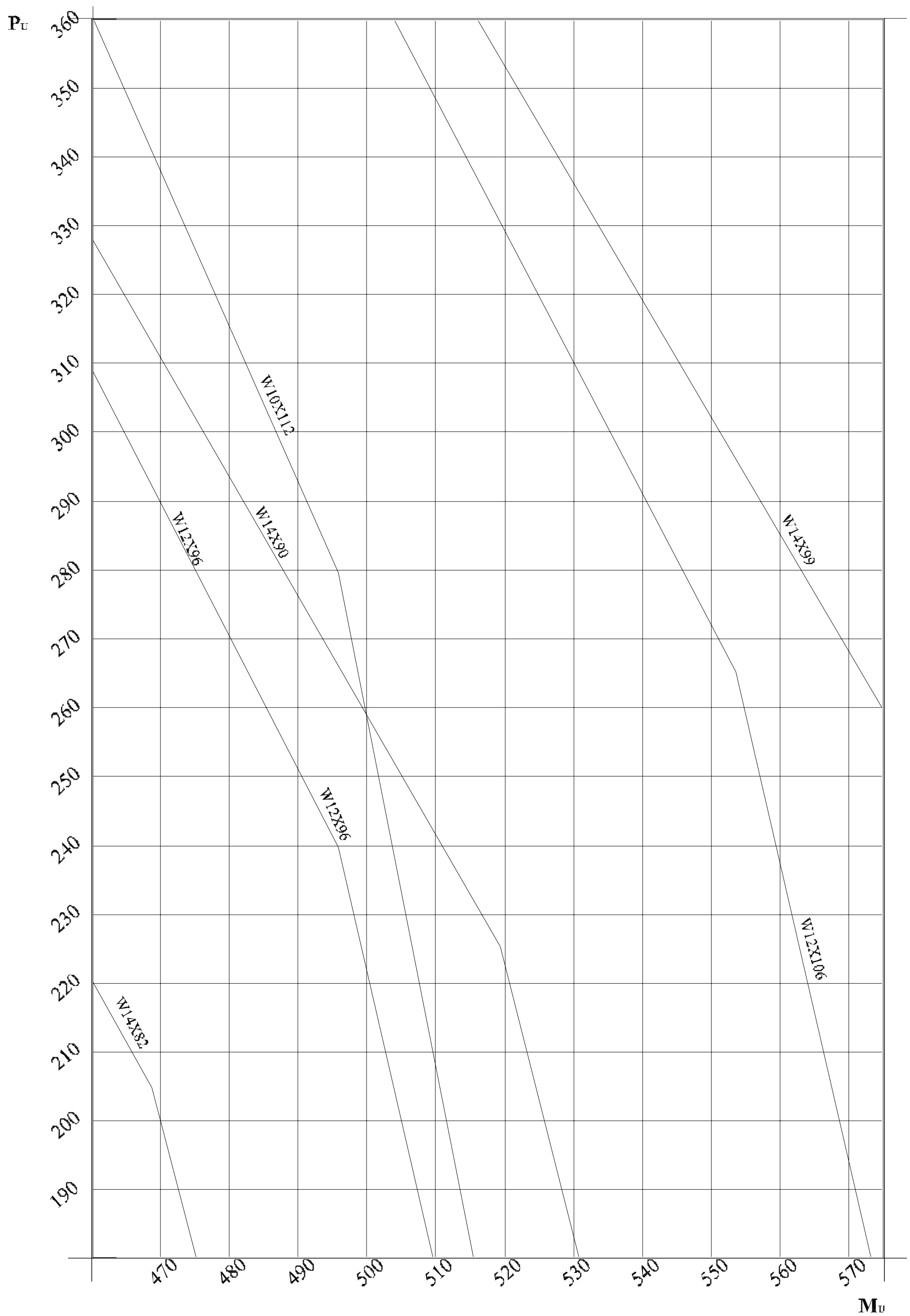
APPENDIX D (continued)

Chart D10. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



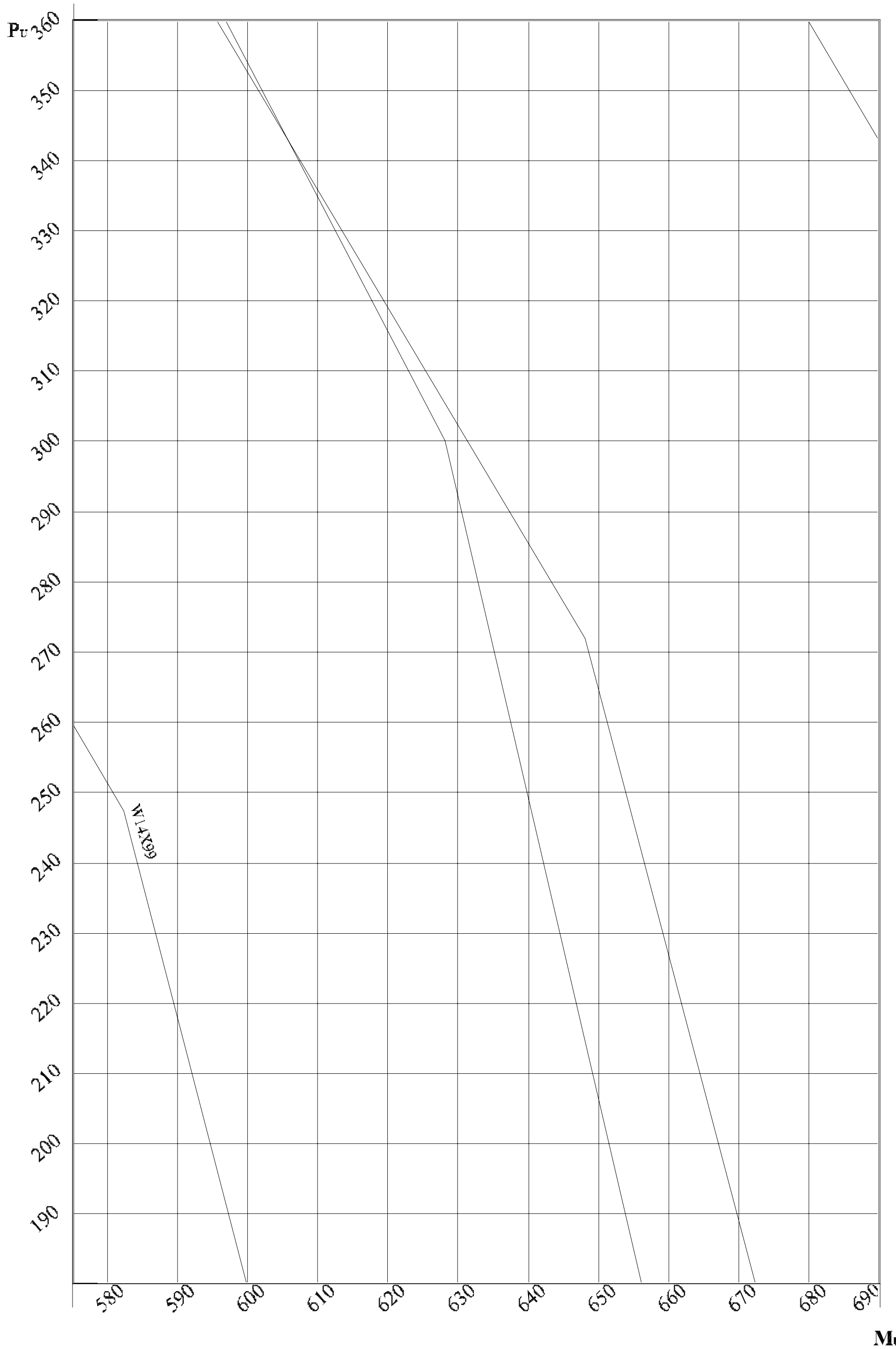
APPENDIX D (continued)

Chart D11. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



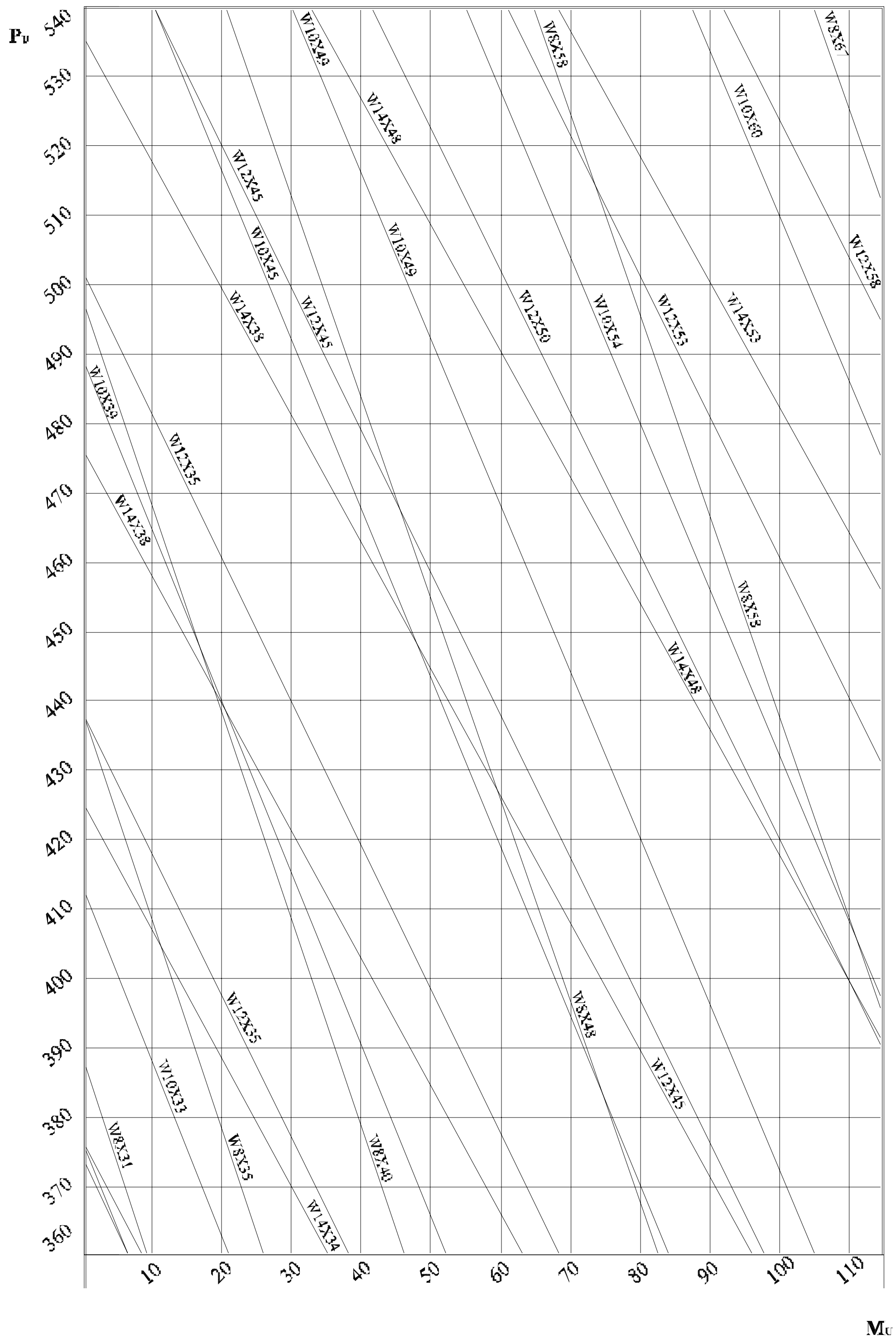
APPENDIX D (continued)

Chart D12. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



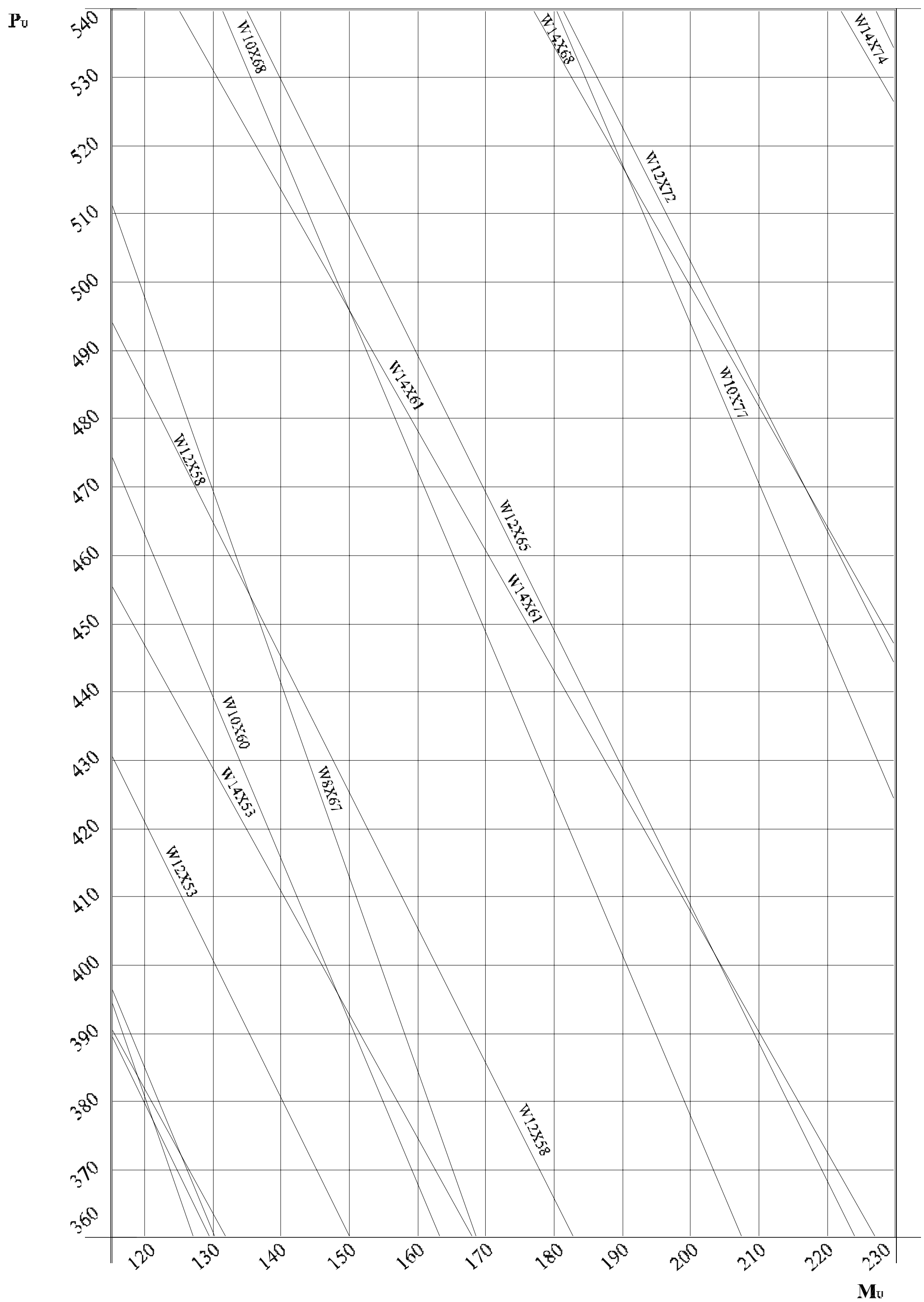
APPENDIX D (continued)

Chart D13. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



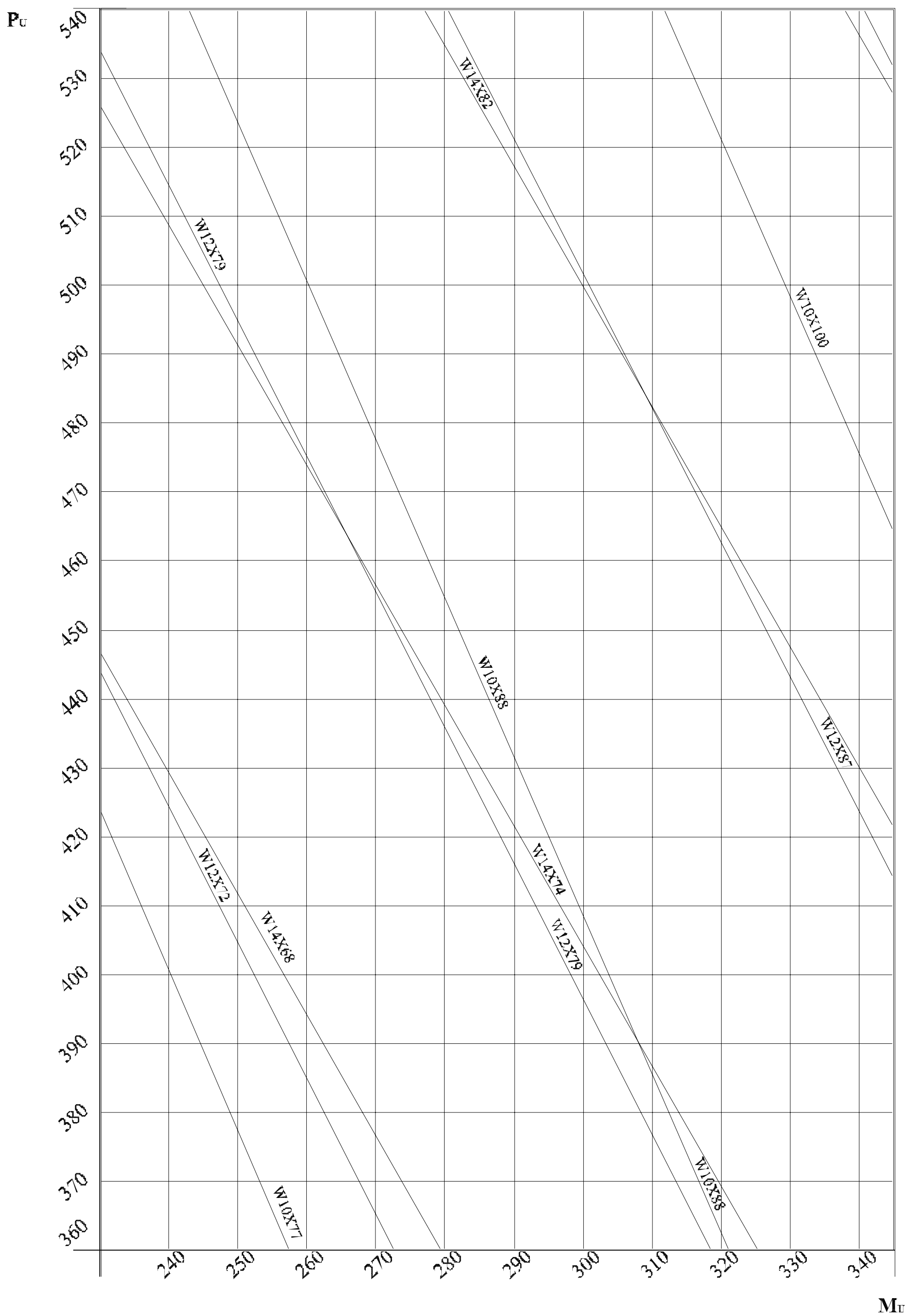
APPENDIX D (continued)

Chart D14. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



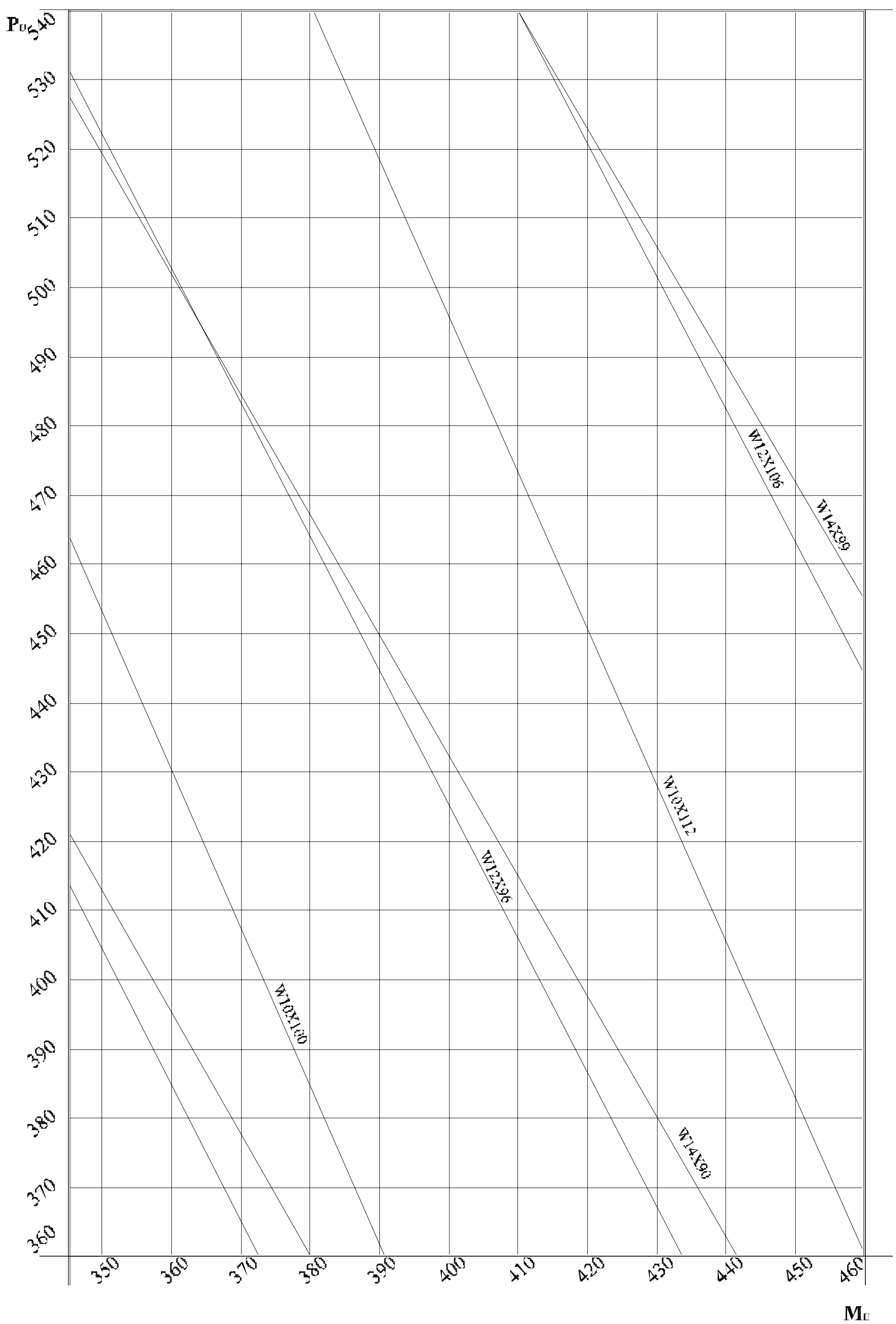
APPENDIX D (continued)

Chart D15. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



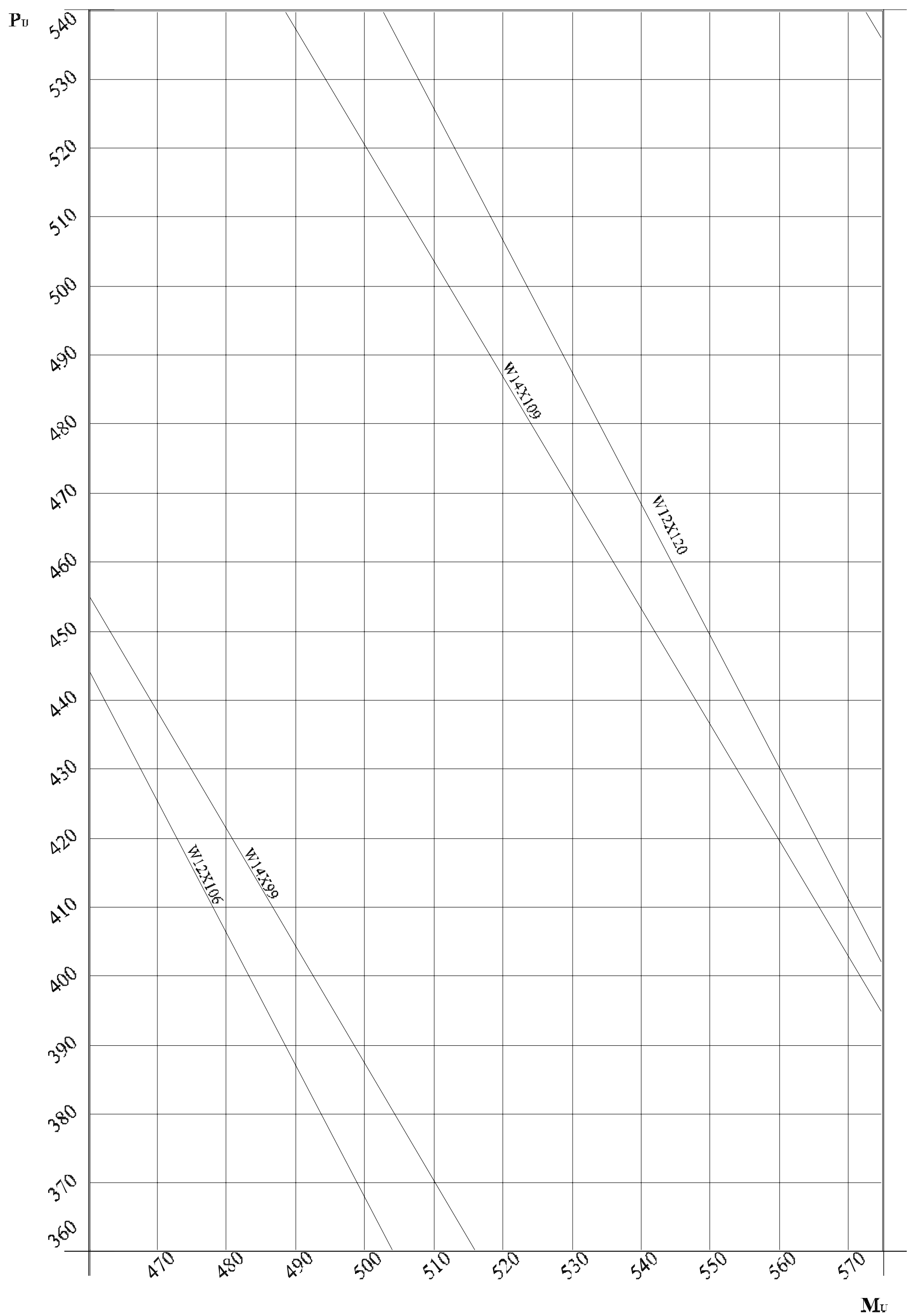
APPENDIX D (continued)

Chart D16. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



APPENDIX D (continued)

Chart D17. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)



APPENDIX D (continued)

Chart D18. Design Curves for Interaction Equation (continued)
(P_u in kips and M_u in kip-ft)