

T.M. III (sterkteleer) : aanvulling knik van staven

Citation for published version (APA):

Esmeijer, W. L. (1967). *T.M. III (sterkteleer) : aanvulling knik van staven*. (DCT rapporten; Vol. 1967.019a). Technische Hogeschool Eindhoven.

Document status and date:

Gepubliceerd: 01/01/1967

Document Version:

Uitgevers PDF, ook bekend als Version of Record

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
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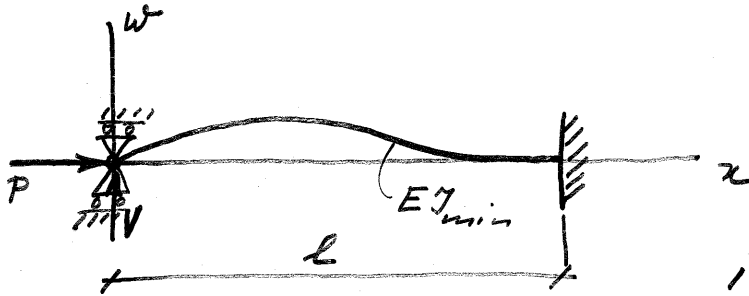
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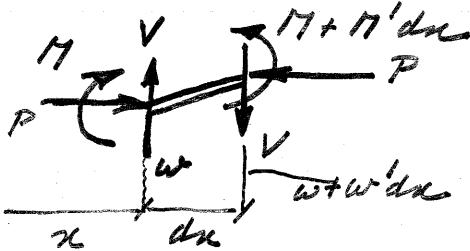
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Nov. '67 W.L.

Aanvulling Kruik van staven



$I = \frac{d^2}{dx^2}$



$V dx - Pw' dx - N' dx = 0$

$M' = V - Pw'$ Evenw.

$EI w'' = M$ elast.

Hieruit $EI w'''' + Pw'' = 0$

$\alpha^2 = \frac{P}{EI}$

$w = A \cos \alpha x + B \sin \alpha x + Cx + D$

4 Randvoorwaarden \Rightarrow homogene vergelijkingen in A, B, C en D.

Voorbeeld boven:

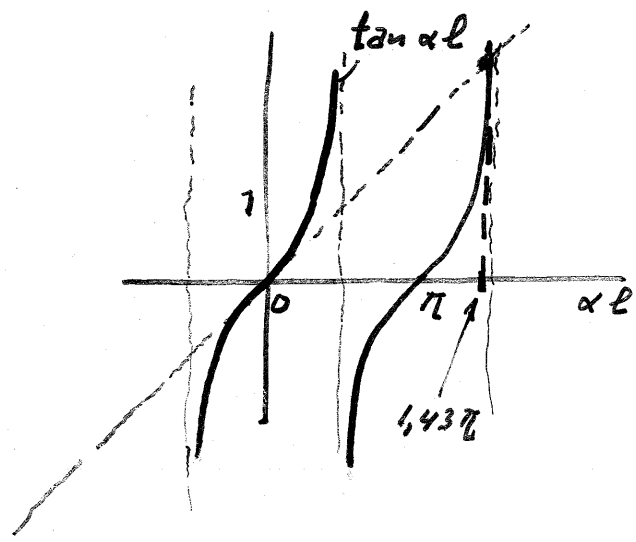
$$\begin{array}{l}
 x=0 \left\{ \begin{array}{l} w=0 \rightarrow A + D = 0 \\ w''=0 \rightarrow -\alpha^2 A = 0 \end{array} \right. \begin{array}{l} \textcircled{1} \\ \textcircled{2} \end{array} \\
 x=l \left\{ \begin{array}{l} w=0 \rightarrow A \cos \alpha l + B \sin \alpha l + Cl + D = 0 \\ w'=0 \rightarrow -A \alpha \sin \alpha l + B \alpha \cos \alpha l + C = 0 \end{array} \right. \begin{array}{l} \textcircled{3} \\ \textcircled{4} \end{array}
 \end{array}$$

Uit ① en ② : $A = D = 0$

Uit ③ en ④

$$\begin{vmatrix} \sin \alpha l & l \\ \alpha \cos \alpha l & 1 \end{vmatrix} = 0$$

Hieruit knikvoorwaarde: $\alpha l = \tan \alpha l$



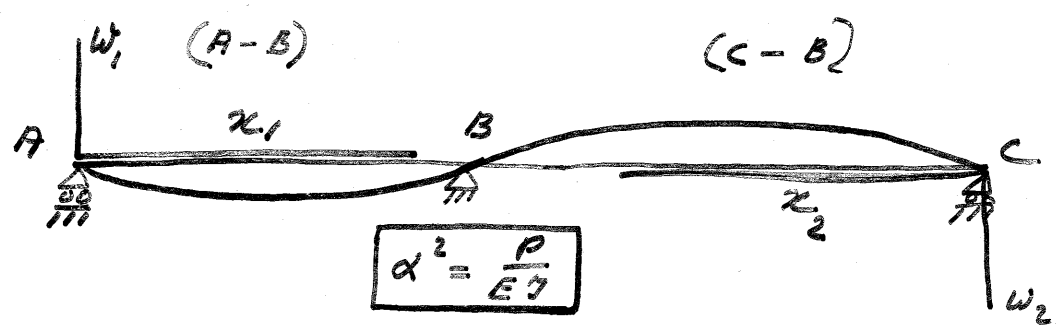
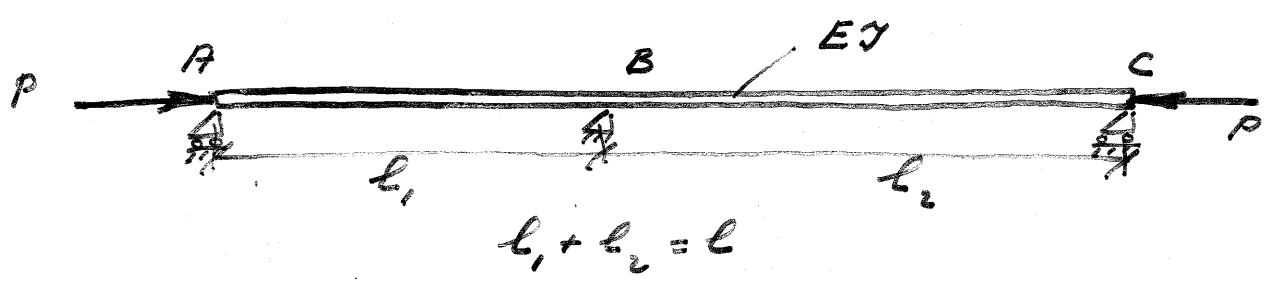
Kleinste oplossing:

$$\alpha l = 1,43 \pi$$

$$P_k = 3,04 \frac{\pi^2 EJ}{l^2}$$

##

Voorbeeld:

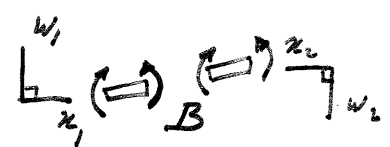


$$0 \leq x_1 \leq l_1 ; w_1 = A_1 \cos \alpha x_1 + B_1 \sin \alpha x_1 + C_1 x_1 + D_1$$

$$0 \leq x_2 \leq l_2 ; w_2 = A_2 \cos \alpha x_2 + B_2 \sin \alpha x_2 + C_2 x_2 + D_2$$

$$\left. \begin{array}{l} x_1 = 0 \\ x_2 = 0 \end{array} \right\} \text{ dan: } \left. \begin{array}{l} w_1'' = 0 \text{ en } w_1 = 0 \\ w_2'' = 0 \text{ en } w_2 = 0 \end{array} \right\} \Rightarrow \begin{array}{l} A_1 = 0 = D_1 \\ A_2 = 0 = D_2 \end{array}$$

Aansluiting bij B :



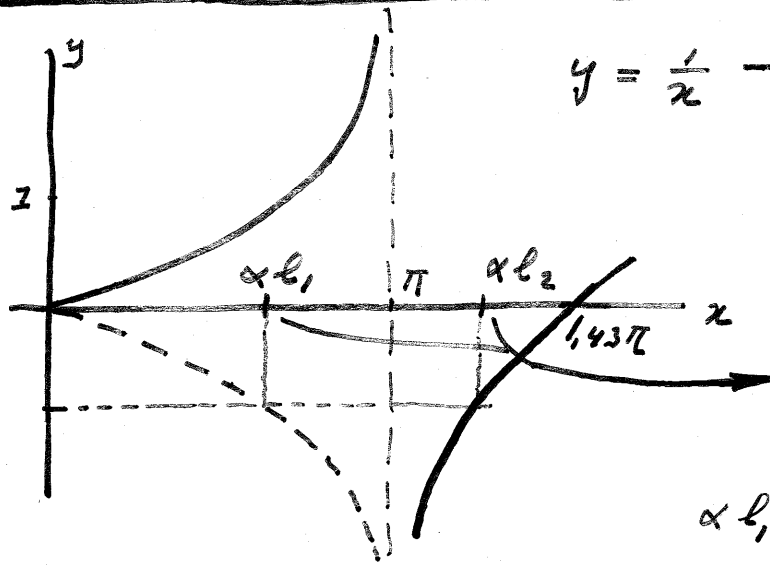
$$\begin{cases} x_1 = l_1 \\ x_2 = l_2 \end{cases} ; \begin{cases} \frac{dw_1}{dx_1} = \frac{dw_2}{dx_2} \\ w_1 = w_2 = 0 \end{cases} \Leftrightarrow \begin{cases} \frac{d^2 w_1}{dx_1^2} = - \frac{d^2 w_2}{dx_2^2} \end{cases} \quad (4 \text{ relaties})$$

$$\left. \begin{aligned} B_1 \sin \alpha l_1 + C_1 l_1 &= 0 \\ B_2 \sin \alpha l_2 + C_2 l_2 &= 0 \\ B_1 \alpha \cos \alpha l_1 + C_1 &= -B_2 \alpha \cos \alpha l_2 - C_2 \\ B_1 \alpha^2 \sin \alpha l_1 &+ B_2 \alpha^2 \sin \alpha l_2 = 0 \end{aligned} \right\}$$

$$\left\{ \begin{aligned} B_1 \left(\cos \alpha l_1 - \frac{\sin \alpha l_1}{\alpha l_1} \right) - B_2 \left(\cos \alpha l_2 - \frac{\sin \alpha l_2}{\alpha l_2} \right) &= 0 \\ B_1 \sin \alpha l_1 + B_2 \sin \alpha l_2 &= 0 \end{aligned} \right\}$$

$$\left(\cos \alpha l_1 - \frac{\sin \alpha l_1}{\alpha l_1} \right) \sin \alpha l_2 + \left(\cos \alpha l_2 - \frac{\sin \alpha l_2}{\alpha l_2} \right) \sin \alpha l_1 = 0$$

$$\boxed{- \left[\frac{1}{\alpha l_1} - \cot \alpha l_1 \right] = \left[\frac{1}{\alpha l_2} - \cot \alpha l_2 \right]}$$



$$y = \frac{1}{x} - \frac{1}{\tan x} = \frac{\tan x - x}{x \tan x}$$

$x \rightarrow 0 \quad \text{dan} \quad y \approx \frac{1}{3} x$

αl_1 en αl_2 voldoen aan \square ; dan $\alpha l_1 + \alpha l_2 = \alpha l$ (getal)

$$\text{en } \boxed{P_K = \frac{(\alpha l)^2 EJ}{l^2}}$$

$$P_c = \frac{\pi^2 EJ}{l^2}$$

$\frac{P_K}{P_c}$

