Sonderfälle

1. *Symmetrische Bogen* : $\zeta_x = J_c \,/\, J_x \cos\varphi$,

Es gilt : $\gamma_L^R = \gamma_R^L = \gamma, \quad \lambda_L = \lambda_R = \lambda.$

$$\Delta H = -\lambda \frac{\Delta M_L - \Delta M_R}{(1+\gamma)}$$

a) Einseitig fest eingespannte Bogen :

Für Gelenk an den Kampfer L : $\Delta M_L = - M_L, \; \Delta M_R = \gamma M_L$

$$\Delta H = \lambda M_L$$

Für Gelenk an den Kampfer R : $\Delta M_L = \gamma M_R, \; \Delta M_R = - M_R$

$$\Delta H = -\lambda M_R .$$

b) Zweigelenkbogen : $\Delta M_L = - M_L, \; \Delta M_R = - M_R$

$$\Delta H = \lambda \frac{M_L - M_R}{1+\gamma}$$

2. *Symmetrische Bogen* : $\zeta = 1$

Es gilt : $\lambda = \dfrac{15}{2f(9+4\nu)}, \quad \dfrac{\lambda}{1+\gamma} = \dfrac{15}{4f(6+\nu)}$

a) Einseitig fest eingespannte Bogen : $\Delta H = \pm \dfrac{15}{2f(9+4\nu)} M_{L,R}.$

$$\nu = 0 \qquad \Delta H = \pm \frac{5}{6f} M_{L,R}$$

b) Zweigelenkbogen : $\Delta H = \dfrac{15}{4f(6+\nu)} (M_L - M_R)$

$$\nu = 0 \qquad \Delta H = \frac{5}{8f}(M_L - M_R).$$

ΕΦΗΡΜΟΣΜΕΝΗ ΣΤΑΤΙΚΗ. — **Περὶ τοῦ ἐμβαδοῦ τοῦ ἀνηγμένου διαγράμματος τῶν ῥοπῶν κάμψεως ἀμφιερείστου δοκοῦ μεταβλητῆς διατομῆς**, ὑπὸ ***Ἀχιλλ. Π. Σιμοπούλου****. Ἀνεκοινώθη ὑπὸ τοῦ κ. Βασ. Αἰγινήτου.

Κατὰ τὴν ἔκφρασιν τῶν νόμων τῆς ἐλαστικῆς λειτουργίας τῶν φορτιζομένων δοκῶν ἀπαιτεῖται ἡ τιμὴ τοῦ ἐμβαδοῦ τοῦ ἀνηγμένου διαγράμματος τῶν ῥοπῶν

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* ACHILL. P. SIMOPULOS : Inhalt der verzerrte Momentenfläche des frei aufliegenden Trägers veränderlichen Querschnitts.

κάμψεως, ὡς καὶ ἡ στατικὴ ροπὴ τούτου, ὡς πρὸς ἓν στήριγμα τῆς δοκοῦ. Ἤτοι ὁ ὑπολογισμὸς ἑκάστοτε τῆς τιμῆς τῶν ὁλοκληρωμάτων.

$$E_{\alpha\nu} = \frac{1}{EJ_c} \cdot \int_o^l \zeta_x M_x \, dx, \qquad E_{\alpha\nu} . \alpha_1' = \frac{1}{EJ_c} \int_o^l \zeta_x M_x \, x dx.$$

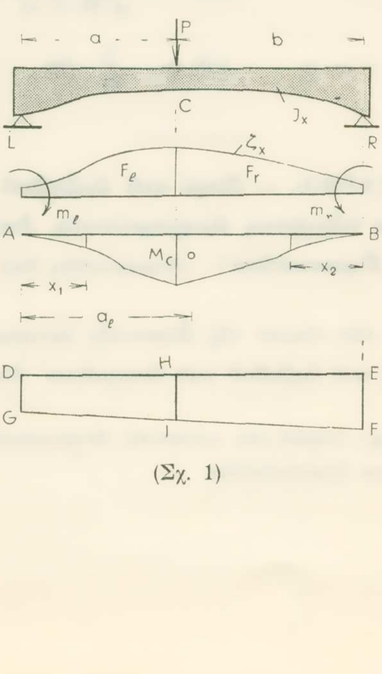
Ὁ ὑπολογισμὸς τῶν ὁλοκληρωμάτων τούτων ἐν τῇ περιπτώσει δοκῶν μεταβλητῆς διατομῆς, ἔνθα ζ_x = μεταβλητόν, ἐμφανίζει πολλὰς δυσκολίας συνεπείᾳ τοῦ καταμερισμοῦ τῶν ὁλοκληρώσεων εἰς πολλὰς περιοχάς. Δι' ὃ δὲν ὑπάρχουσιν ἐν τῇ σχετικῇ τεχνικῇ βιβλιογραφίᾳ κλειστοὶ τύποι ὑπολογισμοῦ αὐτῶν.

Ἡ μαθηματικὴ διερεύνησις τοῦ θέματος τούτου κατέληξεν εἰς τὸ κάτωθι θεώρημα, δι' ἐφαρμογῆς τοῦ ὁποίου προσδιωρίσθησαν ἐν συνεχείᾳ οἱ κλειστοὶ τύποι ὑπολογισμοῦ τῶν μεγεθῶν $E_{\alpha\nu}$, καὶ $E_\alpha . \alpha_1'$ ὡρισμένων περιπτώσεων φορτιζομένων δοκῶν.

Θεώρημα. *Ἡ εἰς θέσιν C ἐπὶ ἀμφιερείστου δοκοῦ δρῶσα δύναμις P διαχωρίζει τὴν ἐπιφάνειαν τῆς καμπύλης ζ_x τῆς δοκοῦ εἰς δύο τμήματα, ὧν αἱ ροπαὶ ὡς πρὸς τὰ πλησίον κείμενα στηρίγματα, ἐὰν ληφθῶσιν ὡς ροπαὶ στηρίξεως τῆς δοκοῦ, ὁρίζουσιν ἰδεατὸν τραπέζιον ροπῶν, οὗ τὸ* $\frac{P}{lJE_c}$ *πλάσιον τῆς εἰς C τεταγμένης ἰσοῦται πρὸς τὸ ἐμβαδὸν τοῦ συνεπείᾳ P ἀνηγμένου διαγράμματος τῆς δοκοῦ.*

Ἀπόδειξις.

Ἔστω δοκὸς μεταβλητῆς ἀδρανείας ἐφ' ἧς ἐνεργεῖ δύναμις P (α, b). Τὸ ἐμβαδὸν τοῦ ἀνηγμένου διαγράμματος θὰ ἰσοῦται :



(Σχ. 1)

$$E_{\alpha\nu} = \frac{1}{EJ_c} \int_0^l \zeta_x M_x dx = \frac{1}{EJ_c} \left[\int_0^\alpha \zeta_x \frac{M_c}{\alpha} x_1\, dx_1 + \zeta_x \frac{M_c}{b} x_2 dx_2 \right] \quad (1)$$

Ἡ σχέσις αὕτη συναρτήσει τῆς $M_c = P\,ab/l$ γράφεται

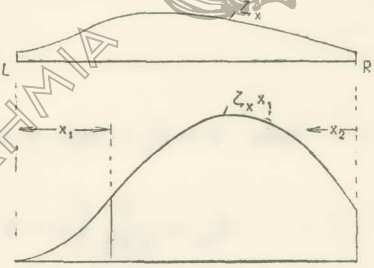
$$E_{\alpha\nu} = \frac{P}{lEJ_c} \left[b \int_0^\alpha \zeta_x\, x_1\, dx_1 + \alpha \int_0^b \zeta_x\, x_2\, dx_2 \right] \quad (2)$$

Ἐν τῇ σχέσει ταύτῃ παρατηροῦμεν πράγματι ὅτι ἡ ἐντὸς παρενθέσεων παράστασις ἐκφράζει τὴν τεταγμένην HI τοῦ τραπεζίου DEFGD (σχ. 1), οὗ αἱ βάσεις ἰσοῦνται ἀντιστοίχως πρὸς τὰς ροπάς:

$$m_\alpha = DG = \int_0^\alpha \zeta_x\, x_1\, dx_1\,, \quad m_b = EF = \int_0^b \zeta_x\, x_2\, dx_2$$

τῶν ἐπιφανειῶν F_l, F_r τῆς καμπύλης ζ_x, ὡς πρὸς τὰ γειτονικὰ στηρίγματα L, R τῆς δοκοῦ, ἀποδεικνυομένου οὕτω τοῦ θεωρήματος.

Ὡς πρὸς τὴν τιμὴν τῆς στατικῆς ροπῆς τοῦ ἀνηγμένου διαγράμματος ἰσχύουσι τὰ αὐτά, ἀλλὰ διὰ καμπύλην $\zeta_x x_1$ (σχ. 2).



(Σχ. 2)

Συμβολίζοντες συνεπῶς δι᾽ α_l τὴν ἀπόστασιν τοῦ Κ. Β. τῆς ἐπιφανείας $E_{\alpha\nu}$ ἀπὸ τοῦ στηρίγματος L τῆς δοκοῦ θὰ ἔχωμεν τὸν τύπον.

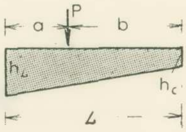
$$E_{\alpha\nu}\, \alpha_l = \frac{P}{lEJ_c} \left[b \int_0^\alpha \zeta_x\, x_1^2 dx_1 + \alpha \int_0^b \zeta_x\, x_1 x_2 dx_2 \right] \quad (3)$$

ΕΞΑΓΟΜΕΝΑ ΕΦΑΡΜΟΓΗΣ ΤΩΝ ΤΥΠΩΝ (2). (3)

Κατωτέρω δίδομεν τὰ ἐξαγόμενα τῆς ἐφαρμογῆς τῶν τύπων (2), (3) ἐπὶ 24 περιπτώσεων φορτιζομένων δοκῶν.

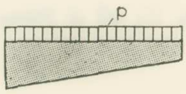
1. ΕΥΘΥΓΡΑΜΜΟΙ ΕΝΙΣΧΥΣΕΙΣ

$$q = h_c / h_L, \quad n = q^3, \quad k = 1 - q$$



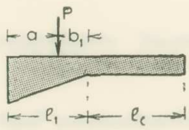
$$E_{\alpha\nu} = \frac{q^2 L P}{2EJ_c}\left(\frac{ab}{L - ka}\right)$$

$$E_{\alpha\nu}\alpha'_1 = \frac{nL^2P}{2k^2EJ_c}\left[\frac{kab}{q\,(L - ka)} + \frac{2}{k}\left(a\ln q - L\ln\frac{L - ka}{L}\right)\right]$$



$$E_{\alpha\nu} = \frac{pL^3n}{2k^2EJ_c}\left(\frac{1 + q}{2q} + \frac{\ln q}{k}\right)$$

$$E_{\alpha\nu}\alpha'_1 = \frac{nL^4p}{2k^2EJ_c}\left[\frac{1 + 5q}{2\,kq} + \frac{2 + q}{k^2}\ln q\right]$$

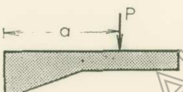


$$E_{\alpha\nu} = \frac{P}{2EJ_c}\left[q_1 l\left(\frac{L}{k} - l_1\right)\frac{\alpha}{L} - \frac{nl_1^2}{k}\frac{\alpha}{(l_1 - k\alpha)} + \frac{l_c^2}{L}\alpha\right]$$

$$E_{\alpha\nu}\alpha'_1 = \frac{P}{EJ_c}\left\{\frac{nl_1^2}{2k^2}\delta\alpha - \frac{nl_1^3}{2k^2}\left[\frac{\alpha}{l_1 - k\alpha} + \frac{2}{k}\left(\ln\frac{l_1 - k\alpha}{l_1} - \frac{\alpha}{L}\ln q\right)\right] + \right.$$

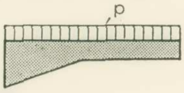
$$\left. + \frac{(L^3 - 3Ll_1^2 + 2l_1^3)}{6L}\alpha\right\}$$

$$\text{ἔνθα} \quad \delta = (l_c - 2qL + 3ql_1) / q^2L$$



$$E_{\alpha\nu} = \frac{P}{2\,EJ_c}\left(\alpha - k\,\frac{l_1^2}{L}\right)b$$

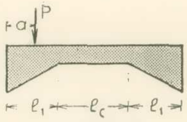
$$E_{\alpha\nu}\alpha'_1 = \frac{P}{EJ_c}\left[\frac{nl_1^3}{k^3}\left(\frac{k^2}{2q^2} - \frac{k}{q} - \ln q\right)\frac{b}{L} + \frac{(L + \alpha)\alpha b}{6} - \frac{l_1^3 b}{3L}\right]$$



$$E_{\alpha\nu} = \frac{p}{2EJ_c}\left[\frac{nl_1^3}{k^2}\left(1 + \frac{\ln q}{k}\right) + \frac{ql_1^3}{2k} + \frac{ql_1^2}{2}(l_c - l_1) + \frac{L^3 - 3Ll_1^2 + 2l_1^3}{6}\right]$$

$$E_{\alpha\nu}\alpha'_1 = \frac{p}{EJ_c}\left\{\frac{nl_1^4}{2k^3}\left[3 + \frac{(1 - 2q)k}{2q^2} + \frac{(1 - 3q)k}{2q^2}\frac{l_c - l_1}{l_1} + \right.\right.$$

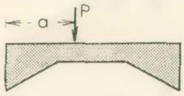
$$\left.\left. + \left(\frac{1 + 2q}{k} - \frac{l_c - l_1}{l_1}\right)\ln q\right] + \frac{L^4 - 4Ll_1^3 + 3l_1^4}{24}\right\}$$



$$E_{\alpha\nu} = \frac{P}{2EJ_c}\left(\frac{ql_1}{k}\,\alpha - \frac{nl_1^2}{k}\,\frac{\alpha}{l_1 - k\alpha} + l_c\alpha\right)$$

$$E_{\alpha\nu}\,\alpha_1' = \frac{P}{EJ_c}\left\{\frac{2nl_1^3}{k^3}\left(\frac{k}{q} - \frac{k^2}{2q^2} + l\mathrm{n}q\right)\frac{\alpha}{L} + \right.$$

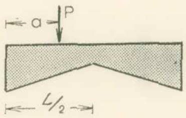
$$\left. + nl_1^2\left(\frac{1}{q^2} - \frac{1}{2k^2} - \frac{l_1}{2k^2(l_1 - k\alpha)}\right)\alpha - \frac{nl_1^3}{k^3}\,l\mathrm{n}\frac{l_1 - k\alpha}{l_1} + \frac{L^3 - 6Ll_1^2 + 4l_1^3}{6L}\,\alpha\right\}$$



$$E_{\alpha\nu} = \frac{P}{2EJ_c}\,(\alpha b - kl_1^2)$$

$$E_{\alpha\nu}\,\alpha_1' = \frac{P}{EJ_c}\left\{\frac{nl_1^3}{k^3}\left[\frac{k^2}{2q^2} - \frac{k}{q} - \ln q\right]\frac{L - 2\alpha}{L} + \frac{nl_1^2\alpha}{2q^2} + \right.$$

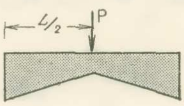
$$\left. + \frac{(4l_1^3 - 3l_1^2L + L^3)\alpha - L\alpha^3 - 2l_1^3L}{6L}\right\}$$



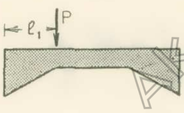
$$E_{\alpha\nu} = \frac{PL^2}{4kEJ_c}\left(q\frac{\alpha}{L} - \frac{n}{2}\,\frac{\alpha}{(l_1 - k\alpha)}\right)$$

$$E_{\alpha\nu}\,\alpha_1' = \frac{PnL^3}{8k^3EJ_c}\left\{\left(\frac{2k}{q} - \frac{k^2}{q^2} + 2\ln q\right)\frac{\alpha}{L} + \left(\frac{2k^2}{q^2} - 1\right)k\frac{\alpha}{L} - \right.$$

$$\left. - \frac{k\alpha}{L - 2k\alpha} - l\mathrm{n}\frac{L - 2k\alpha}{L}\right\}$$

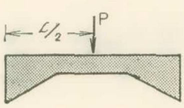


$$E_{\alpha\nu} = \frac{PL^2}{8EJ_c}\,q$$

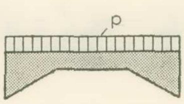


$$E_{\alpha\nu} = \frac{P}{2EJ_c}\;l_1(l_1q + l_c)$$

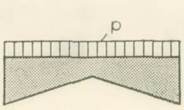
$$E_{\alpha\nu}\,\alpha_1' = \frac{P}{EJ_c}\left\{\frac{nl_1^3}{k^3}\left[\frac{k^2}{2q^2} - \frac{k}{q} - l\mathrm{n}q\right]\frac{l_c}{L} + \frac{nl_1^3}{2q^2} + \frac{(L^3 - 6Ll_1^2 + 4l_1^3)\;l_1}{6L}\right\}$$



$$E_{\alpha\nu} = \frac{P}{8EJ_c}\,(L^2 - 4kl_1^2)$$



$$E_{\alpha\nu} = \frac{p}{2EJ_c}\left\{\frac{2nl_1^3}{k^2}\left(1 + \frac{l\mathrm{n}q}{k}\right) + \frac{ql_1^3}{k} + ql_1^2l_c + \frac{L^3 - 6Ll_1^2 + 4l_1^3}{6}\right\}$$

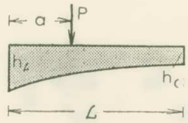


$$E_{\alpha\nu} = \frac{pL^3}{8kEJ_c}\left[\frac{q}{2} + \frac{n}{k}\,(1 + \frac{1}{k}\,l\mathrm{n}q)\right]$$

2. ΠΑΡΑΒΟΛΙΚΑΙ ΕΝΙΣΧΥΣΕΙΣ

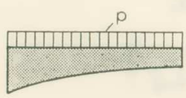
$$q = h_c/h_L,\quad k = 1 - q,\quad n = q^3,\quad \sqrt{\frac{q}{k}}\,\text{τοξ εφ}\sqrt{\frac{k}{q}} = \Phi$$

$$\sqrt{\frac{q}{k}}\,\text{τοξ. εφ}\sqrt{\frac{k}{q}}\frac{b}{L} = \Phi_b,\quad \sqrt{\frac{q}{k}}\,\text{τοξ. εφ}\sqrt{\frac{k}{q}}\frac{b_1}{l_1} = \Phi_{b_1}$$



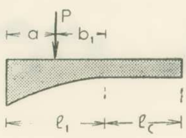
$$E_{\alpha\nu} = \frac{Pq^2L}{8kEJ_c}\left\{\frac{L^3}{qL^2 + kb^2} - \frac{\alpha}{q} - b + 3\,\frac{b}{q}\,(\Phi - \Phi_b)\right\}$$

$$E_{\alpha\nu}\alpha_1 = \frac{PL^2}{8EJ_c}\left\{\frac{2k+1}{k}\,b\Phi - \frac{3kb + ql_1}{k}\Phi_b - \frac{q\alpha b^2}{ql_1^2 + kb^2}\right\}$$



$$E_{\alpha\nu} = \frac{pqL^3}{16kEJ_c}\left[1 + k - \Phi\right]$$

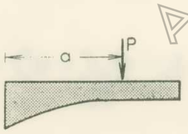
$$E_{\alpha\nu}\alpha_c' = \frac{pL^4}{8EJ_c}\frac{q}{k}\left(1 - \Phi\right)$$



$$E_{\alpha\nu} = \frac{P}{8EJ_c}\left(\frac{q^2l_1^2(2l_1 - \alpha)\alpha}{(ql_1^2 + kb_1^2)} + (4l_c^2 - ql_1^2)\frac{\alpha}{L} + 3\left(l_1^2\frac{b}{L}\Phi - l_1 b_1 \Phi_{b_1}\right)\right)$$

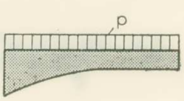
$$E_{\alpha\nu}\alpha_1' = \frac{Pl_1^2}{8kEJ_c}\left(-\frac{(L + l_c)q\alpha}{L} + \frac{q^2l_1^2\alpha}{ql_1^2 + kb_1^2} + \frac{l_1(2k+1)}{L}b\Phi - \right.$$

$$\left. - (3kb_1 + ql_1)\,\Phi_{b_1}\right) + \frac{P}{EJ_c}\frac{L^3 - 3Ll_1^2 + 2l_1^3}{6}\frac{\alpha}{L}$$



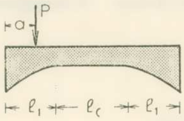
$$E_{\alpha\nu} = \frac{P}{2EJ_c}\left(\alpha b - (k + 3 - 3\Phi)\frac{l_1^2}{4}\frac{b}{L}\right)$$

$$E_{\alpha\nu}\alpha_1' = \frac{P}{EJ_c}\left(-\frac{ql_1^3b}{8kL} + \frac{l_1^3b}{8L}\frac{2k+1}{k}\Phi + \frac{(L+\alpha)\alpha b}{6} - \frac{l_1^3b}{3L}\right)$$



$$E_{\alpha\nu} = \frac{p}{16EJ_c}\left[\left(\frac{3l_c}{l_1} - \frac{q}{k}\right)l_1^3\,\Phi + \frac{l_1^3}{k} - kl_1^2L + \frac{4L^3 - 9Ll_1^2 + 5l_1^3}{3}\right]$$

$$E_{\alpha\nu}\alpha_1' = \frac{p}{EJ_c}\left\{\frac{l_1^3}{16k}\left(q(2l_1 - l_c) + (3l_c - 2Lq)\Phi\right) + \frac{L^4 - 4Ll_1^3 + 3l_1^4}{24}\right\}$$

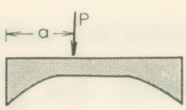


$$E_{\alpha\nu} = \frac{P}{8\,EJ_c}\left(\frac{(2l_1 - \alpha)\alpha}{ql_1^2 + kb_1^2}\,q^2 l_1^2 + 3l_1^2\,\Phi - 3l_1 b_1\,\Phi_{b_1} + 4l_c\alpha\right)$$

$$E_{\alpha\nu}\,\alpha_1' = \frac{P}{EJ_c}\left\{-\frac{ql_1^2\alpha}{8k}\left(\frac{L-2\alpha}{L} - \frac{ql_1^2}{ql_1^2+kb_1^2} + q\right) + \right.$$

$$+\frac{l_1^2}{8}\left(\frac{(2k+1)}{k}\,\frac{(L-2\alpha)}{L}\,l_1 + 3\alpha\right)\Phi - \frac{l_1}{8}\left(3l_1 b_1 + \frac{q}{k}l_1^2\right)\Phi_{b1} +$$

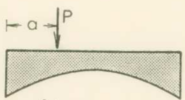
$$\left. + \left(L^3 - 6Ll_1^2 + 4l_1^3\right)\alpha/6L\right\}$$



$$E_{\alpha\nu} = \frac{P}{8\,EJ_c}\left(ql_1^2 + 3l_1^2\,\Phi + 4(\alpha b - l_1^2)\right)$$

$$E_{\alpha\nu}\,\alpha_1' = \frac{P}{EJ_c}\left\{\frac{ql_1^2}{8}\left(\alpha - \frac{l_1(L-2\alpha)}{kL}\right) + \frac{l_1^2}{8}\left(\frac{2k+1)}{k}\,\frac{(L-2\alpha)}{L}l_1 + 3\alpha\right)\Phi\right.$$

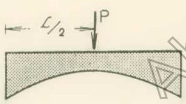
$$\left. + \frac{\left(4l_1^3 - 3l_1^2 L + L^3\right)\alpha - L\alpha^3 - 2l_1^3 L}{6L}\right\}$$



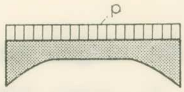
$$E_{\alpha\nu} = \frac{P}{8\,EJ_c}\left(ql_1^2\,\frac{b\alpha}{ql_1^2 + kb_1^2} + 3l_1^2\Phi - 3l_1 b_1\,\Phi_1\right)$$

$$E_{\alpha\nu}\,\alpha_1' = \frac{PL^2}{32\,EJ_c}\left\{\frac{q\alpha}{k}\left(\frac{qL^2}{qL^2 + 4kb_1^2} - 1 + \frac{2\alpha}{L} - q\right) + \right.$$

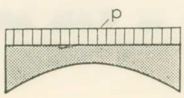
$$\left. + \left(\frac{2k+1}{2k}(L-2\alpha) + 3\alpha\right)\Phi - \left(3b_1 + \frac{qL}{2k}\right)\Phi_{b_1}\right\}$$



$$E_{\alpha\nu} = \frac{PL^2}{32\,EJ_c}\left(q + 3\,\Phi\right)$$



$$E_{\alpha\nu} = \frac{pl_1^2}{8\,EJ_c}\left\{\left(q\frac{l_1}{k} + L\right) + \left(2L + l_c - \frac{l_1}{k}\right)\Phi + \frac{2}{3}\,\frac{L^3 - 6Ll_1^2 + 4l_1^3}{l_1^2}\right\}$$



$$E_{\alpha\nu} = \frac{pL^3}{64\,EJ_c}\left\{\frac{q}{k}\,(1 + 2\,k) + \frac{4k - 1}{k}\,\Phi\right\}$$

ZUSAMMENFASSUNG

Bei der Berechnung des durchlaufenden Trägers mit veränderlichem Trägheitsmoment ist erforderlich die verzerrte Momentenfläche $E_{\alpha\nu}$ sowie

ihr statisches Moment $E_{\alpha\nu}\alpha_1'$ bezüglich des linken b. w. rechten Auflagerstützes zu wissen. Es lautet :

$$E_{\alpha\nu} = \frac{1}{EJ_c}\int_0^l \zeta_x M_x dx, \qquad \alpha_1' E_{\alpha\nu} = \frac{1}{EJ_c}\int_0^l \zeta_x M_x x dx.$$

Mit J_c bezeichnen wir irgend ein festes, unveränderliches Trägheitsmoment und setzen : $\zeta_x = J_c / J_x$.

Die mathematische Untersuchung der obigen Formeln führte zum folgenden Satz (Abb, 1,2).

Der Inhalt der verzerrten Momentenfläche eines beiderseitig frei aufliegenden Balkens infolge einer Last im Pukte C, ist gleich dem $\frac{P}{lEJ_c}$ fache des Biegungsmomentes welches man im Punkt C bekommt wenn auf beiden Stützen die Momente

$$m_L = \int_0^\alpha \zeta_x \ x_1 dx_1 \quad , \quad m_R = \int_0^b \zeta_x x_2 dx_2$$

wirken lässt.

Es bedeutet :

m_L, m_R : Das Moment der zwischen $\frac{L}{R}$ und P liegenden ζ_xFläche bezogen auf den Auflager $\frac{L}{R}$.

Bezüglich des Momentes der verzerrten Momentenfläche bezogen auf den linken Auflager L gilt die Kurve $\zeta_x x_1$.

Es ist (Abb. 2).

$$E_{\alpha\nu}\alpha_1' = \frac{P}{lEJ_c}\left(b\int_0^\alpha \zeta_x x_1^2 dx_1 + \alpha\int_0^b \zeta_x x_1 x_2 dx_2 \right) \tag{3}$$

Duch Anwendung der Formeln (2) (3) ergeben sich die obigen Ausdrücke für die Berechnung der verzerrten Momentenfläche $E_{\alpha\nu}$ sowie ihres Momentes $E_{\alpha\nu}\alpha_1'$ bezogen auf den linken Auflager L, von 24 Fälle belasteten Trägern.