

Coefficiente de impacto

$$\phi = 1,4 - 0,007L$$

Sendo $\phi \geq 1$

No balanço:

$$L = 3,5$$

$$\phi = 1,4 - 0,007 \times 3,5 = 1,3755 \approx 1,38$$

No vão:

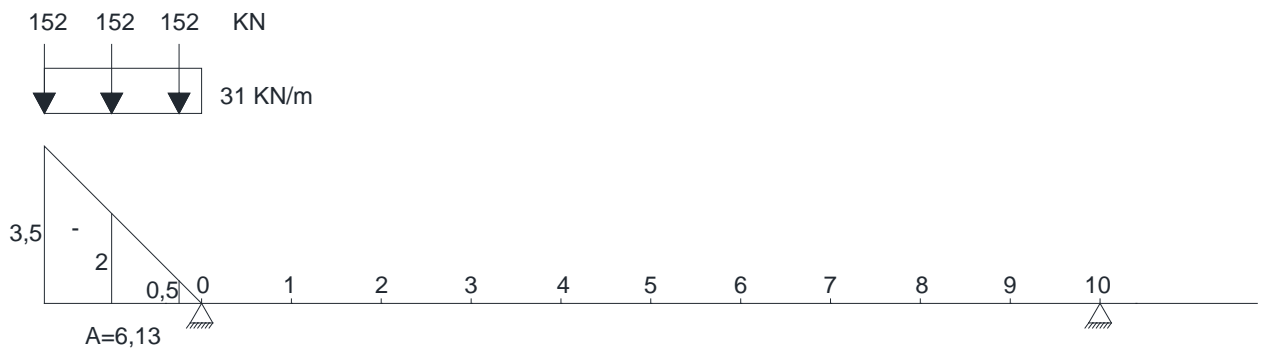
$$L = 20$$

$$\phi = 1,4 - 0,007 \times 20 = 1,26$$

Cálculo dos máximos esforços positivos e negativos devido às cargas móveis

Máximos esforços de momentos fletores por cargas móveis

Seção 0



$$\frac{3,5}{3,5} = \frac{x_1}{2} = \frac{x_2}{0,5}$$

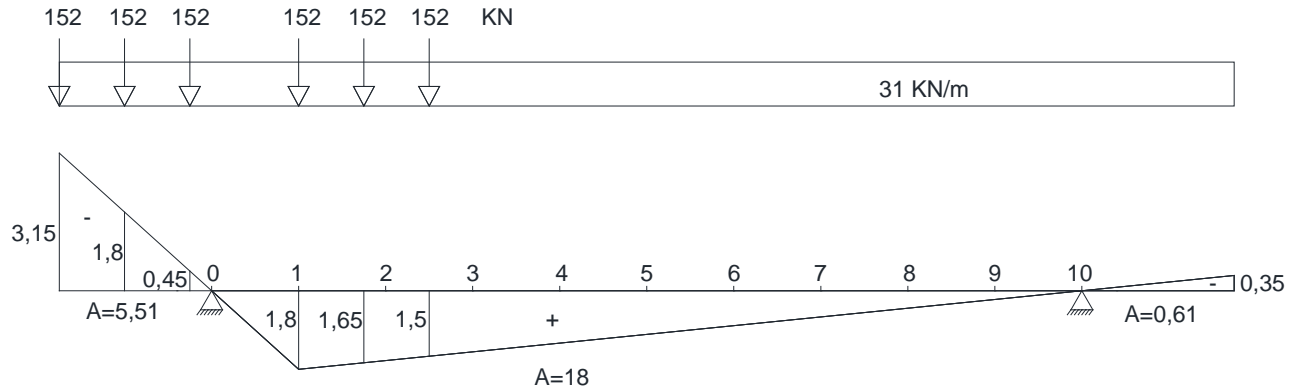
$$x_1 = 2$$

$$x_2 = 0,5$$

$$\phi M_{0+} = 0$$

$$\phi M_{0-} = -1,38[152(3,5 + 2 + 0,5) + 31 \times 6,13] = -1\,520,80 \text{ KNm}$$

Seção 1



$$\frac{Pab}{L} = \frac{1 \times 2 \times 18}{20} = 1,8$$

$$\frac{1,8}{18} = \frac{x_1}{16,5} = \frac{x_2}{15}$$

$$x_1 = 1,65$$

$$x_2 = 1,5$$

$$y_1 = \frac{b \times L_1}{L} = \frac{18 \times 3,5}{20} = 3,15$$

$$\frac{3,15}{3,5} = \frac{x_3}{2} = \frac{x_4}{0,5}$$

$$x_3 = 1,8$$

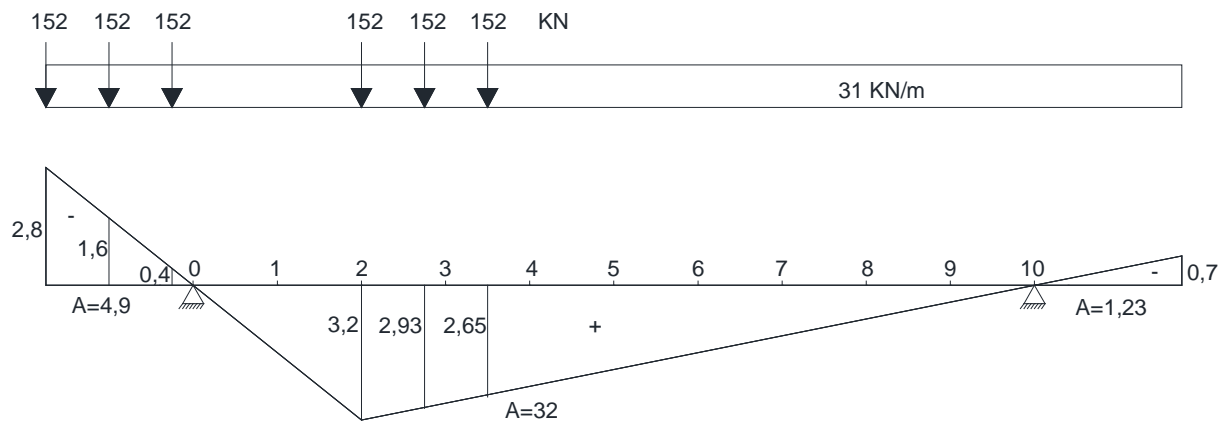
$$x_4 = 0,45$$

$$y_2 = \frac{a \times L_1}{L} = \frac{2 \times 3,5}{20} = 0,35$$

$$\phi M_{0+} = 1,26[152(1,8 + 1,65 + 1,5) + 31 \times 18] = 1\,651,10 \text{ KNm}$$

$$\phi M_{0-} = -1,38[152(3,15 + 1,8 + 0,45) + 31 \times 5,51 + 31 \times 0,61] = -1\,394,52 \text{ KNm}$$

Seção 2



$$\frac{Pab}{L} = \frac{1 \times 4 \times 16}{20} = 3,2$$

$$\frac{3,2}{16} = \frac{x_1}{14,5} = \frac{x_2}{13}$$

$$x_1 = 2,93$$

$$x_2 = 2,65$$

$$y_1 = \frac{b \times L_1}{L} = \frac{16 \times 3,5}{20} = 2,8$$

$$\frac{2,8}{3,5} = \frac{x_3}{2} = \frac{x_4}{0,5}$$

$$x_3 = 1,6$$

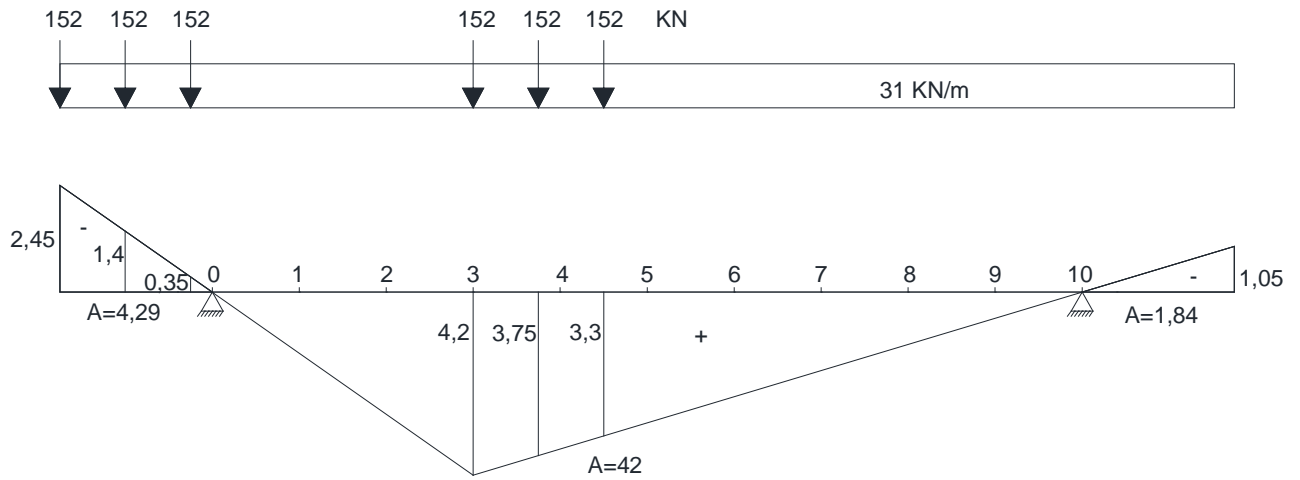
$$x_4 = 0,4$$

$$y_2 = \frac{a \times L_1}{L} = \frac{4 \times 3,5}{20} = 0,7$$

$$\phi M_{0+} = 1,26[152(3,2 + 2,93 + 2,65) + 31 \times 32] = 2\,931,47 \text{ KNm}$$

$$\phi M_{0-} = -1,38[152(2,8 + 1,6 + 0,4) + 31 \times 4,9 + 31 \times 1,23] = -1\,269,09 \text{ KNm}$$

Seção 3



$$\frac{Pab}{L} = \frac{1 \times 6 \times 14}{20} = 4,2$$

$$\frac{4,2}{14} = \frac{x_1}{12,5} = \frac{x_2}{11}$$

$$x_1 = 3,75$$

$$x_2 = 3,3$$

$$y_1 = \frac{b \times L_1}{L} = \frac{14 \times 3,5}{20} = 2,45$$

$$\frac{2,45}{3,5} = \frac{x_3}{2} = \frac{x_4}{0,5}$$

$$x_3 = 1,4$$

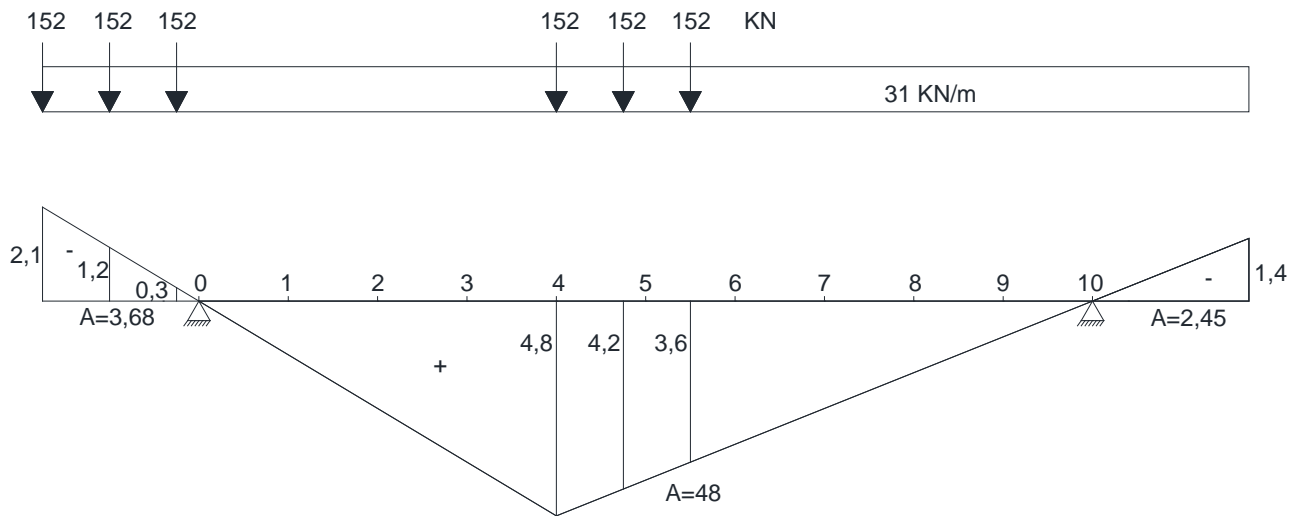
$$x_4 = 0,35$$

$$y_2 = \frac{a \times L_1}{L} = \frac{6 \times 3,5}{20} = 1,05$$

$$\phi M_{0+} = 1,26[152(4,2 + 3,75 + 3,3) + 31 \times 42] = 3\,795,12 \text{ KNm}$$

$$\phi M_{0-} = -1,38[152(2,45 + 1,4 + 0,35) + 31 \times 4,29 + 31 \times 1,84] = -1\,143,23 \text{ KNm}$$

Seção 4



$$\frac{Pab}{L} = \frac{1 \times 8 \times 12}{20} = 4,8$$

$$\frac{4,8}{12} = \frac{x_1}{10,5} = \frac{x_2}{9}$$

$$x_1 = 4,2$$

$$x_2 = 3,6$$

$$y_1 = \frac{b \times L_1}{L} = \frac{12 \times 3,5}{20} = 2,1$$

$$\frac{2,1}{3,5} = \frac{x_3}{2} = \frac{x_4}{0,5}$$

$$x_3 = 1,2$$

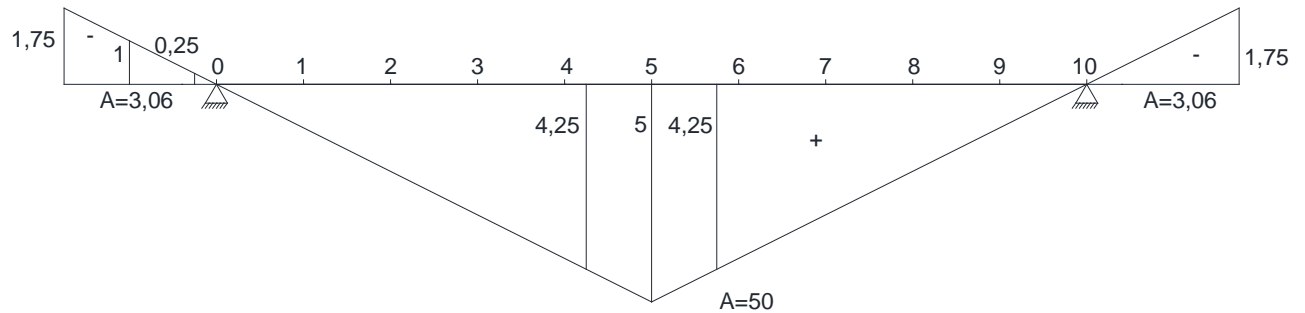
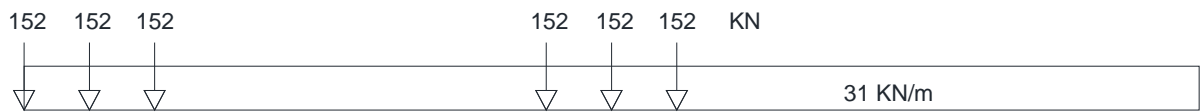
$$x_4 = 0,3$$

$$y_2 = \frac{a \times L_1}{L} = \frac{8 \times 3,5}{20} = 1,4$$

$$\phi M_{0+} = 1,26[152(4,8 + 4,2 + 3,6) + 31 \times 48] = 4\,288,03 \text{ KNm}$$

$$\phi M_{0-} = -1,38[152(2,1 + 1,2 + 0,3) + 31 \times 3,68 + 31 \times 2,45] = -1\,017,38 \text{ KNm}$$

Seção 5



$$\frac{Pab}{L} = \frac{1 \times 10 \times 10}{20} = 5$$

$$\frac{5}{10} = \frac{x_1}{8,5} = \frac{x_2}{8,5}$$

$$x_1 = 4,25$$

$$x_2 = 4,25$$

$$y_1 = \frac{b \times L_1}{L} = \frac{10 \times 3,5}{20} = 1,75$$

$$\frac{1,75}{3,5} = \frac{x_3}{2} = \frac{x_4}{0,5}$$

$$x_3 = 1$$

$$x_4 = 0,25$$

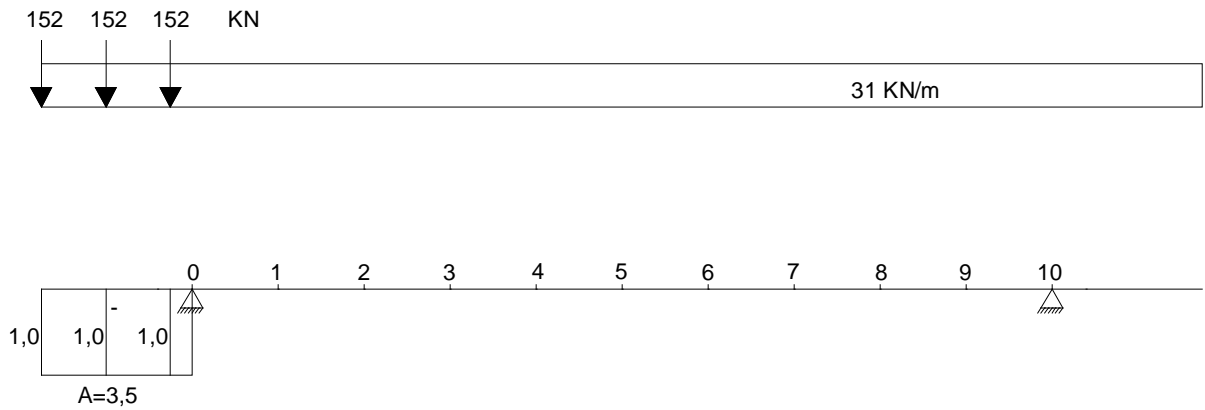
$$y_2 = \frac{a \times L_1}{L} = \frac{10 \times 3,5}{20} = 1,75$$

$$\phi M_{0+} = 1,26[152(5 + 4,25 + 4,25) + 31 \times 50] = 4\,538,52 \text{ KNm}$$

$$\phi M_{0-} = -1,38[152(1,75 + 1 + 0,25) + 31 \times 3,06 + 31 \times 3,06] = -891,09 \text{ KNm}$$

Máximos esforços cortantes por cargas móveis

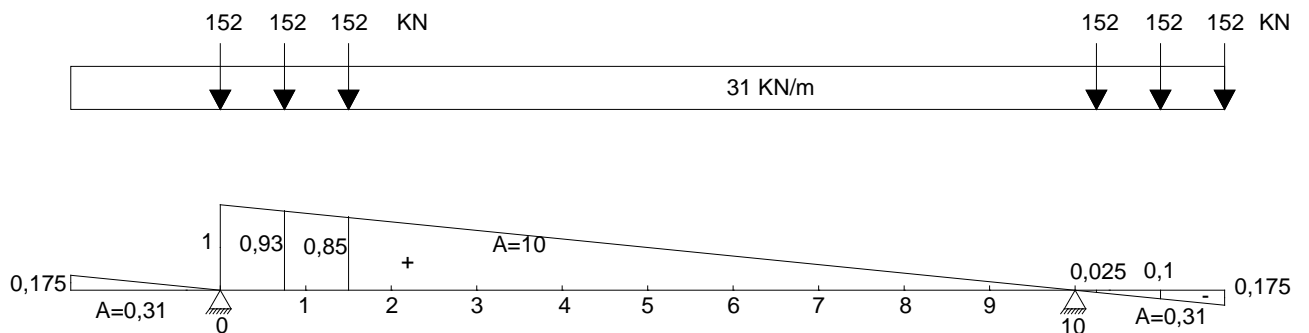
Seção 0 a esquerda



$$\emptyset Q_0^{esq} += 0$$

$$\emptyset Q_0^{esq} - = -1,38[152(1 + 1 + 1) + 31 \times 3,5] = -779,01 \text{ KN.m}$$

Seção 0 a direita



$$\frac{1}{20} = \frac{x_1}{18,5} = \frac{x_2}{17} = \frac{x_3}{3,5} = \frac{x_4}{2} = \frac{x_5}{0,5}$$

$$x_1 = 0,93$$

$$x_2 = 0,85$$

$$x_3 = 0,175$$

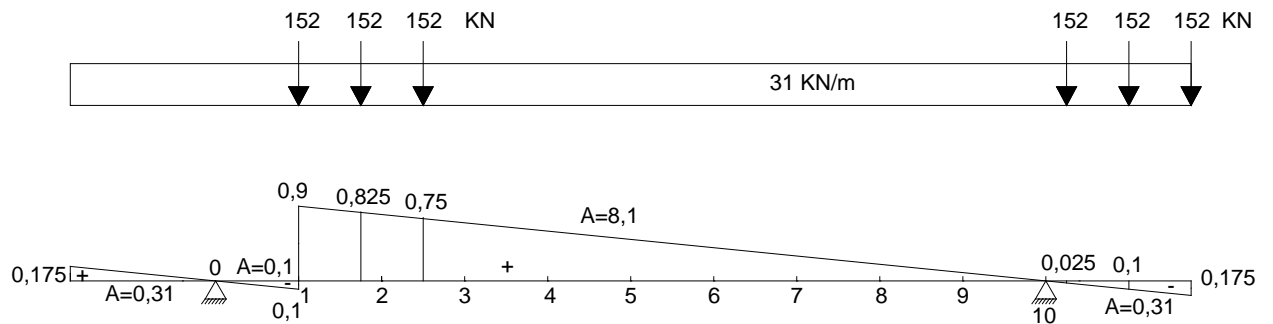
$$x_4 = 0,1$$

$$x_5 = 0,025$$

$$\emptyset Q0_{dir} += 1,26[152(1 + 0,93 + 0,85) + 31 \times 10] + 1,38(31 \times 0,31) = 936,29 \text{ KN}$$

$$\emptyset Q0_{esq} -= -1,38[152(0,175 + 0,1 + 0,025) + 31 \times 0,31] = -76,19 \text{ KN}$$

Seção 1



$$\frac{1}{20} = \frac{x_1}{18} = \frac{x_2}{16,5} = \frac{x_3}{15} = \frac{x_4}{3,5} = \frac{x_5}{2} = \frac{x_6}{0,5}$$

$$x_1 = 0,9$$

$$x_2 = 0,825$$

$$x_3 = 0,75$$

$$x_4 = 0,175$$

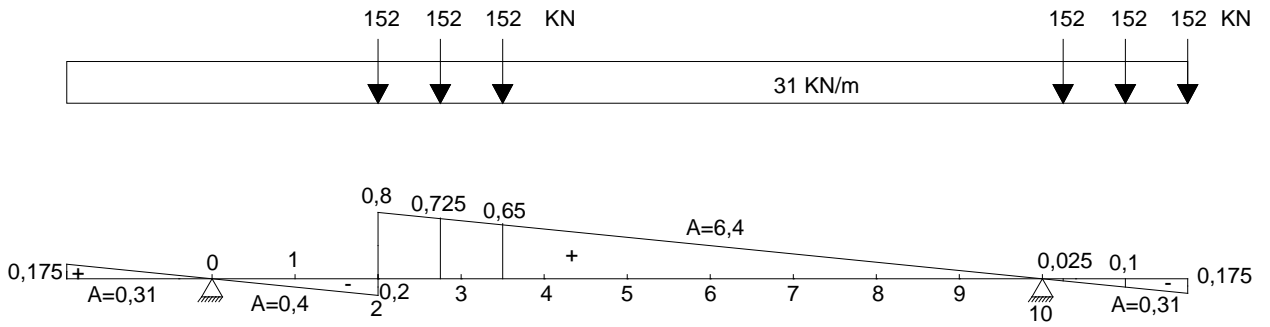
$$x_5 = 0,1$$

$$x_6 = 0,025$$

$$\emptyset Q1_{dir} += 1,26[152(0,9 + 0,825 + 0,75) + 31 \times 8,1] + 1,38(31 \times 0,31) = 803,66 \text{ KN}$$

$$\emptyset Q1_{esq} -= -1,26(31 \times 0,1) - 1,38[152(0,175 + 0,1 + 0,025) + 31 \times 0,31] = -80,10 \text{ KN}$$

Seção 2



$$\frac{1}{20} = \frac{x_1}{16} = \frac{x_2}{14,5} = \frac{x_3}{13} = \frac{x_4}{3,5} = \frac{x_5}{2} = \frac{x_6}{0,5}$$

$$x_1 = 0,8$$

$$x_2 = 0,725$$

$$x_3 = 0,65$$

$$x_4 = 0,175$$

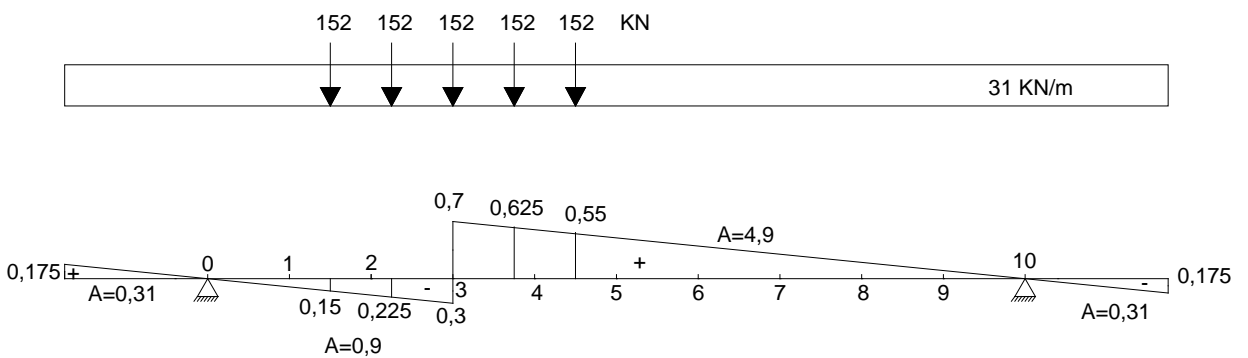
$$x_5 = 0,1$$

$$x_6 = 0,025$$

$$\emptyset Q0_{dir} = 1,26[152(0,8 + 0,725 + 0,65) + 31x6,1] + 1,38(31x0,31) = 668,08 \text{ KN}$$

$$\emptyset Q0_{esq} = -1,26(31x0,4) - 1,38[152(0,175 + 0,1 + 0,025) + 31x0,31] = -91,81 \text{ KN}$$

Seção 3



$$\frac{1}{20} = \frac{x_1}{14} = \frac{x_2}{12,5} = \frac{x_3}{11} = \frac{x_4}{3,5} = \frac{x_5}{6} = \frac{x_6}{4,5} = \frac{x_7}{3}$$

$$x_1 = 0,7$$

$$x_2 = 0,625$$

$$x_3 = 0,55$$

$$x_4 = 0,175$$

$$x_5 = 0,3$$

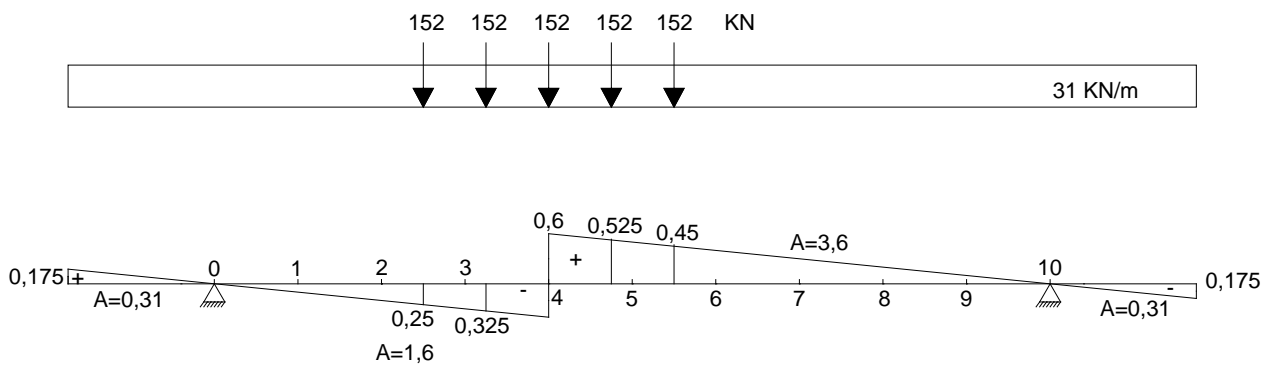
$$x_6 = 0,225$$

$$x_7 = 0,15$$

$$\emptyset Q Q_{dir} + = 1,26[152(0,7 + 0,625 + 0,55) + 31 \times 4,9] + 1,38(31 \times 0,31) = 563,76 \text{ KN}$$

$$\emptyset Q Q_{esq} - = -1,26[152(0,3 + 0,225 + 0,15) + 31 \times 0,9] - 1,38(31 \times 0,31) = -177,69 \text{ KN}$$

Seção 4



$$\frac{1}{20} = \frac{x_1}{12} = \frac{x_2}{10,5} = \frac{x_3}{9} = \frac{x_4}{3,5} = \frac{x_5}{8} = \frac{x_6}{6,5} = \frac{x_7}{5}$$

$$x_1 = 0,6$$

$$x_2 = 0,525$$

$$x_3 = 0,45$$

$$x_4 = 0,175$$

$$x_5 = 0,4$$

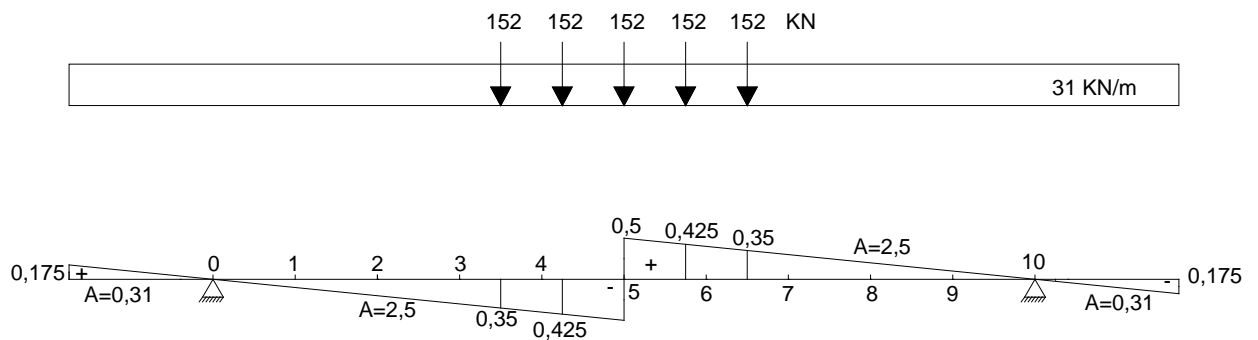
$$x_6 = 0,325$$

$$x_7 = 0,25$$

$$\emptyset QO_{dir} += 1,26[152(0,6 + 0,525 + 0,45) + 31 \times 3,6] + 1,38(31 \times 0,31) = 455,52 \text{ KN}$$

$$\emptyset QO_{esq} -= -1,26[152(0,4 + 0,325 + 0,25) + 31 \times 1,6] - 1,38(31 \times 0,31) = -203,44 \text{ KN}$$

Seção 5



$$\frac{1}{20} = \frac{x_1}{10} = \frac{x_2}{8,5} = \frac{x_3}{7} = \frac{x_4}{5,5} = \frac{x_5}{3,5}$$

$$x_1 = 0,5$$

$$x_2 = 0,425$$

$$x_3 = 0,35$$

$$x_4 = 0,275$$

$$x_5 = 0,175$$

$$\emptyset QO_{dir} += 1,26[152(0,5 + 0,425 + 0,35) + 31 \times 2,5] + 1,38(31 \times 0,31) = 355,10 \text{ KN}$$

$$\emptyset QO_{esq} -= -1,26[152(0,5 + 0,425 + 0,35) + 31 \times 2,5] - 1,38(31 \times 0,31) = -355,10 \text{ KN}$$