Content of Post 18b:

① Find Cb Values for Simple beam with braces at mid point and edges (Case-2) – Uniform Load (what would be the old Cb values?

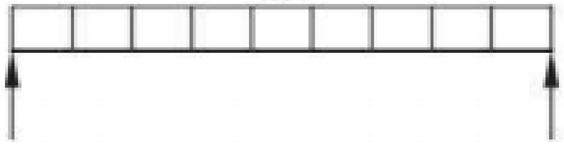
② Find Cb value for simple beam with End bracings Under Central Load (Cb = 1.32)

③ ← Do → with three braces Cb = 1.67

④ Find Cb Value For Fixed end moment Beam under U. Load, bracings 3 braces. → 3 braces

⑤ Cb For Fixed moment → Under P. Load

Table 3-1
Values of C_b for Simply Supported Beams

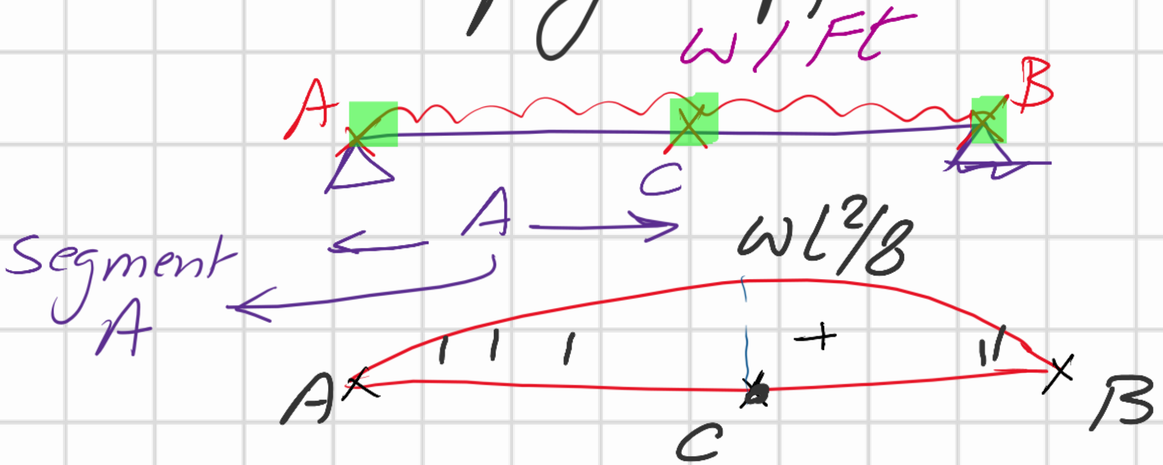
Load	Lateral Bracing Along Span	C_b
	None	1.14
	At midpoint	1.30 1.30
	At third points	1.45 1.01 1.45
	At quarter points	1.52 1.06 1.06 1.52
	At fifth points	1.56 1.12 1.00 1.12 1.56

included in → Post 17

post → 18b

post → 18c

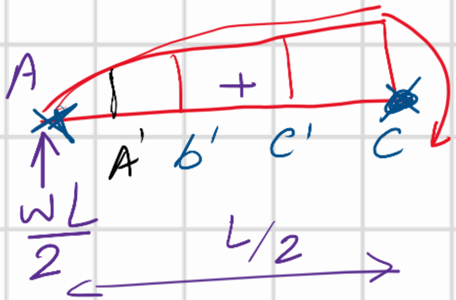
C_b for simply supported beam



Three braces at A, B, C

Parts AC & CB

Maximum $M = wL^2/8$



Divide part $\boxed{A-C}$ to Four quarters, A', b', c'

$$\left.\begin{matrix} AA' \\ Ab' \\ b'c' \end{matrix}\right\} = L/8$$

$$M_{A'} = \frac{wL}{2}\left(\frac{L}{8}\right) - \frac{wL^2}{8(16)} = \frac{7}{16} wL^2 \left(\frac{1}{8}\right)$$

$$M_{b'} = \frac{wL}{2}\left(\frac{l}{4}\right) - w\frac{L}{4}\left(\frac{L}{8}\right) = \frac{3}{32} wL^2$$

$$M_{c'} = \frac{wL}{2}\left(\frac{3l}{8}\right) - w\left(\frac{3L}{8}\right)\left(\frac{3L}{16}\right) = \frac{(24-9)wL^2}{8(16)} = \frac{15}{8(16)} wL^2$$

$$M_C = \frac{wL^2}{8} = M_{max}$$

$$\boxed{AA' = \frac{L}{2}\left(1/4\right) = L/8}$$

Apply C_b Equation:

$$C_b = \frac{(12.5\, M_{max})}{(2.5\, M_{max} + 3M_b + 4M_c + 3M_d)}$$

$M_{a'}$ $\quad$ $M_{b'}$ $\quad$ $M_{c'}$

$$M_{max} = \frac{wL^2}{8}$$

$$M_{a'} = \frac{7}{16(8)} wL^2$$

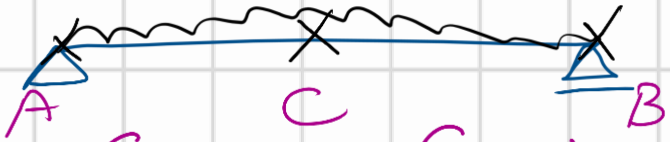
$$M_{b'} = \frac{3}{32} wL^2$$

$$M_{c'} = \frac{15}{8(16)} wL^2$$

$$C_b = \frac{12.5\,(wL^2/8)}{wL^2\left[2.5\left(\frac{1}{8}\right) + 3\left(\frac{7}{(16)(8)}\right) + 4\left(\frac{3}{32}\right) + 3\left(\frac{15}{(8)(16)}\right)\right]}$$

$$C_b = \frac{12.5}{8}\left[\frac{1}{\frac{40 + 21 + 48 + 45}{8(16)}}\right] = \frac{12.50}{8}\left[\frac{8(16)}{154}\right] = 1.298$$

taken $C_b = 1.30$



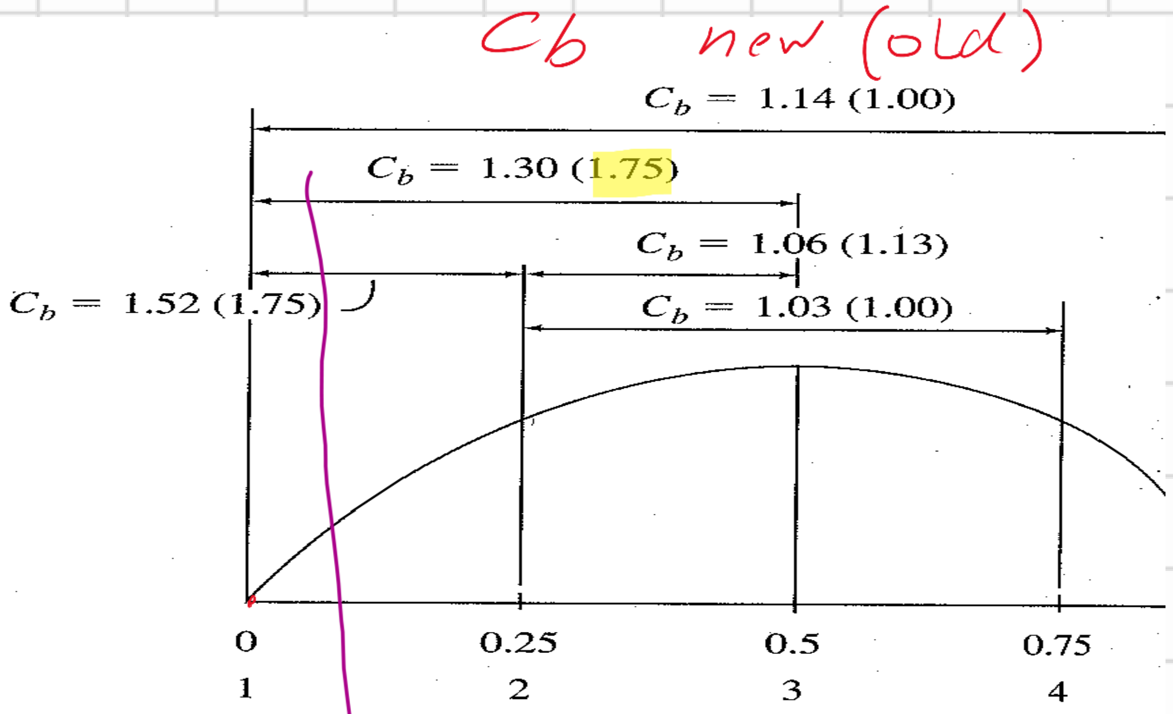
$C_b = 1.3$ $\qquad$ $C_b = 1.30$

Part $\left.\begin{array}{l} AC \\ CB \end{array}\right\} C_b = 1.30$

C_b FOR PARABOLIC SEGMENTS USING LRFD-F1.2a, FORMULA (C-F1-3), EQ. 9.6.11*

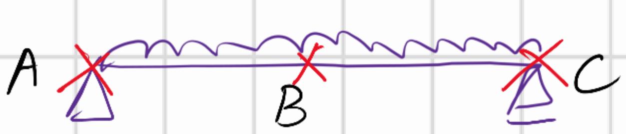
Case 1	Laterally braced at ends; points 1 and 5 only; M_{max} at 3	$C_b = 1.14$
Case 2	Laterally braced at ends and midspan; points 1,3, and 5 only; M_{max} at 3	$C_b = 1.30$
Case 3	Laterally braced at end and 1st quarter point; bracing at points 1 and 2; M_{max} at 2	$C_b = 1.52$
Case 4	Laterally braced at 1st and 2nd quarter points; bracing at points 2 and 3; M_{max} at 3	$C_b = 1.06$
Case 5	Laterally braced at 1st and 3rd quarter points; bracing at points 2 and 4; M_{max} at 3	$C_b = 1.03$

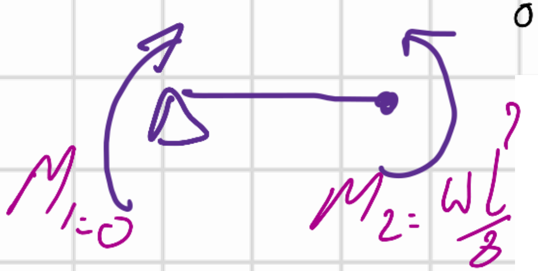
* Values from 1986 LRFD, Eq. 9.6.12 shown in parenthesis.



First Case C_b new $= 1.14$, C_b : old $= 1$

2nd Case C_b new $= 1.30$ $C_b = 1.75$ old





M_1 at A $= 0$

$M_2 = wl^2/8$

$$C_b = 1.75 + \left(\frac{0}{\frac{wL^2}{8}}\right) + 0.3\left(\frac{0}{\frac{wL^2}{8}}\right)^2 < 2.3$$

$$C_b = \left[1.75 + 1.05\frac{M_1}{M_2} + 0.3\left(\frac{M_1}{M_2}\right)^2\right] \le 2.3$$) old

C_b old $= 1.75$

VALUES OF C_b FOR SIMPLY SUPPORTED BEAMS

LOAD	LATERAL BRACING ALONG SPAN	C_b
P (18a)	NONE LOAD AT MIDPOINT	1.32
(18a)	AT LOAD POINT	1.67 1.67
P P	NONE LOADS AT THIRD POINTS	1.14
	AT LOAD POINTS LOADS SYMMETRICALLY PLACED	1.67 1.00 1.67
P P P	NONE LOADS AT QUARTER POINTS	1.14
	AT LOAD POINTS LOADS AT QUARTER POINTS	1.67 1.11 1.11 1.67
w	NONE	1.14
	AT MIDPOINT	1.30 1.30
	AT THIRD POINTS	1.45 1.01 1.45
	AT QUARTER POINTS	1.52 1.06 1.06 1.52
	AT FIFTH POINTS	1.56 1.12 1.00 1.12 1.56

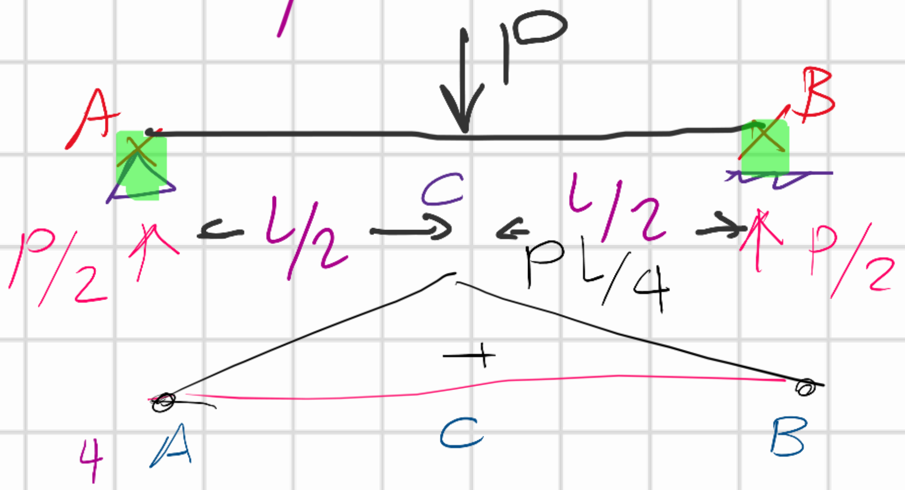
NOTE: LATERAL BRACING MUST ALWAYS BE PROVIDED AT POINTS OF SUPPORT PER AISC SPECIFICATION CHAPTER F.

Adapted from *Steel Construction Manual*, 14th ed., AISC, 2011.

Table 3-1

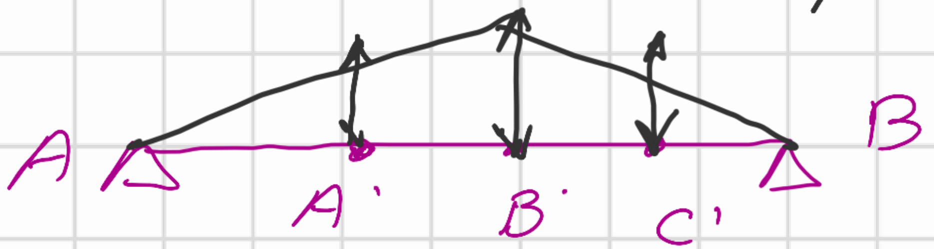
Prepared by Eng.Maged Kamel.

Cb For a simple beam with (under CL) $\Rightarrow$ with Two braces at A, B



$M_{max} = PL/4$

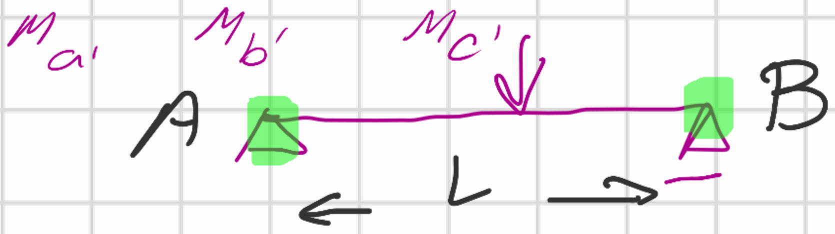
Divide AB into Quarter points $\Rightarrow$ Each quarter $= \frac{1}{4} l$



$R_A = \frac{P}{2}$ $\quad M_{A'} = M_{C'} = \frac{P}{2}(l/4) = PL/8$

$M_{B'} = P/2\left(\frac{L}{2}\right) = \frac{PL}{4}$

Apply C_b Formula for part AB $= \left(\dfrac{12.5\, M_{max}}{2.5\, M_{max} + 3M_b + 4M_c + 3M_d} \right)$



$M_{max} = \dfrac{PL}{4}$

$M_{A'} = PL/8$

$M_{b'} = PL/4$

$M_{c'} = PL/8$

$$C_b = \frac{12.5\,(PL/4)}{PL\left[2.5\left(\frac{1}{4}\right) + 3\left(\frac{1}{8}\right) + 4\left(\frac{1}{4}\right) + 3\left(\frac{1}{8}\right)\right]}$$

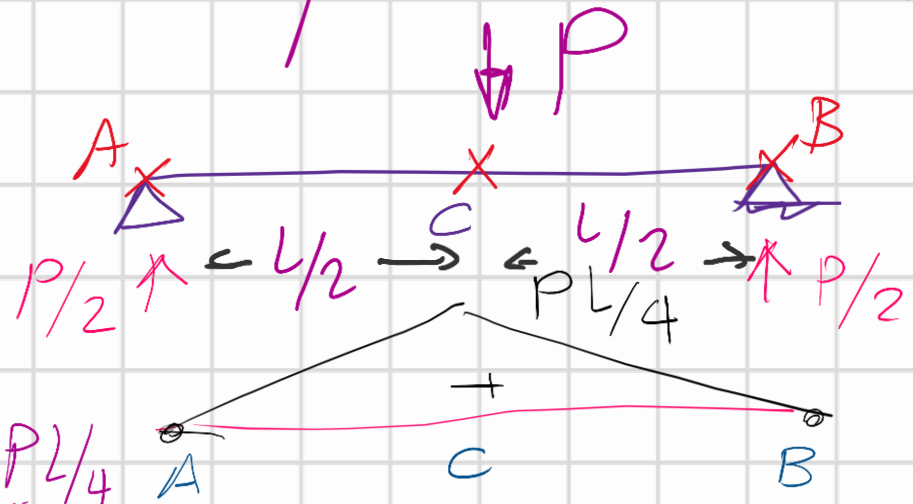
$$C_b = \frac{12.5}{4}\left[\frac{1}{\left(\frac{10+6+16+6}{16}\right)}\right] = \frac{12.5(16)}{4}\left(\frac{1}{38}\right) = 1.316$$

C_b for AB $= 1.32 \Rightarrow$ refer to Table 3.1

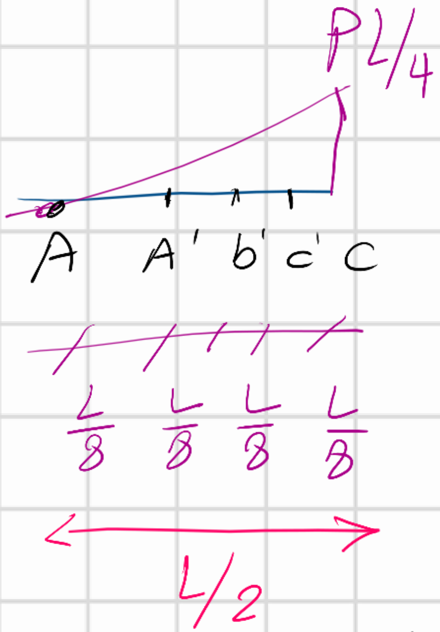
Cb For a Simple beam with (under CL)

$\Downarrow$ Three braces at A, B, C

Part ab $\leftrightarrow$ Cb



$M_{max} = PL/4$



Divide part A-C to Four quarters $\rightarrow$ $\boxed{\text{Each} = \frac{L}{8}}$

$\rightarrow$ Cb part is symmetrical

$AA' = \frac{L}{2}\left(\frac{1}{4}\right)$

$= \frac{L}{8}$

$M_{A'} = \left(\frac{L}{8}\right)\left(\frac{PL}{4}\right) / \left(\frac{L}{2}\right) = \frac{PL^2}{32}\left(\frac{2}{L}\right) = \frac{PL}{16}$

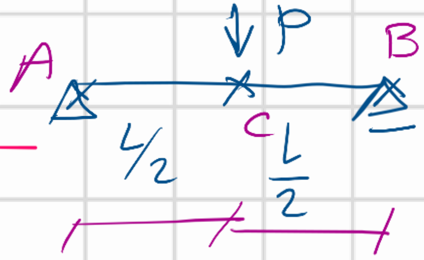
$M_{b'} = \left(\frac{2L}{8}\right)\left(\frac{PL}{4}\right) / \left(\frac{L}{2}\right) = \frac{PL}{8}$

$M_{c'} = \left(\frac{3L}{8}\right)\left(\frac{PL}{4}\right) / \left(L/2\right) = \frac{3PL}{16}$

$M_C = PL/4$

Apply C_b Formula Part ac $= C_b$ $= \dfrac{12.5\, M_{max}}{2.5\, M_{max} + 3M_b + 4M_c + 3M_d}$

$M_{a'}$ $\quad M_{b'}$ $\quad M_{c'}$



$M_{max} = \dfrac{PL}{4}$

$M_{A'} = \dfrac{PL}{16}$

$M_{b'} = \dfrac{PL}{8}$

$M_{c'} = \dfrac{3PL}{16}$

$$C_b = \frac{12.5\,(PL/4)}{PL\left[2.5\left(\frac{1}{4}\right) + 3\left(\frac{1}{16}\right) + 4\left(\frac{1}{8}\right) + 3\left(\frac{3}{16}\right)\right]}$$

$$C_b = \frac{12.5}{4}\left(\frac{1}{\frac{20+6+16+18}{32}}\right) = \frac{12.50}{4}\left(\frac{32}{(60)}\right) = 12.50\left(\frac{8}{60}\right)$$

$$C_b = \frac{5}{3} = 1.666 \approx 1.67$$

taken 1.67

C_b for parts Ac, cb $\Rightarrow$ 1.67 as in Table 3.1

Refer to Cb Equation

The lateral-torsional buckling modification factor, C_b, for nonuniform moment diagrams when both ends of the segment are braced is determined as follows:

$$C_b = \frac{12.5M_{max}}{2.5M_{max} + 3M_A + 4M_B + 3M_C} \qquad \text{(F1-1)}$$

Absolute Values are taken For Mmax

where

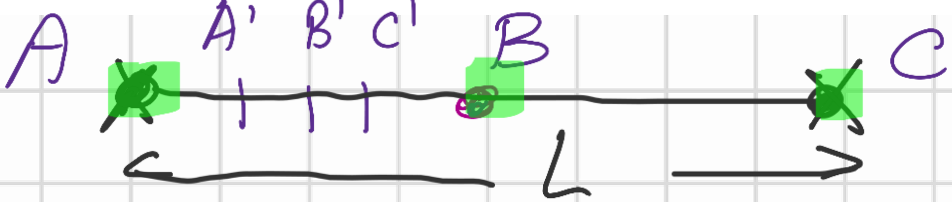
Check M_{max} = absolute value of maximum moment in the unbraced segment, kip-in. (N-mm)

A' M_A = absolute value of moment at quarter point of the unbraced segment, kip-in. (N-mm)

B' M_B = absolute value of moment at centerline of the unbraced segment, kip-in. (N-mm)

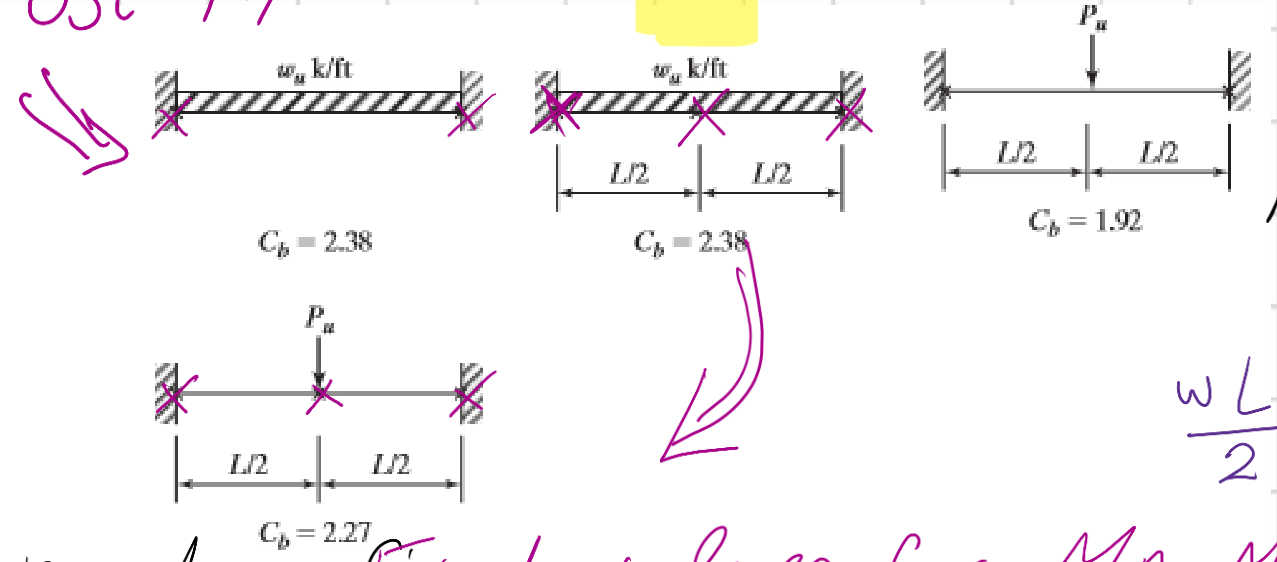
C' M_C = absolute value of moment at three-quarter point of the unbraced segment, kip-in. (N-mm)

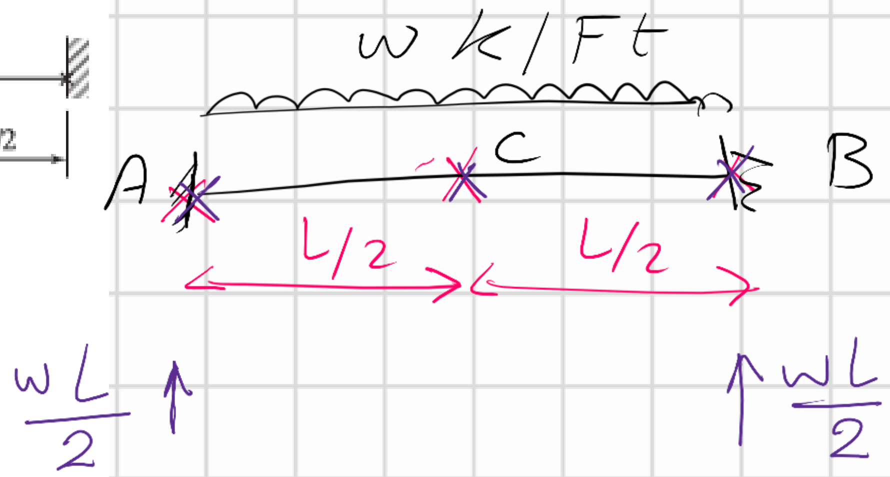
quarters = 4/8



Post 17

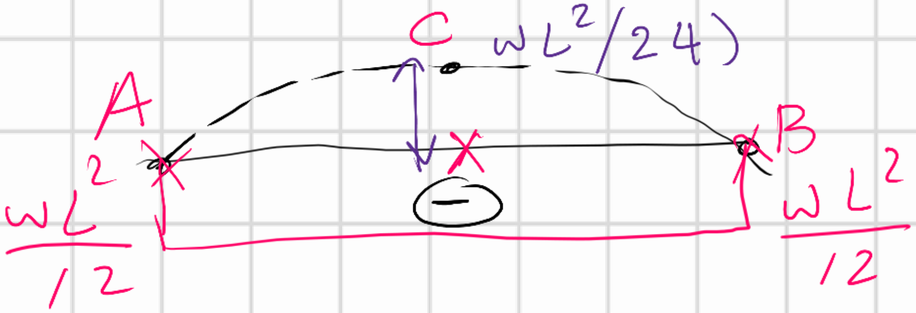
3ree braces



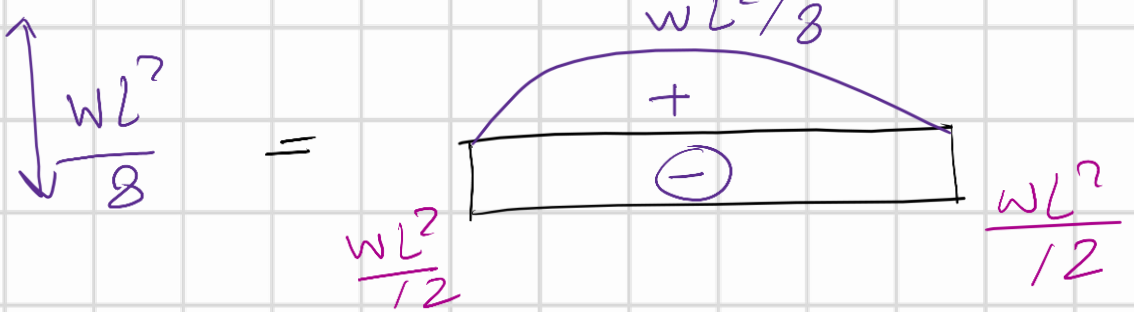


Step # 1 Find values for M_A, M_B and M_C

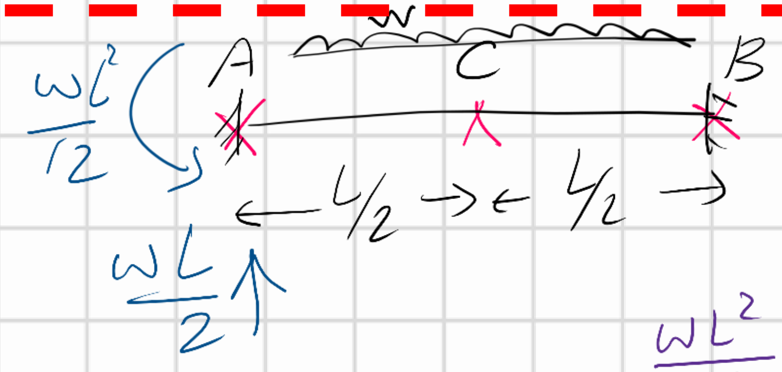
$$M_A = -\frac{wL^2}{12} = M_b, \quad M_C = +\frac{wL^2}{24}$$



As super position

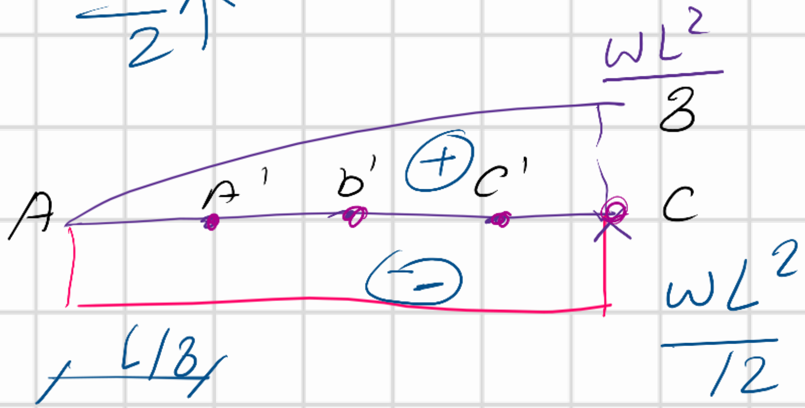


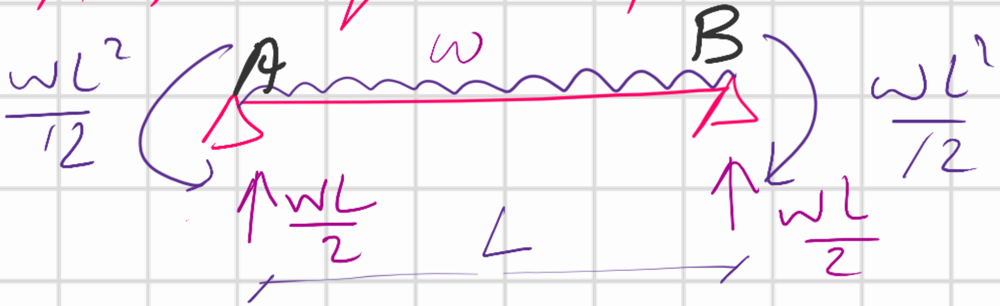
Prepared by Eng.Maged Kamel.



Divide part AC → to Four quarters

Find the moment values at A', B', C' quarter points



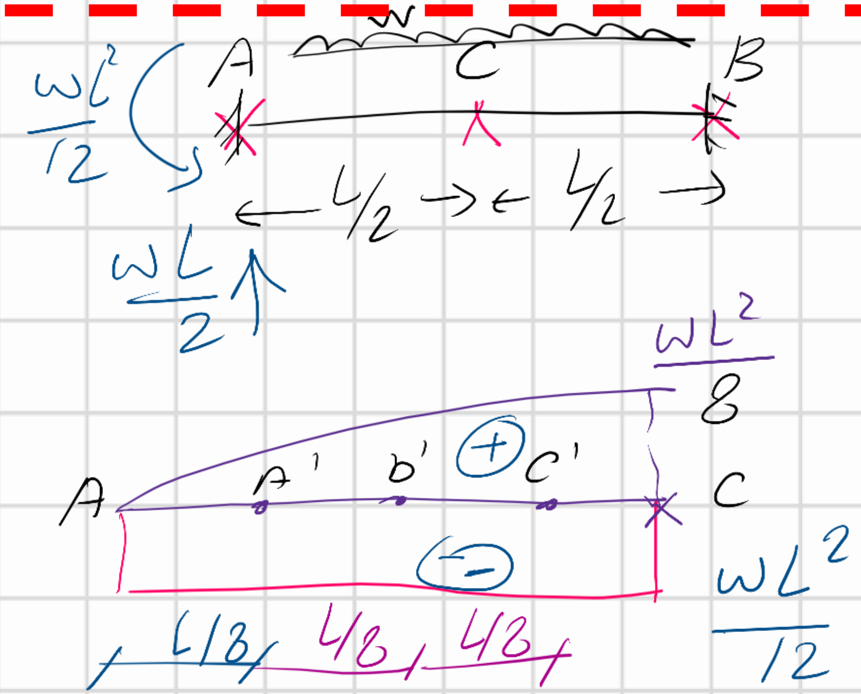


$$M_{A'} = -\frac{wL^2}{12} + \frac{wL}{2}\left(\frac{L}{8}\right) - w\left(\frac{l}{8}\right)\left(\frac{L}{16}\right) = \left(\frac{-16+12-1.50}{12(16)}\right) wL^2$$

$$M_{A'} = \frac{wL^2}{(12)(16)}(-5.50) \Rightarrow \frac{11}{384} wL^2$$

$$M_{b'} = -\frac{wL^2}{12} + \frac{wl}{2}\left(\frac{l}{4}\right) - w\left(\frac{l}{4}\right)\left(\frac{l}{8}\right) = \left(\frac{-8+12-3}{96}\right) wL^2$$

$$M_{b'} = \frac{wL^2}{96}(1)$$



Find $M_{c'}$ and M_{max}

At

M_C max value of moment

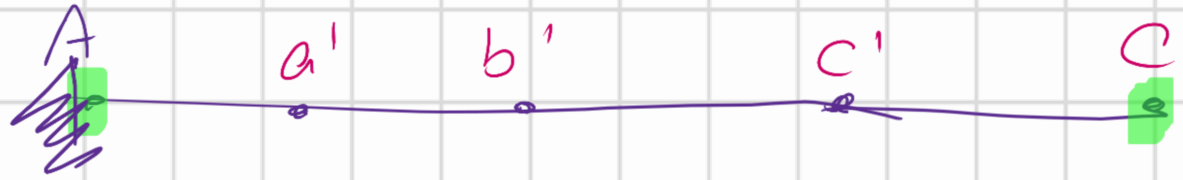
$$M_{c'} = -\frac{wL^2}{12} + \frac{wL}{2}\left(\frac{3L}{8}\right) - w\left(\frac{3L}{8}\right)\left(\frac{3L}{16}\right) = \left(\frac{-16+36-13.50}{12(16)}\right) wL^2$$

$$M_{c'} = \frac{wL^2}{(12)(16)}(6.50) \Rightarrow \frac{13}{384} wL^2$$

To check value at $M_C \Rightarrow M_C = -\frac{wl^2}{12} + \frac{wL}{2}\left(\frac{l}{2}\right) - w\left(\frac{l}{2}\right)\left(\frac{l}{4}\right)$

$$M_C = wL^2\left[-\frac{1}{12} + \frac{1}{4} - \frac{1}{8}\right] = \frac{wL^2}{24}\left[-2 + 6 - 3\right] = \frac{wL^2}{24}$$

List all values for moments to Find Mmax part AC



Moment multiplier $\left(\frac{1}{12}\right)$ $\left(\frac{11}{384}\right)$ $\left(\frac{1}{96}\right)$ $\left(\frac{13}{384}\right)$ $\left(\frac{1}{24}\right)$

wL^2

(3) (4) (3)

$M_{max} = \frac{1}{12} wl^2$

$(2.5) \rightarrow \frac{2.5}{12}$ $\frac{33}{384}$ $\frac{4}{96}$ $\frac{39}{384}$

denominator

$$\text{Denominator} = wL^2 \left[\frac{2.5}{12} + \frac{33}{384} + \frac{4}{96} + \frac{39}{384} \right]$$

$$wL^2 \left[\frac{80+33+16+39}{384} \right] = \frac{7}{16} wL^2$$

Apply C_b formula $= \dfrac{12.5\, M_{max}}{2.5\, M_{max} + 3M_b + 4M_c + 3M_d}$

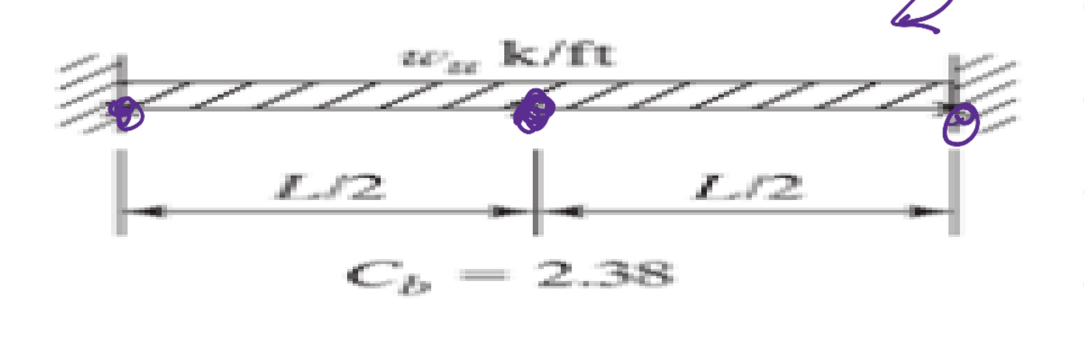
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad M_a' \quad M_b' \quad M_c'$

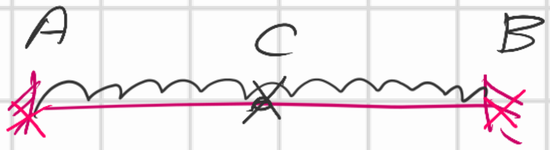
C_b For part # AC or cd

$$C_b = \frac{12.5}{12}(wL^2) \Big/ \left(\frac{7}{16}\right)wL^2$$

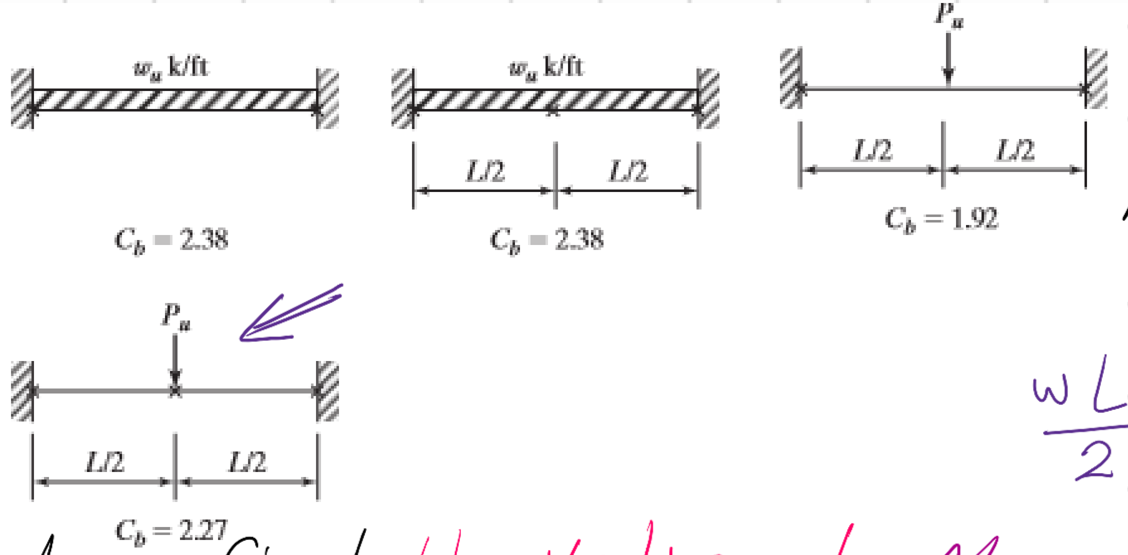
$$C_b = \frac{12.5}{12}\left(\frac{16}{7}\right) = 2.38$$

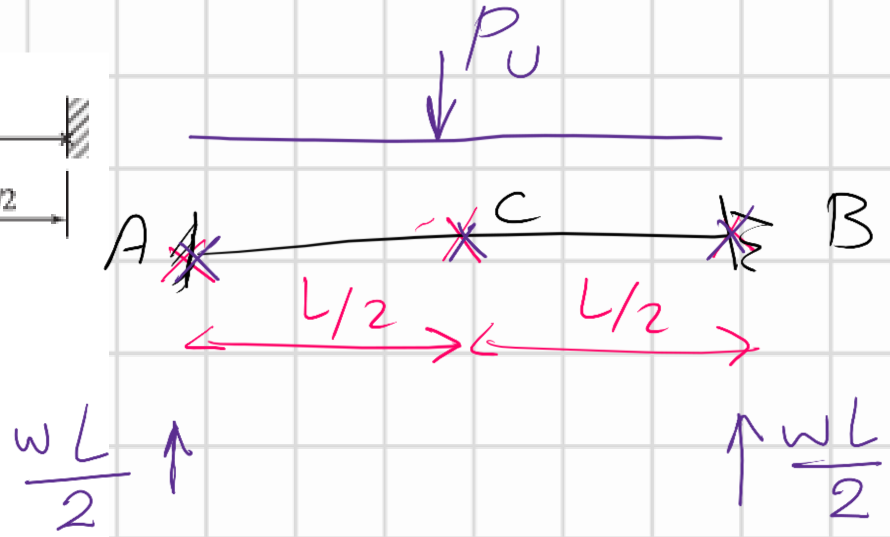
C_b for parts AC, cb $\Rightarrow$ 2.38





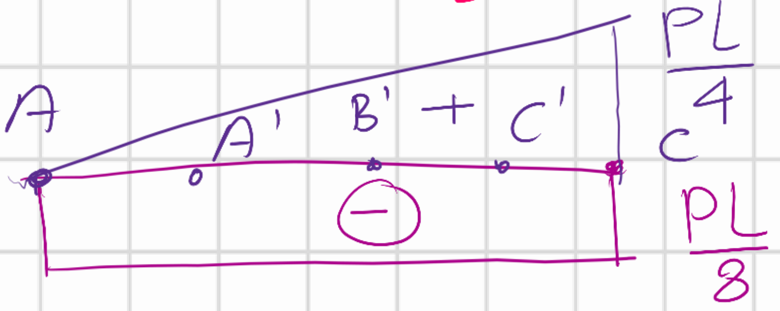
Three braces





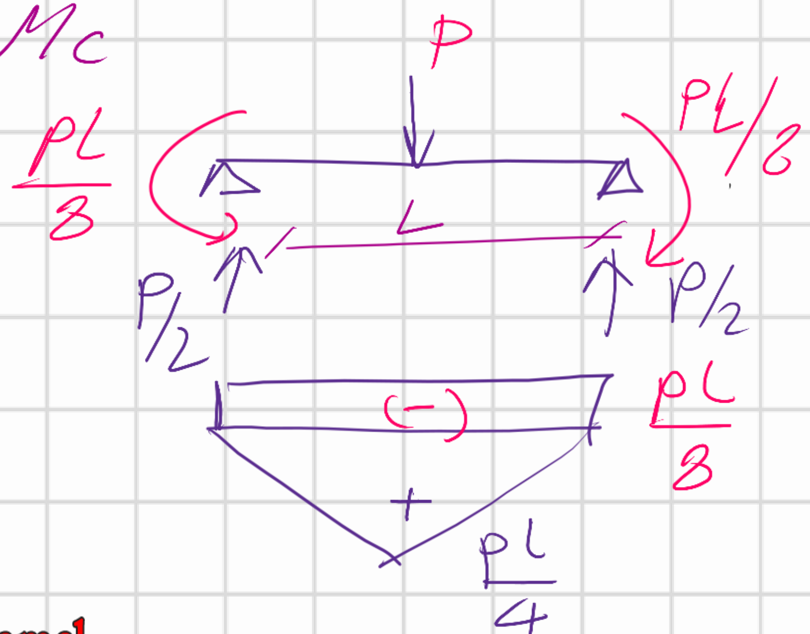
Step # 1 find the value of M_A, M_B, M_C

$M_A = \frac{PL}{8}$, $M_{A'} = \frac{PL}{16} - \frac{PL}{8} = -\frac{PL}{16}$



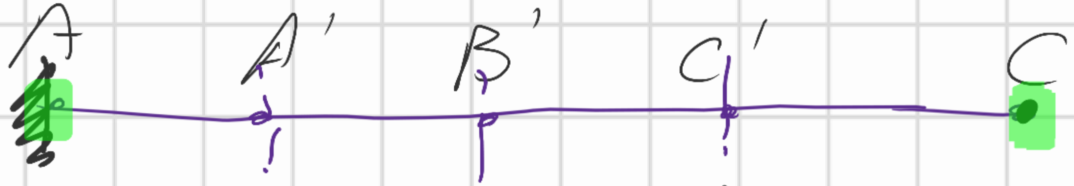
$M_{b'} = \frac{PL}{8} - \frac{PL}{8} = 0$

$M_{c'} = \frac{3PL}{16} - \frac{PL}{8} = \frac{PL}{16}$



Prepared by Eng.Maged Kamel.

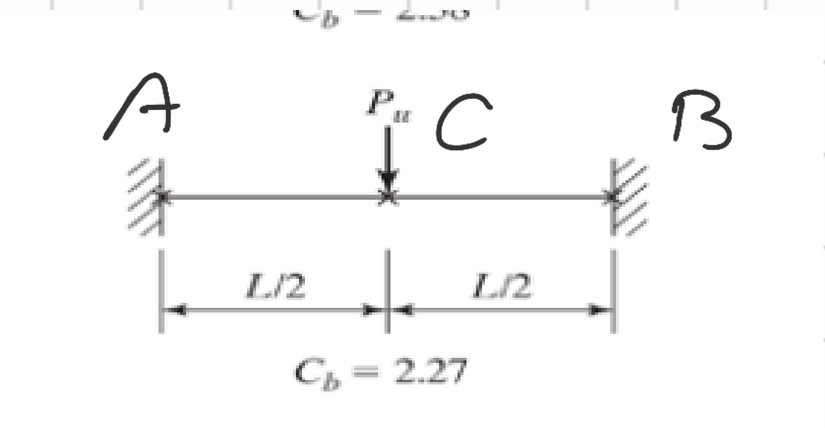
To get M_{max} - list all values of M For quarters



Moment Multiplier of PL

$\left(\frac{1}{8}\right)$ $\left(\frac{1}{16}\right)$ (0) $\left(\frac{1}{16}\right)$ $\left(\frac{1}{8}\right)$

(3) (4) (3)



$M_{max} = \frac{1}{8} PL \rightarrow 2.5$

$$\left[\frac{2.5}{8} + \frac{3}{16} + 0 + \frac{3}{16}\right] PL$$ denominator

$$= PL\left[\frac{5+3+3}{16}\right] = \frac{11}{16} PL$$

Numerator $= 12.5 \frac{PL}{8}$

Apply C_b formula $= \dfrac{12.5\, M_{max}}{2.5\, M_{max} + 3M_b + 4M_c + 3M_d}$

$\qquad\qquad\qquad\qquad\qquad\qquad M_{a'} \qquad M_{b'} \qquad M_{c'}$

$M_{max} = \dfrac{PL}{8}$

$M_{A'} = \dfrac{PL}{16}$

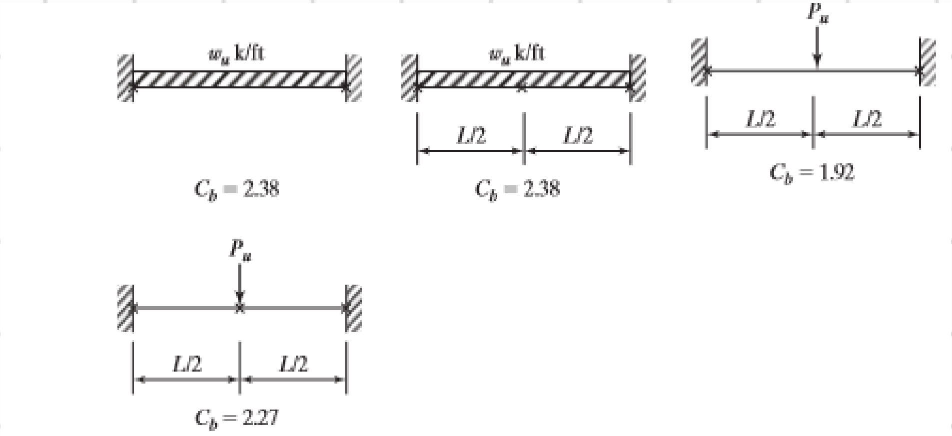
$M_{b'} = 0$

$M_{c'} = \dfrac{PL}{16}$

$C_b = 12.5 \dfrac{PL}{8} \Big/ \dfrac{11}{16} PL$

$C_b = \dfrac{12.50}{8}\left(\dfrac{16}{11}\right) = \dfrac{25}{11} = 2.272$

Three braces



$C_b = 2.27$

Cb for parts AC, CB $\Rightarrow$ 2.27