1-

Maqle

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[illegible]

$$y_T'' - \frac{T}{E_T I_T} y_T = \frac{M_T}{E_T I_T} - \frac{Q}{2E_T I_T}x \quad ; \quad 0 \le x \le \frac{l_T}{2} \qquad (1)$$

$$a = \sqrt{\frac{T l_T^2}{E_T I_T}}$$

[illegible]

$$y_T = A_T \sinh\left(\frac{a}{l_T}x\right) + B_T \cosh\left(\frac{a}{l_T}x\right) + \frac{Q}{2T}x - \frac{M_T}{T} \qquad (2)$$

[illegible] $x = \frac{l_T}{2}$ [illegible] $x=0$ [illegible]

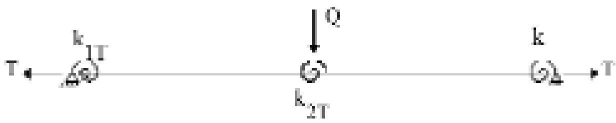
$-E_T I_T y_T'' = 2k_{2T} y_T'$ [illegible] $M_{int} = 2k_{2T} y_T'$ [illegible] $y_T = 0$ [illegible]

[illegible] A_T [illegible] B_T [illegible]

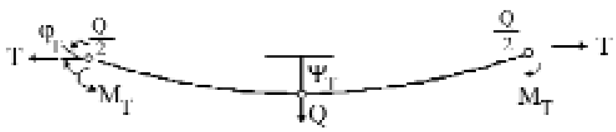
$$B_T = \frac{M_T}{T} \qquad (3)$$

[illegible]

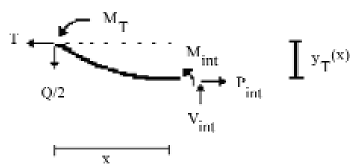
$$A_T = \frac{-k_{2T}\frac{Q}{T} - M_T\cosh\frac{a}{2} - \frac{2M_T k_{2T}}{T}\frac{a}{l_T}\sinh\frac{a}{2}}{T\sinh\frac{a}{2} + 2k_{2T}\frac{a}{l_T}\cosh\frac{a}{2}} \qquad (4)$$



[illegible]



[illegible]



[illegible]

[illegible]

[illegible]

$$y_T = \frac{-k_{2T}\frac{Q}{T} - M_T\cosh\frac{a}{2} - \frac{2M_T k_{2T}}{T}\frac{a}{l_T}\sinh\frac{a}{2}}{T\sinh\frac{a}{2} + 2k_{2T}\frac{a}{l_T}\cosh\frac{a}{2}}\sinh\frac{a}{l_T}x + \frac{M_T}{T}\cosh\frac{a}{l_T}x + \frac{Q}{2T}x - \frac{M_T}{T} \qquad (5)$$

[illegible]

$$y_{\frac{l_T}{2}} = \Psi_T = \frac{-k_{2T}\frac{Q}{T} - M_T\cosh\frac{a}{2} - \frac{2M_T k_{2T}}{T}\frac{a}{l_T}\sinh\frac{a}{2}}{T\sinh\frac{a}{2} + 2k_{2T}\frac{a}{l_T}\cosh\frac{a}{2}}\sinh\frac{a}{2} + \frac{M_T}{T}\cosh\frac{a}{2} + \frac{Q}{4T}l_t - \frac{M_T}{T} \qquad (6)$$

[illegible]

$$\varphi_T = \frac{-k_{2T}\frac{Q}{T} - M_T\cosh\frac{a}{2} - \frac{2M_T k_{2T}}{T}\frac{a}{2}\sinh\frac{a}{2}}{T\sinh\frac{a}{2} + 2k_{2T}\frac{a}{l_T}\cosh\frac{a}{2}}\frac{a}{l_T} + \frac{Q}{2T} \qquad (7)$$

[illegible]

$$y_{0T}' = \varphi_T = \frac{M_T}{k_{1T}} \qquad (8)$$

[illegible]

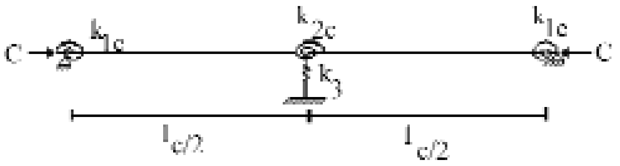
$$M_T = \frac{-\frac{k_{2T}}{T}\frac{a}{l_T} + \frac{1}{2}\sinh\frac{a}{2} + \frac{k_{2T}}{T}\frac{a}{l_T}\cosh\frac{a}{2}}{\frac{a}{l_T}\cosh\frac{a}{2} + \frac{a^2}{l_T^2}\frac{2k_{2T}}{T}\sinh\frac{a}{2} + \frac{T}{k_{1T}}\sinh\frac{a}{2} + \frac{2k_{2T}}{k_{1T}}\frac{a}{l_T}\cosh\frac{a}{2}}Q \qquad (9)$$

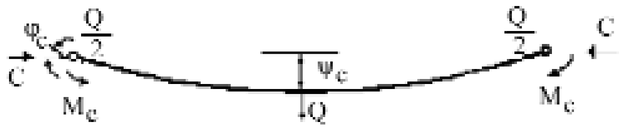
[illegible] Ψ_T [illegible] M_T [illegible]

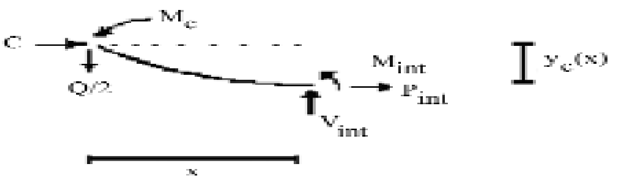
[illegible] M_T [illegible]

[illegible]

$$y_c'' + \frac{C}{E_cI_c} y_c = \frac{M_c}{E_cI_c} + \frac{Q}{2E_cI_c} x : 0 \le x \le \frac{l_c}{2} \qquad (10)$$







$$y_c = A_c \sin\left(\frac{\upsilon}{l_c} x\right) + B_c \cos\left(\frac{\upsilon}{l_c} x\right) + \frac{Q}{2C} x + \frac{M_c}{C} \qquad (11)$$

$\upsilon = \sqrt{\frac{C l_c^2}{E_c I_c}}$; B_c ; $x=0$; $y_c=0$

$$B_c = -\frac{M_c}{C} \qquad (12)$$

$M_{int} = 2k_{2c} y_c'$; $x = \frac{l_c}{2}$; $-E_cI_c y_c'' = 2k_{2c} y_c'$; A_c

$$A_c = \frac{k_{2c}\frac{Q}{C} + M_c \cos\frac{\upsilon}{2} + \frac{2M_ck_{2c}}{C}\frac{\upsilon}{l_c}\sin\frac{\upsilon}{2}}{\left(C\sin\frac{\upsilon}{2} - 2k_{2c}\frac{\upsilon}{l_c}\cos\frac{\upsilon}{2}\right)} \qquad (13)$$

$$y_c = \frac{k_{2c}\frac{Q}{C} + M_c \cos\frac{\upsilon}{2} + \frac{2M_ck_{2c}}{C}\frac{\upsilon}{l_c}\sin\frac{\upsilon}{2}}{C\sin\frac{\upsilon}{2} - 2k_{2c}\frac{\upsilon}{l_c}\cos\frac{\upsilon}{2}} \sin\frac{\upsilon}{l_c}x - \frac{M_c}{C}\cos\frac{\upsilon}{l_c}x + \frac{Q}{2C}x + \frac{M_c}{C} \qquad (14)$$

$x = \frac{l_c}{2}$

$$y_{\frac{l_c}{2}} = \Psi_c = \frac{k_{2c}\frac{Q}{C} + M_c \cos\frac{\upsilon}{2} + \frac{2M_ck_{2c}}{C}\frac{\upsilon}{l_c}\sin\frac{\upsilon}{2}}{C\sin\frac{\upsilon}{2} - 2k_{2c}\frac{\upsilon}{l_c}\cos\frac{\upsilon}{2}} \sin\frac{\upsilon}{x} - \frac{M_c}{C}\cos\frac{\upsilon}{2} + \frac{Q}{4C}l_c + \frac{M_c}{C} \qquad (15)$$

$x=0$

$$y'_{0C} = \varphi_c = \frac{k_{2c}\frac{Q}{C} + M_c \cos\frac{\upsilon}{2} + \frac{2M_ck_{2c}}{C}\frac{\upsilon}{l_c}\sin\frac{\upsilon}{2}}{C\sin\frac{\upsilon}{2} - 2k_{2c}\frac{\upsilon}{l_c}\cos\frac{\upsilon}{2}} \frac{\upsilon}{l_c} + \frac{Q}{2C} \qquad (16)$$

$$y'_{0C} = \varphi_c \frac{M_c}{k_{1C}} \qquad (17)$$

$$M_c = \frac{\frac{k_{2C}}{C}\frac{\upsilon}{l_C} + \frac{1}{2}\sin\frac{\upsilon}{2} + \frac{k_{2C}}{C}\frac{\upsilon}{l_C}\cos\frac{\upsilon}{2}}{-\frac{\upsilon}{l_C}\cos\frac{\upsilon}{2} - \frac{\upsilon^2}{l_C^2}\frac{2k_{2C}}{C}\sin\frac{\upsilon}{2} + \frac{C}{k_{1c}}\sin\frac{\upsilon}{2} - \frac{2k_{2C}}{k_{1c}}\frac{\upsilon}{l_c}\cos\frac{\upsilon}{2}} Q \qquad (18)$$

$$\psi_C = \psi_T \qquad (19)$$

-4

-4-1-

$$\Psi_C = \frac{k_{2C} Q \sin\frac{\upsilon}{2}}{C^2 \sin\frac{\upsilon}{2} - 2k_{2C} C \frac{\upsilon}{1} \cos\frac{\upsilon}{2}} + \frac{Ql}{4C} \qquad (20)$$

$$\lim_{k_{2c}\to\infty} \psi_C = \frac{Q\sin\frac{\upsilon}{2}}{-2C\frac{\upsilon}{1}\cos\frac{\upsilon}{2}} + \frac{Ql}{4C} = \frac{Ql}{4C}\left(1 - \frac{\sin\frac{\upsilon}{2}}{\frac{\upsilon}{2}\cos\frac{\upsilon}{2}}\right) \qquad (21)$$

$$\psi_T = \frac{-k_{2T} Q \sinh\frac{\alpha}{2}}{T^2 \sinh\frac{\alpha}{2} - 2k_{2T} T \frac{\alpha}{1} \cosh\frac{\alpha}{2}} + \frac{Ql}{4T} \qquad (22)$$

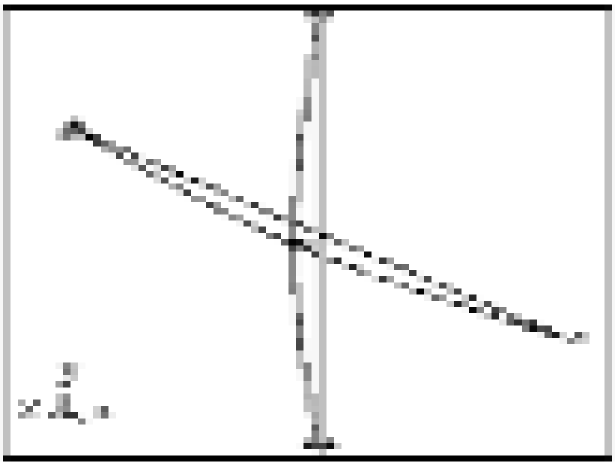
$$\lim_{k_{2T}\to\infty} \psi_T = \frac{Q\sinh\frac{\alpha}{2}}{-2T\frac{\upsilon}{1}\cosh\frac{\alpha}{2}} + \frac{Ql}{4T} = \frac{Ql}{4T}\left(1 - \frac{\sinh\frac{\alpha}{2}}{\frac{\alpha}{2}\cosh\frac{\alpha}{2}}\right) \qquad (23)$$

$$\frac{Ql}{4T} - \left(1 - \frac{\sinh\frac{\alpha}{2}}{\frac{\alpha}{2}\cosh\frac{\alpha}{2}}\right) = \frac{Ql}{4C}\left(1 - \frac{\sin\frac{\upsilon}{2}}{\frac{\upsilon}{2}\cos\frac{\upsilon}{2}}\right) \qquad (24)$$

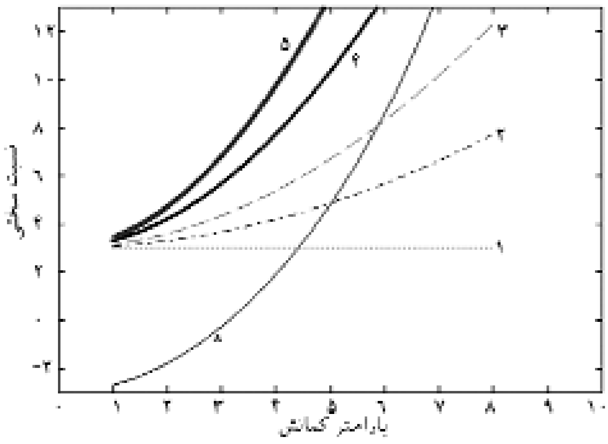
$$\frac{\left(\frac{\upsilon}{2}\right)^3}{\tan\frac{\upsilon}{2} - \frac{\upsilon}{2}} = \frac{\left(\frac{\alpha}{2}\right)^3}{\tanh\frac{\alpha}{2} - \frac{\alpha}{2}} \qquad (25)$$

$$P_{cr} = 0.00029620 \quad \upsilon = \sqrt{\frac{PL^2}{EI}} = \sqrt{\frac{(0.00029620)(300)^2}{(1)(1)}} = 5.163 \qquad (26)$$

$(\upsilon = 5.02)$



ANSYS 5.4



4-1-1- ANSYS 5.4

MAEB-D3 ... 50 ... $(\alpha = 0.5\upsilon)$ ... 300 ...

ANSYS ... 0.29620E-03 ... υ ... (26)

***** INDEX OF DATA SETS ON RESULTS FILE *****

SET TIME/FREQ LOAD STEP SUBSTEP CUMULATIVE

1 0.29620E-03 1 1 1

4-2-

$(k_{2C} \to \infty, \varphi_C = 0)$ (26)

$$\lim_{k_{2T}\to\infty} \varphi_C = \frac{Q + 2M_C \frac{\upsilon}{1}\sin\frac{\upsilon}{2}\upsilon}{-2\frac{\upsilon}{1}C\cos\frac{\upsilon}{2}}\frac{\upsilon}{1} + \frac{Q}{2C} = 0 \qquad (27)$$

M_C ... Q

$$M_C = \frac{1-\cos\frac{\upsilon}{2}}{2\sin\frac{\upsilon}{2}}\frac{1}{\upsilon}Q \qquad (28)$$

(29)

$$\lim_{k_{2T}\to\infty} \psi_C = \frac{Ql}{4C}\left(\frac{\frac{\upsilon}{4} - \tan\frac{\upsilon}{4}}{\frac{\upsilon}{4}}\right) \qquad (29)$$

[illegible] $k_{2T}\to\infty$ ، $M_T=0$ [illegible]

[illegible]

$$\lim_{k_{2T}\to\infty}\psi_T=\frac{Ql}{4T}\left(\frac{\frac{\alpha}{4}-\tanh\frac{\alpha}{4}}{\frac{\alpha}{4}}\right) \qquad (30)$$

[illegible] ψ_C ، ψ_T [illegible] [9]:

$$\frac{\left(\frac{\upsilon}{4}\right)^3}{\tan\frac{\upsilon}{4}-\frac{\upsilon}{4}}=\frac{\left(\frac{\alpha}{4}\right)^3}{\tanh\frac{\alpha}{4}-\frac{\alpha}{4}} \qquad (31)$$

[illegible]

4-3- [illegible]

[illegible] $k_{2T}\to\infty$ ، $M_T=0$ [illegible] (32):

$$\lim_{k_{2T}\to\infty}\psi_T=\frac{Ql}{4T}-\frac{Q\sinh\frac{\alpha}{2}}{2T\frac{\alpha}{l}\cosh\frac{\alpha}{2}} \qquad (32)$$

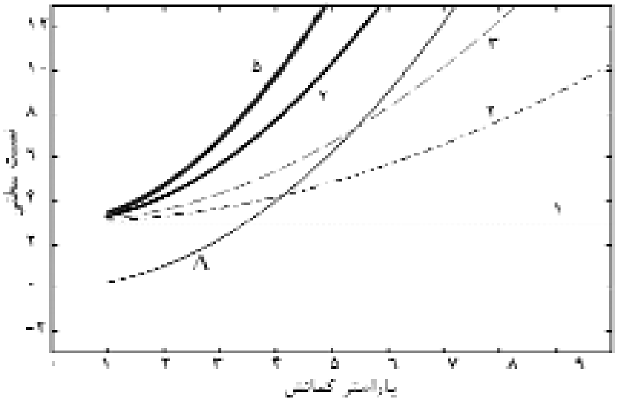
[illegible] $k_{2C}=0$ ، $M_C=0$ [illegible] (33):

$$\psi_C=\frac{Ql}{4C} \qquad (33)$$

[illegible] ψ_C ، ψ_T [illegible]:

$$\left(\frac{\upsilon}{2}\right)^2=\frac{\left(\frac{\alpha}{2}\right)^3}{\frac{\alpha}{2}-\tanh\frac{\alpha}{2}} \qquad (34)$$

[illegible] (5) [illegible] (34) [illegible]



[illegible] (5) [illegible]

5- [illegible]

[illegible]

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