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ESTIMATION OF RIVER BANKS INFLUENCE ON TACHOIDA SHAPE AT MERIDIAN

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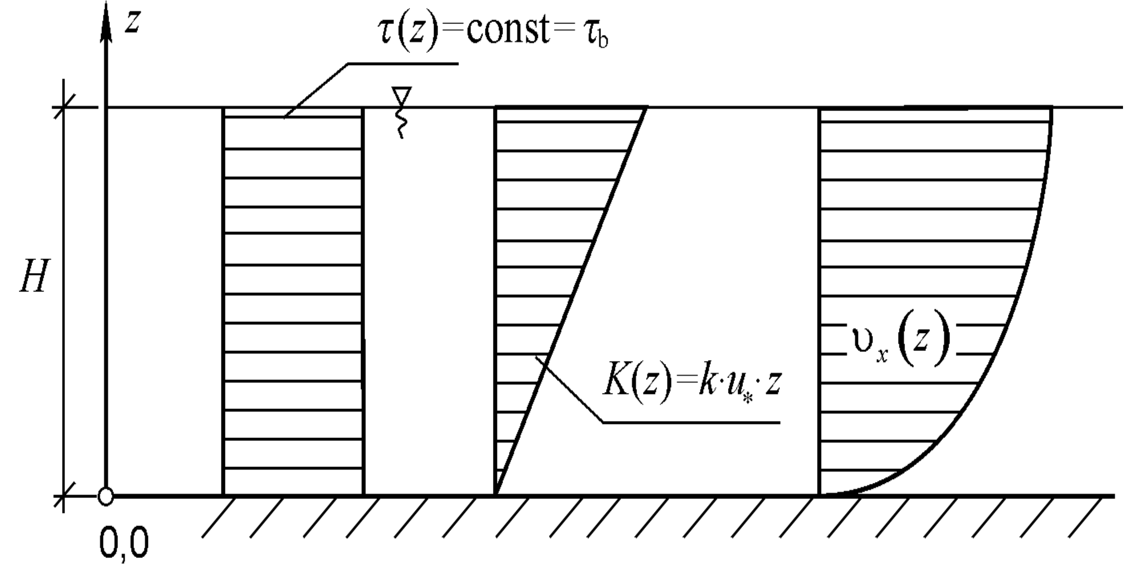

Fig. 1. Flow parameters in Prandtl logarythmic profile

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$$\tau_{zx}(z) = \rho \cdot K(z) \frac{d\upsilon_x(z)}{dz} \tag{1}$$

$$\tau_{zx}(z) = const = \tau_b = \rho \cdot u_*^2 = \rho g \cdot H \cdot I \tag{2}$$

$$K(z) = k \cdot u_* \cdot z \tag{3}$$

$$\upsilon_x(z) = \frac{u_*}{k} \cdot ln \frac{z}{z_s} + const \tag{4}$$

$$z_s = \frac{\nu}{k \cdot u_*} \tag{5}$$

$$\bar{\upsilon} = \frac{1}{H} \int_{z_s}^{H} \upsilon_x(z) dz \tag{6}$$

$$\bar{\upsilon} = \frac{u_*}{k} \cdot ln \frac{H}{k_s} \tag{7}$$

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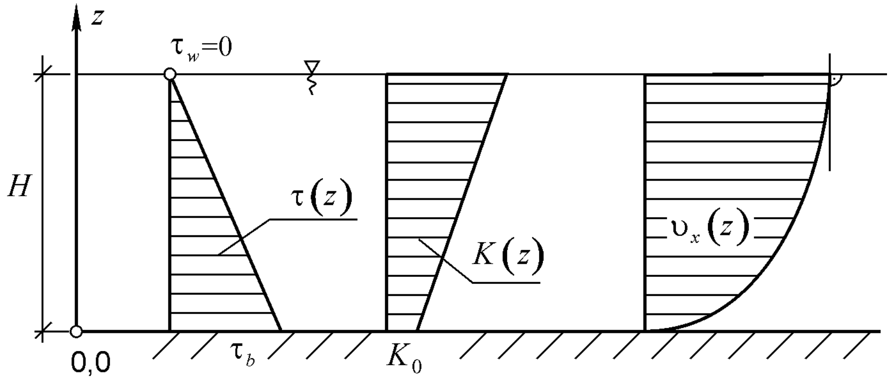

Fig. 2. Flow parameters distribution

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$$\tau_{zx}(z)=\tau_b\left(1-\frac{z}{H}\right) \qquad (8)$$

$$K(z)=K_0+k\cdot u_*\cdot z=K_0\left(1+\frac{z}{z_0}\right) \qquad (9)$$

$$z_0=\frac{K_0}{k\cdot u_*} \qquad U=\frac{H}{z_0} \qquad (10)$$

$$\upsilon_x(z)\Big|_{z=0}=0 \qquad (11)$$

$$\upsilon_x(z)=\frac{u_*}{k}\left[\frac{(1+U)ln\left(1+U\cdot\frac{z}{H}\right)-U\cdot\frac{z}{H}}{U}\right] \qquad (12)$$

$$\bar{\upsilon}=\frac{u_*}{k}\left[\frac{(1+U)^2\,ln(1+U)-U\cdot(1+U)}{U^2}-\frac{1}{2}\right] \qquad (13)$$

$$\upsilon_x(z)=\frac{u_*}{k}\left[ln\left(U\cdot\frac{z}{H}\right)-\frac{z}{H}\right] \qquad (14)$$

$$\bar{\upsilon}=\frac{u_*}{k}ln\left(\frac{U}{e^{3/2}}\right) \qquad (15)$$

$$\lim_{z\to 0}\upsilon_x(z)=\frac{u_*}{k}\cdot\frac{z}{z_0}=\frac{u_*^2}{K_0}z \qquad (16)$$

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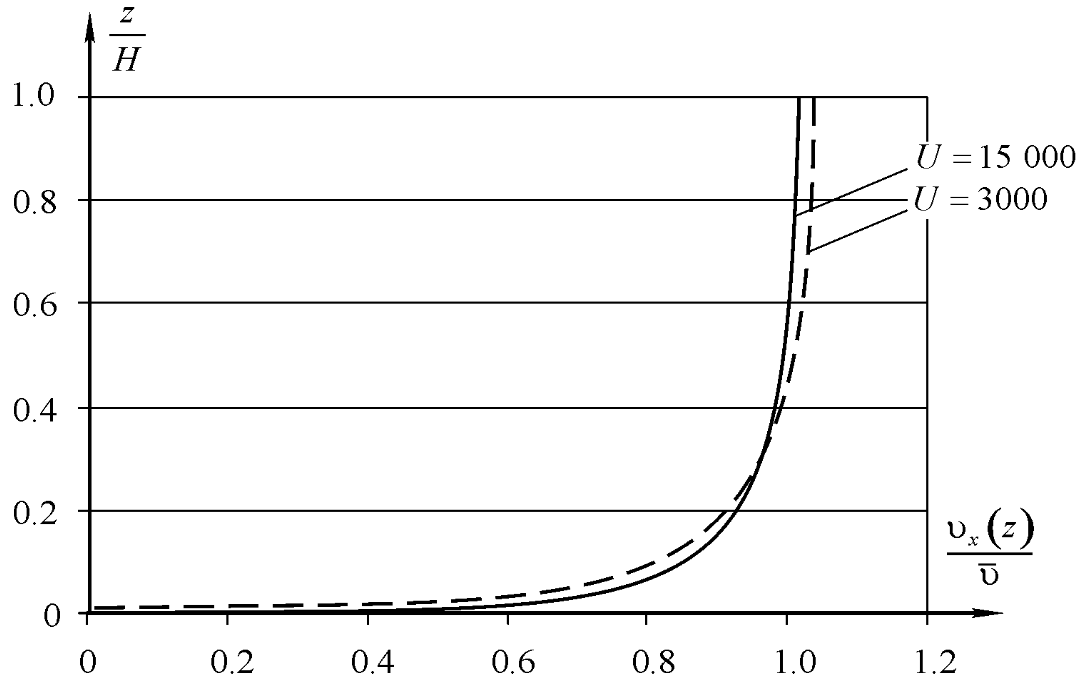

Fig. 3. An Example of function $\upsilon_x(z)$

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$$lnU = \frac{3}{2}\left[-ln\,n + \sqrt{ln^2 n + 2\,ln\,n}\right] \tag{17}$$

$$K_0 = g \cdot H^{4/3} \cdot \sqrt{I} \cdot n\frac{ln\left(\frac{U}{e^{3/2}}\right)}{U} \tag{18}$$

$$n = exp\left[-\frac{1}{3}\frac{ln^2 U}{lnU - \frac{3}{2}}\right] \tag{19}$$

$$\frac{K_0}{\nu} = \frac{1 + 1{,}25 \cdot C_0 + 6{,}25 \cdot C_0^2 + 15{,}62 \cdot C_0^3}{1 + (S - 1) \cdot C_0} \tag{20}$$

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Table 1

$C_0[g/l]$	0.5	1.0	1.5	2.0	2.5
K_0/ν	2.82	9.10	20.04	36.27	58.62

If the concentration C_0 is known, the sediment transport rate at the bottom can be calculated by the help of the formula:

$$w_b = \frac{C_0 \cdot Q}{U\, ln\left(\frac{U}{e^{3/2}}\right)} \cdot \left(\frac{\sqrt{g}}{2}\right)^2 \qquad (21)$$

$$k = \frac{\sqrt{g}}{C} ln\left(\frac{U}{e^{3/2}}\right) \qquad (22)$$

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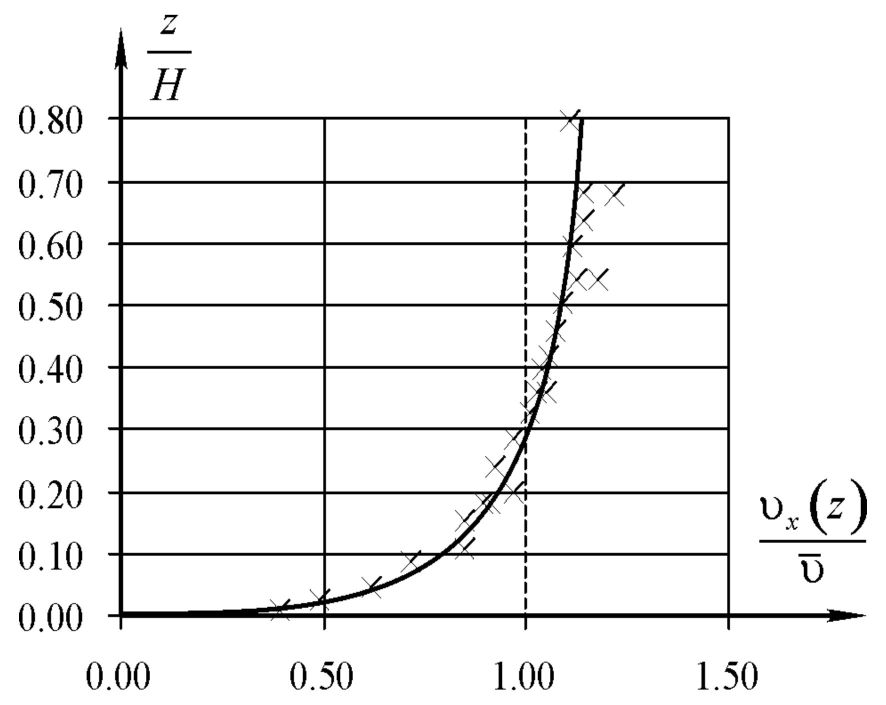

Fig. 4. Vertical distribution of flow velocity in river approximated with modified tachoida

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$$\upsilon_x(z)=\upsilon_0\left[1+\frac{\frac{3}{2}-\frac{z}{H}+ln\frac{z}{H}}{ln\left(\frac{U}{e^{3/2}}\right)}\right] \qquad (23)$$

$$\upsilon_0=\frac{\sum\left(Y_i^2\right)\cdot\sum\left(\upsilon_i^2\right)-\left[\sum\left(\upsilon_iY_i\right)\right]^2}{\sum\left(\upsilon_i\right)\cdot\sum\left(Y_i^2\right)-\sum\left(Y_i\right)\cdot\sum\left(\upsilon_iY_i\right)}$$

(24)

$$ln\left(\frac{U}{e^{3/2}}\right)=\frac{\sum\left(Y_i^2\right)\cdot\sum\left(\upsilon_i^2\right)-\left[\sum\left(\upsilon_iY_i\right)\right]^2}{\sum\left(Y_i\right)\cdot\sum\left(\upsilon^2\right)-\sum\left(\upsilon_i\right)\cdot\sum\left(\upsilon Y_i\right)}$$

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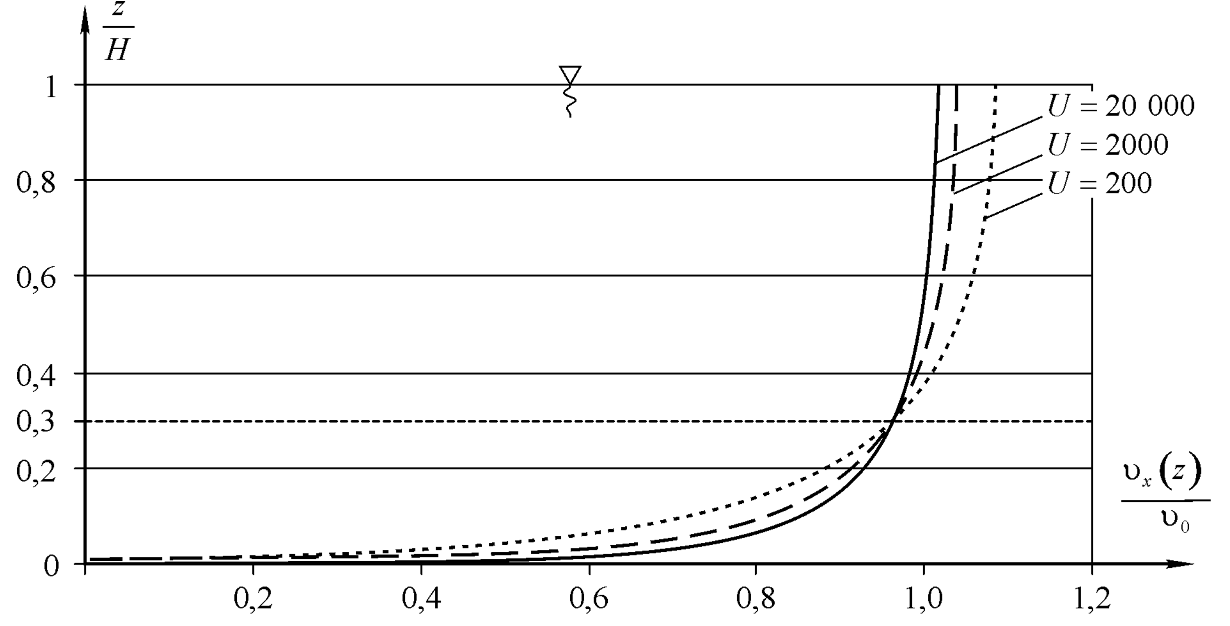

Fig. 4. The course of curves $\upsilon_x(z,U)$

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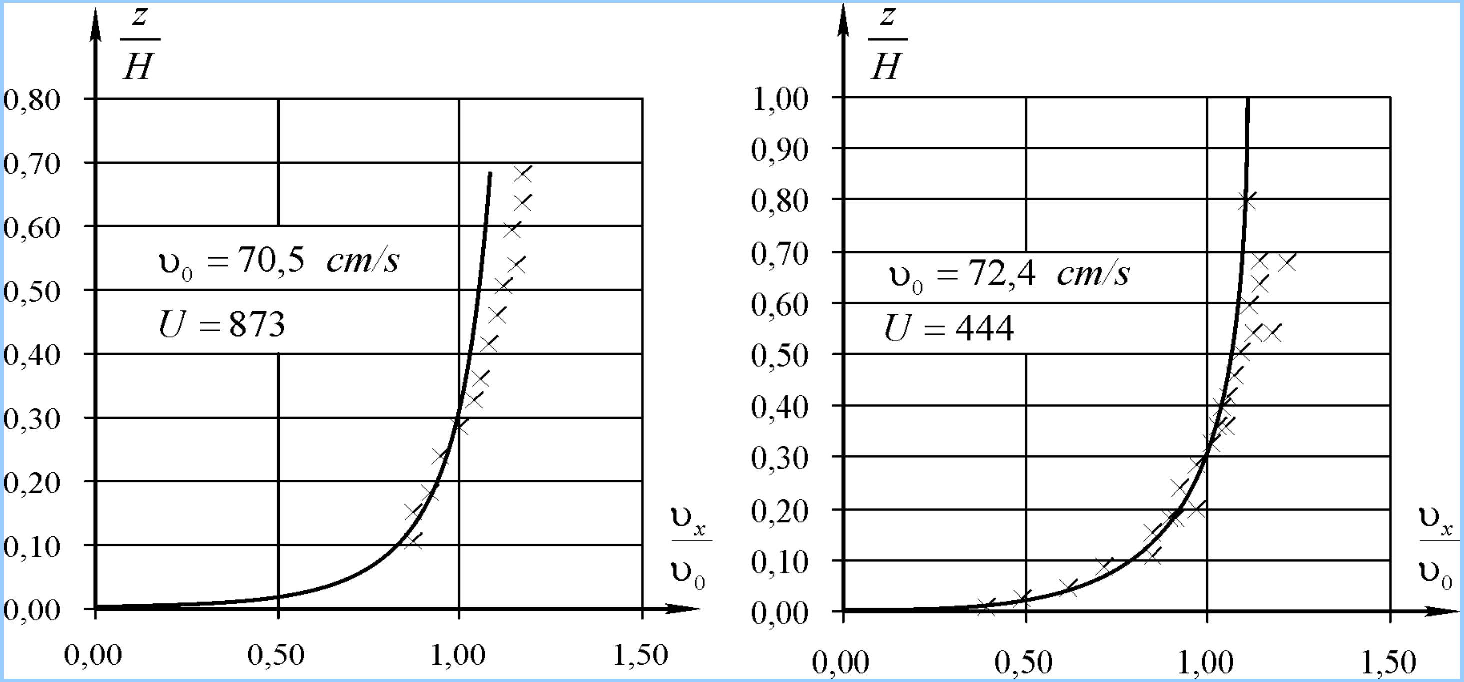

Fig. 5. Approximation results using for modified tachoida

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$$\tau_{xz} = \rho \cdot K_z \cdot \frac{\partial \upsilon_x}{\partial z} = C_z \cdot f_1(y) \cdot \left(1 - \frac{z}{H}\right)$$

$$\tau_{xy} = \rho \cdot K_y \cdot \frac{\partial \upsilon_x}{\partial y} = C_y \cdot f_2(z) \cdot \left(1 - \frac{y}{B}\right)$$

(25)

$$f_2(z) = \int \frac{\left(1 - \frac{z}{H}\right)}{K_z(z)} \cdot dz$$

$$f_1(y) = \int \frac{\left(1 - \frac{y}{B}\right)}{K_y(y)} \cdot dy$$

(26)

$$K_z(z) = K_{0z}\left(1 + \frac{z}{z_{01}}\right)$$

$$K_y(y) = K_{0y}\left(1 + \frac{y}{z_{02}}\right)$$

(27)

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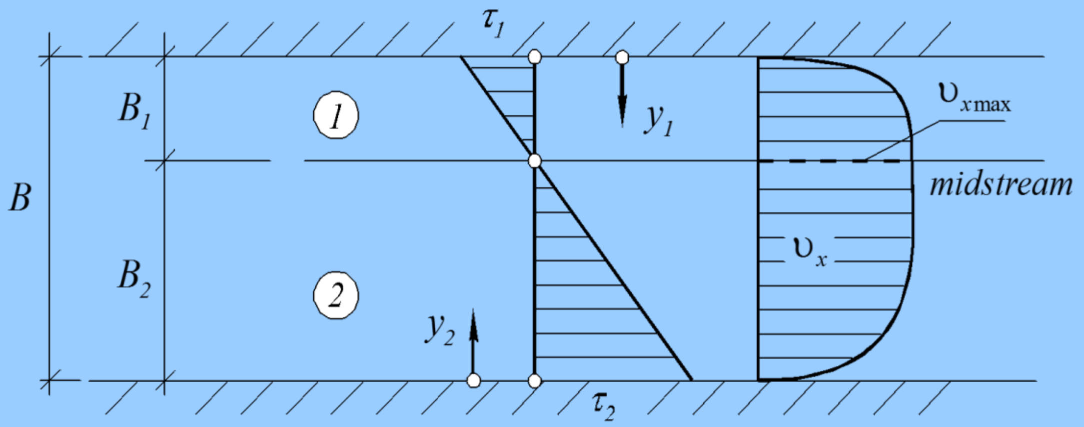

Fig. 6. Scheme of flow elements changes in the horizontal plane

$$\frac{\tau_1}{\tau_2} = \frac{B_1}{B_2}$$

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$$\upsilon_x(y,z)=\upsilon_{01}\cdot\left[1+\frac{\frac{3}{2}-\frac{y_1}{B_1}+ln\frac{y_1}{B_1}}{ln\left(\frac{U_1}{e^{3/2}}\right)}\right]\cdot\left[1+\frac{\frac{3}{2}-\frac{z}{H}+ln\frac{z}{H}}{ln\left(\frac{U_3}{e^{3/2}}\right)}\right]$$

$$\upsilon_x(y,z)=\upsilon_{02}\cdot\left[1+\frac{\frac{3}{2}-\frac{y_2}{B_2}+ln\frac{y_2}{B_2}}{ln\left(\frac{U_2}{e^{3/2}}\right)}\right]\cdot\left[1+\frac{\frac{3}{2}-\frac{z}{H}+ln\frac{z}{H}}{ln\left(\frac{U_3}{e^{3/2}}\right)}\right] \qquad (28)$$

$$Q=\upsilon_0\cdot B\cdot H=\upsilon_{01}\cdot B_1\cdot H+\upsilon_{02}\cdot B_2\cdot H \qquad (29)$$

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$$\varepsilon_i = \frac{1}{2 \cdot \ln\left(\dfrac{U_i}{e^{3/2}}\right)} \tag{30}$$

$$\upsilon_{01} = \frac{Q}{H\left[B_1 + B_2 \cdot \dfrac{1+\varepsilon_1}{1+\varepsilon_2}\right]} \tag{31}$$

$$\upsilon_x(z\ ,B_1) = \frac{Q}{BH} \cdot \frac{(1+\varepsilon_1)\cdot(1+\varepsilon_2)}{\dfrac{B_1}{B}\cdot(1+\varepsilon_2) + \dfrac{B_2}{B}\cdot(1+\varepsilon_1)} \cdot \left[1 + \left(\frac{3}{2} - \frac{z}{H} + \ln\frac{z}{H}\right) 2 \cdot \varepsilon_3\right] \tag{32}$$

$$k = \frac{(1+\varepsilon_1)\cdot(1+\varepsilon_2)}{\dfrac{B_1}{B}(1+\varepsilon_2) + \dfrac{B_2}{B}(1+\varepsilon_1)} \tag{33}$$

$$\frac{\upsilon_x(z)}{\upsilon_0} = k(z)\cdot\left[1 + \left(\frac{3}{2} - \frac{z}{H} + \ln\frac{z}{H}\right)\cdot 2\varepsilon_3\right] \tag{34}$$

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$$\frac{B_1}{B_2}=\left[\frac{n_2\cdot ln\left(\frac{U_2}{e^{3/2}}\right)}{n_1\cdot ln\left(\frac{U_1}{e^{3/2}}\right)}\right]^{0,75} \qquad (35)$$

$$B_1+B_2=B$$

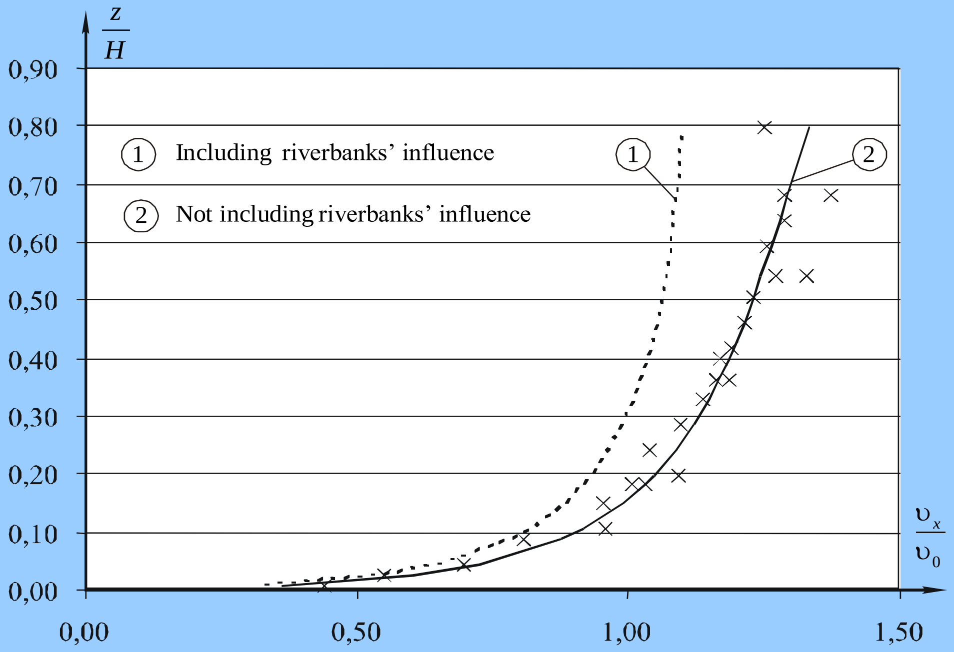

Fig. 7. Riverbanks influence upon the diagram of modified tachoida

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CONCLUSIONS

1. **The paper presents the method for estimation the riverbanks influence on the shape of tachoida at the river meridian.**

2. **It is commonly accepted opinion that if the ratio of river broad to the depth is big enough (*B/H*>30) for the analysis 2D model can be applied i.e. (*z, x*) axes. From the presented analysis it comes that even for the very broad river there is the influence of the riverbanks. Practically the influence does not disappear. The author is conscious of the fact that the conclusions are drawn upon the turbulence model applied in the horizontal plane. So it can be treated as an approach. But the results of experiments presented in literature agrees with the proposed model.**

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3. There were also analysed the river bank friction's influence upon the average flow velocity in the river cross-section. In comparison to the velocity that was calculated by the Chezy's formula, this value is smaller by ca. 6% according to the flow conditions. Every time this value can be calculated from the formulae mentioned in the present paper.

4. Further analysis is needed to explain the role of movable bed in creation of the eddy viscosity coefficient at the bottom and its influence an the river depth.