Jun 21st, 4:45 PM - 5:00 PM

Fish Passage Studies III: Flow and Turbulence Structure in Brush Fish Pass

Serhat Kucukali

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Flow and turbulence structure in brush fish pass

Prof. Serhat Kucukali
Advantages of Brush Fish Pass

1) Vibrations of Bristles: Guidance for Fishes and Favorable Hydraulic Conditions
2) Suitable for Small and Weak Swimming Capacity Fish
3) Social Benefit: Passage of Canoes

Shared Value
Fish Monitoring Studies in Brush Fish Pass: Spreewald, Berlin

UNESCO Biosphere Reserve

Comparison of Fish Length Distributions in Brush and Vertical Slot Passes
Physical Model of Brush Fish Pass
Scale=1:2 (Froude Similarity)

This work is supported by the Scientific and Technical Research Council of Turkey under Scientific and Technological Research Projects Funding Program (3001 TUBITAK) grant with agreement number 214M518
Flow Resistance of Brush Elements

\[ f = \text{fun}\left( \frac{d}{h}; A_w; S_o; \text{Layout} \right) \]
## Point Velocity Distributions

### Section D

<table>
<thead>
<tr>
<th>Point</th>
<th>V (cm)</th>
<th>z (cm)</th>
<th>V (m/s)</th>
</tr>
</thead>
<tbody>
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<td>5</td>
<td>0.5</td>
<td>0.24</td>
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<tr>
<td>V_{12}</td>
<td>5</td>
<td>5</td>
<td>0.37</td>
</tr>
<tr>
<td>V_{13}</td>
<td>5</td>
<td>10</td>
<td>0.33</td>
</tr>
<tr>
<td>V_{14}</td>
<td>5</td>
<td>15</td>
<td>0.39</td>
</tr>
<tr>
<td>V_{15}</td>
<td>5</td>
<td>19</td>
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<td>0.43</td>
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<td>V_{22}</td>
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<td>5</td>
<td>0.5</td>
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<tr>
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<td>10</td>
<td>10</td>
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<tr>
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<td>10</td>
<td>15</td>
<td>0.54</td>
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<td>10</td>
<td>19</td>
<td>0.43</td>
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<td>0.08</td>
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<td>V_{32}</td>
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<td>5</td>
<td>0.3</td>
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<td>19</td>
<td>0.24</td>
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<td>V_{41}</td>
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<td>V_{42}</td>
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<td>0.52</td>
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<tr>
<td>V_{43}</td>
<td>30</td>
<td>10</td>
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<tr>
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<tr>
<td>V_{55}</td>
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<td>19</td>
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### Typical Velocity Profile

![Typical Velocity Profile](image)

- **S_o**: 4%
- **A_w (m^2/m^2)**: 27.3
- **L=15 cm**
- **Q (l/s)**: 27.3
Field Measurements
Data Source: Mosch (2007)

<table>
<thead>
<tr>
<th>Messpunkt</th>
<th>$v_{\text{avr}}$ [m/s]</th>
<th>$v_{\text{min}}$ [m/s]</th>
<th>$v_{\text{max}}$ [m/s]</th>
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<tr>
<td>A</td>
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<td>0.59</td>
<td>0.74</td>
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<td>D</td>
<td>0.51</td>
<td>0.51</td>
<td>0.39</td>
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<tr>
<td>B</td>
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<td>0.08</td>
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<td>C + E</td>
<td>0.11</td>
<td>0.04</td>
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## Experimental Test Results

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<th>Test No</th>
<th>$S_o$</th>
<th>$Q$ (l/s)</th>
<th>$d$ (mm)</th>
<th>$d/h$</th>
<th>$A_w$ ($m^2/m^2$)</th>
<th>$V$ (m/s)</th>
<th>$f$</th>
<th>$Re$</th>
<th>$Fr$</th>
<th>$\Delta P$ (W/m$^3$)</th>
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<tr>
<td>1</td>
<td>2%</td>
<td>8.5</td>
<td>111.5</td>
<td>0.48</td>
<td>0.016</td>
<td>0.19</td>
<td>3.10</td>
<td>5.46E+04</td>
<td>0.18</td>
<td>37.4</td>
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<tr>
<td>2</td>
<td>2%</td>
<td>15.1</td>
<td>153.7</td>
<td>0.67</td>
<td>0.016</td>
<td>0.25</td>
<td>2.26</td>
<td>8.54E+04</td>
<td>0.20</td>
<td>48.2</td>
</tr>
<tr>
<td>3</td>
<td>2%</td>
<td>18.3</td>
<td>173.5</td>
<td>0.75</td>
<td>0.016</td>
<td>0.26</td>
<td>2.10</td>
<td>9.80E+04</td>
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</tr>
<tr>
<td>4</td>
<td>2%</td>
<td>21.2</td>
<td>192.5</td>
<td>0.84</td>
<td>0.016</td>
<td>0.28</td>
<td>2.03</td>
<td>1.08E+05</td>
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<td>54.0</td>
</tr>
<tr>
<td>5</td>
<td>2%</td>
<td>24.9</td>
<td>209.8</td>
<td>0.91</td>
<td>0.016</td>
<td>0.30</td>
<td>1.83</td>
<td>1.22E+05</td>
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<tr>
<td>6</td>
<td>2%</td>
<td>27.2</td>
<td>225.9</td>
<td>0.98</td>
<td>0.016</td>
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<td>7</td>
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<td>93.3</td>
<td>0.41</td>
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<td>8</td>
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<td>3.02</td>
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<td>2.89</td>
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<td>10</td>
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<td>83.9</td>
<td>0.36</td>
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<td>117.3</td>
<td>0.51</td>
<td>0.016</td>
<td>0.32</td>
<td>3.36</td>
<td>9.52E+04</td>
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<td>189.4</td>
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<tr>
<td>15</td>
<td>6%</td>
<td>18.3</td>
<td>135.2</td>
<td>0.59</td>
<td>0.016</td>
<td>0.34</td>
<td>3.32</td>
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<td>199.1</td>
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<tr>
<td>16</td>
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<td>151.1</td>
<td>0.66</td>
<td>0.016</td>
<td>0.35</td>
<td>3.29</td>
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<td>168.0</td>
<td>0.73</td>
<td>0.016</td>
<td>0.37</td>
<td>3.13</td>
<td>1.35E+05</td>
<td>0.29</td>
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</tr>
<tr>
<td>18</td>
<td>6%</td>
<td>27.2</td>
<td>182.3</td>
<td>0.79</td>
<td>0.016</td>
<td>0.37</td>
<td>3.23</td>
<td>1.42E+05</td>
<td>0.28</td>
<td>219.5</td>
</tr>
</tbody>
</table>

\[
A_w = \frac{n_h \pi D_h^2}{4BL} \quad f = \frac{8S_o Rg}{V^2} \quad Fr = \frac{V}{\sqrt{dg}} \quad \Delta P = \frac{\gamma QS_o}{Bd}
\]
Tumbling Flow Regime

$L = 72 \text{ cm} > 5L_x$ (Spacing Between Brush Bars)
Friction Factor

\[ f = \text{fun}\left( \frac{d}{h}; A_w; S_o; \text{Layout} \right) \]

\[ \frac{1}{\sqrt{f}} = c_1 (d/h) + c_2 \]

\[ A_w = 0.016 \]
Discharge Rating Curves

for $A_w = 0.016 \, \text{m}^2/\text{m}^2$
Velocity Field Around Brush Blocks
(Q=27 L/s, L=35 cm)

So=2%

So=6%
Velocity Field around Concrete Blocks

Top view of some flow characteristics around the simple habitat structures through the measurement area. Measurements were employed at central flow depths. (a) velocity vectors; (b) contour lines of vertical turbulence intensity: relative submergence=0.8, blockage ratio=0.6, q=0.8 m²/s (unit discharge)
Turbulent Kinetic Energy ($m^2/s^2$) Distribution Between Brush Bars, $L=35$ cm

So=2%

Plan View

So=6%

\[ \varepsilon = 0.168 \times \frac{k^{3/2}}{L} \]
Energy Dissipation: Vibration of Bristels

\[ St = \frac{fD}{V} \]
Thank you for your kind interest

Prof. Serhat Kucukali

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