TU Delft Delft University of Technology

22 juni 2016

Catalogue data tree trunk experiments

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Introduction

In this catalogue the measurements of the Bachelor End Project: *Bedprotection with tree trunks* (Translation: Bodembescherming met behulp van boomstammen) are presented. The measurements were done in a flume in the lab of Fluid Mechanics at the faculty Civil Engineering at the Technical University of Delft. First the used method is explained. After that the used bed and the diameters of the stones are shown. Then the models of the tree trunks are shown with their measured densities. Next the formations of the model tree trunks are shown after which the interpretation of the given files is explained (including the height of the Rehbockweir).

Method

The flow velocity was measured with a EMV (Electromagnetic Velocitymeasurer) with number E10 at every 0.01 s. At every 0.25 s a picture of the formation of the model tree trunks was taken. To know the critical flow velocity (the velocity at which the structure becomes instable), it is important to know which velocity belongs to which picture. This was registered by the measuring PC. The starting time (actual time) of the measurements of the flow velocity was registered and the actual time at which the pictures were taken was registered(see properties>date modified). With this being done, it was possible to determine the critical flow velocity.

The formation of the model tree trunks was placed in the flume on a bed that consists of stones (see section Bed). The flume has a width of 0.20 m and the retour flume has a width of 0.24 m. The EMV was placed at 0.10 m in front of the formation and at 3.5 cm above the bed. When the model tree trunks were placed, the tap of the flume was closed and the water level was above the model tree trunks. Then the tap of the flume was opened slowly so the flow velocity was able to increase. Next, the velocity measurements were taken and the camera was turned on. These two measurements were taken until failure of the structure. After this, the process was repeated two times. When the measurements of the flow velocity in front of the structure had finished, the measurements of the flow velocity after the structure (also at 0.10 m) were taken. This was also done three times.

Bed

In this section the diameter of the stones of the used bed is determined.

Table 1 Diameter stones

	Number of stones	Volume [ml]	Volume (V) one stone [m^3]	Diameter(d_n) [m] $d_n = \sqrt{V}$
Large stones	52	450-355 = 95	1,82692E-06	0,012224753
Small stones	30	472,50-450 =22,5	0,00000075	0,0090856
Large and small	82	472.50-355 = 117,5	1,43 E-06	0,011274

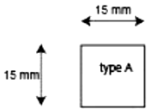
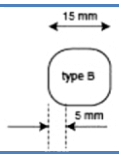
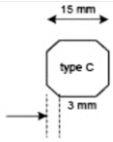
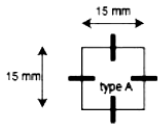
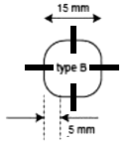
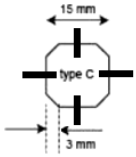
Figure 1 The small and large stones of the bed

Figure 2 Bed with the modeltreetrunks

Model tree trunks

The cross section of the tree trunks varies. Type 1 cross sections have no branches and type 2 cross sections do. Between A, B and C the corners of the cross sections vary. Type A has a squared cross section, type B has curved corners and type C has edged corners. All tree trunks have a length of 18 cm. For every type the density was measured.

Table 2 Types of cross sections and their densities

Type	Cross section	Mass of 5 tree trunks (g)	Mass of 1 tree trunk (g)	Volume of 3 tree trunk (ml)	Volume of 1 tree trunk (ml)	Density= Mass/Volume (kg/m^3)
A1		273.69	54.738	490-355 =135	45	$1.22*10^3$
B1		257.36	51.472	492-365 = 127	42.333	$1.22*10^3$
C1		250.72	50.144	453-330 = 123	41	$1.22*10^3$
A2		284.62	56.924	480-341 = 139	46.333	$1.23*10^3$
B2		269.43	53.886	502-370 = 132	44	$1.22*10^3$
C2		268.30	53.66	490-360 = 130	43.333	$1.24*10^3$

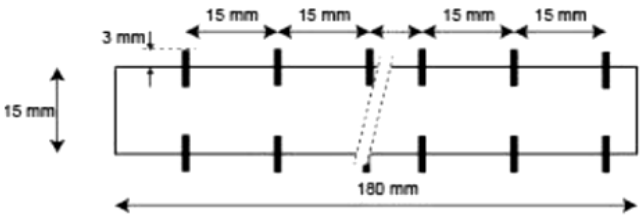


Figure 3 Length of the tree trunk with braches

Formations of the tree trunks

In this section the formation of the tree trunks that were tested are shown. For all tests, except for the tests with different cross sections, cross section A1 is used.

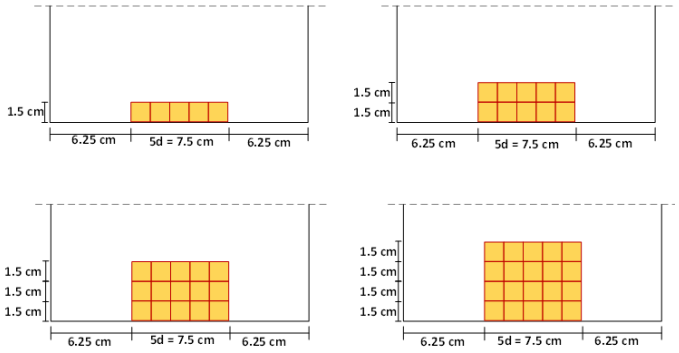


Figure 4 Variable P001: the number of layers varies from 1 up and until 4

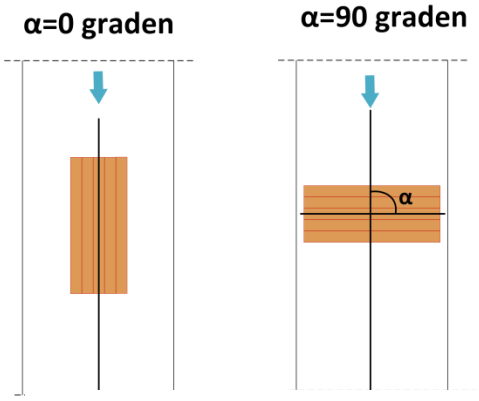


Figure 5 Variable P002: The orientations varies: one orientation parallel to the flow and one orientation perpendicular to the flow

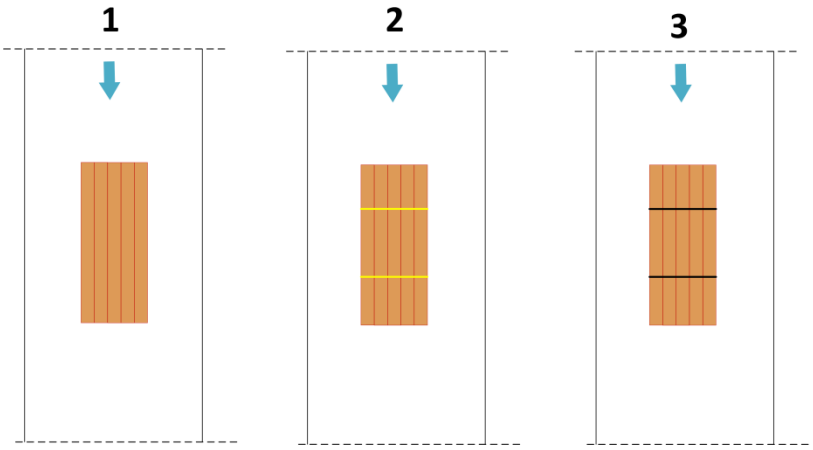


Figure 6 Variable P003: The connections between the treetrunks varies: no connection, two connections with ropes and two connections with tyribs

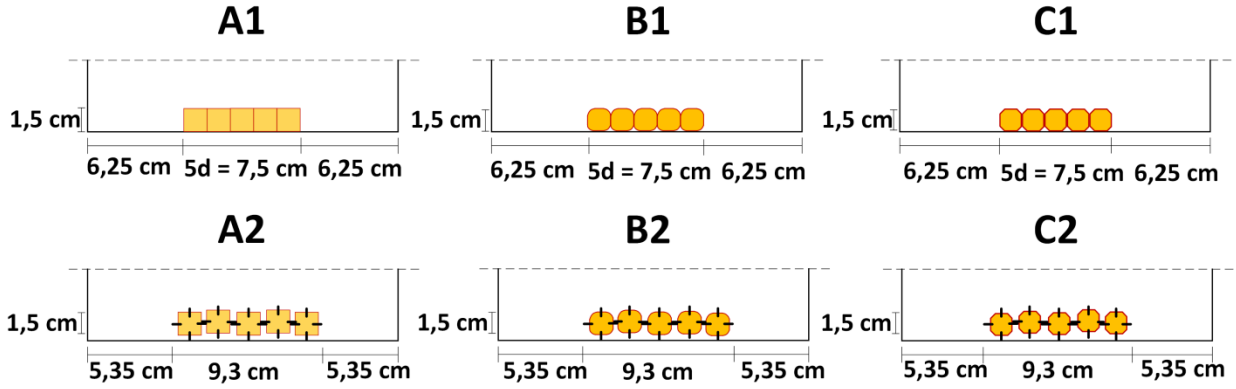


Figure 7 Variable P004: The cross section of the tree trunks varies

The files

In this section there is explained how to read the filenames and how to interpret the data.

Filenames explained

In table 3 it is explained how the filenames can be read. Every filename consists of five parts that are all shown in the table.

table 3 explanation of the filenames

Tested variable	
P001	The number of layers
P002	The orientation of the structure relative to the direction of the flow
P003	The use of connections
P004	The type of cross section
Pcom	Combination of multiple variables
1/2/3/4	The number of layers
0/90	The angle between the length of the structure and the direction of the flow
to/tr	Tree trunks are connected with two pieces of to = rope/ tr = tyrib
A1/A2/B1/B2/C1/C2	The type of cross section
B2+to	Cross section B2 and connection with two ropes
1	This value shows the number of tests that have been executed with the same formation.
a	The EMV is placed after the structure
b	The EMV is placed in front of the structure
s	File where the standard deviation is included and where the velocity and the standard deviation are scaled from Volt to m/s

For example:

P00123b: The first variable (the number of layers) is tested. It is the second formation, this means the structure consists of two layers and it is the third measurement of this formation that has been executed. The EMV is placed in front of the structure.

P002902b: The second variable (the orientation) is tested. The tree trunks are placed at an angle of 90 degrees relative to the direction of the flow. It is the second measurement and the EMV is placed in front of the structure.

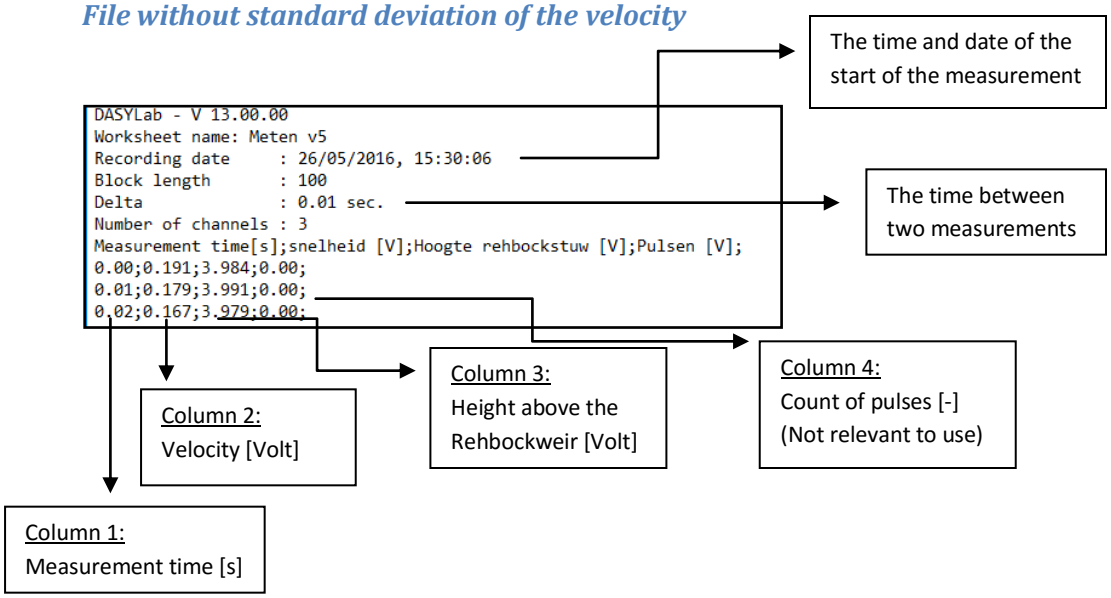
P003to2a: The third variable (the use of connections) is tested. The tree trunks are connected with two ropes, it is the second measurement of this formation and the EMV is placed after the structure.

P004C23a: The fourth variable (the type of cross section) is tested. The tree trunks are of cross section C2, it is the third measurement of this formation and the EMV is placed after the structure.

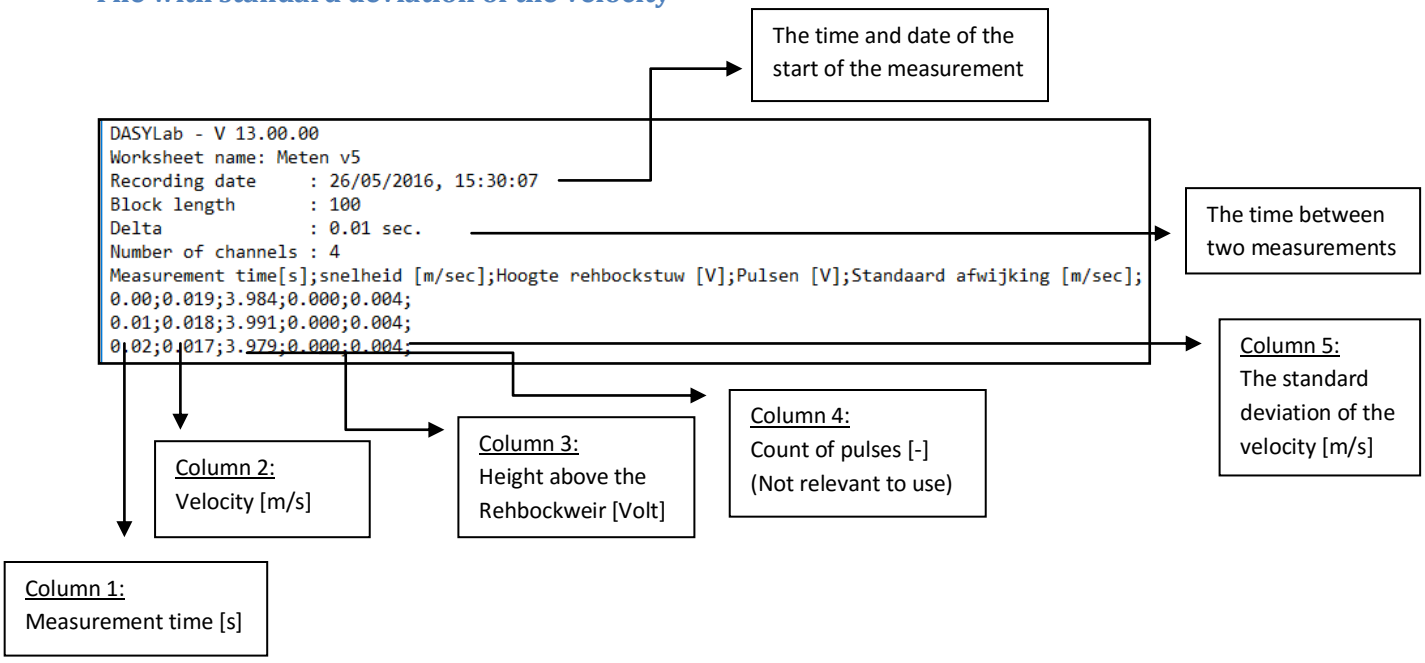
Interpretation of the files

Every measurement has two files, one without standard deviation and one with the measured standard deviation. The files with standard deviation have a filename that end with the letter s.

File without standard deviation of the velocity



File with standard deviation of the velocity



The velocity in Volt can be scaled to a velocity in m/s by multiplying with 0,1. The height above the Rehbockweir (h_k) can be scaled with the following formula:

h_k = 37,59 * U -146,20 (1)

Where h_k = The height above the Rehbockweir in meters

U = The height above the Rehbockweir in Volt

Temperature

At the beginning and at the end of every experiment the temperature of the water in the flume is measured. In table 4 the temperatures are given.

table 4 Measured temperature of every experiment

Filename	T before[℃]	T after [℃]
p00113b	21	20
p00114b	20	20
p00115b	20	20
p00111a	20	20
p00112a	20	20
p00113a	20	20
p00121b	20	20
p00122b	20	20
p00123b	20	20
p00121a	20	20
p00122a	20	20
p00123a	20	20
p00131b	20	20
p00132b	20	20
p00133b	20	20
p00131a	20	20
p00132a	20	20
p00133a	20	20
p00141b	20	20
p00141a	20	20
p00142a	20	20
p00143a	20	20
p00144a	20	20
p002901b	22	22
p002902b	22	22
p002903b	22	22
p002902a	22	22
p002903a	22	22
p002904a	22	22
p003tr1b	22	22
p003tr2b	22	22
p003tr3b	22	22
p003tr4b	22	22
p003tr1a	22	22
p003tr2a	22	22
p003tr3a	22	22
p003to1b	22	22
p003to2b	22	22
p003to3b	22	22
p003to4b	22	22
p003to5b	22	22
p003to1a	22	22
p003to2a	22	22
p003to3a	22	22
p004B14b	21,5	21,5
p004B15b	21,5	21,5
p004B16b	21,5	21,5
p004B11a	21,5	21,5
p004B12a	21,5	21,5
p004B13a	21,5	21,5
p004C11b	21,5	21,5
p004C12b	21,5	21,5
p004C13b	21,5	21,5
p004C11a	22	22
p004C12a	22	22
p004C13a	22	22

p004A21b	22	22
p004A22b	22	22
p004A23b	22	22
p004A22a	22	22
p004A23a	22	22
p004A24a	22	22
p004B21b	22	22
p004B22b	22	22
p004B23b	22	22
p004B21a	22	22

p004B22a	22	22
p004B23a	22	22
p004C22b	21,8	21,8
p004C24b	21,8	21,8
p004C25b	21,8	21,8
p004C26b	22	22
p004C22a	22	22
p004C23a	22	22
pComB2+to1b	22	22
pcomB2+to2b	22	22

Velocity based on height above the Rehbockweir

Beside the velocity of the flow, the height above the Rehbockweir (h_k) was measured for every experiment every 0.01 s. The Rehbockweir is located at the end of the retour flume. The measurements were done to make it possible to determine the specific discharge in the flume. This can be done with the following formulas:

$$q_{retourflume} = m' \frac{2}{3} h_e \sqrt{\frac{2}{3} g h_e} \quad (2)$$

$$m' = 1.045 + 0.141 \frac{h_e}{a} \text{, where a=0.25 m} \quad (3)$$

$$h_e = h_k + 1.1\ mm \quad (4)$$

$$\boxed{q_{flume} = \frac{q_{retourflume} * b_{retourflume}}{b_{flume}}} \quad (5)$$

With this information and if the water level is known, the flow velocity (average over depth) can be determined (see formula 5). The water height is visible in the photographs because a measuring tape was placed in front of and after the structure.

$$u = \frac{q_{flume}}{h} \quad (6)$$