OPERATING INSTRUCTIONS

04.32 BED-LOAD TRANSPORT METER TYPE ARNHEM

Contents

On these operating instructions

☞ **If the text follows a mark (as shown on the left), this means that an important instruction follows.**

⚠ **If the text follows a mark (as shown on the left), this means that an important warning follows relating to danger to the user or damage to the apparatus.**

1. General description

This sampler is used to measure bed-load of coarse sand and fine gravel in rivers and other watercourses. The streamlined sampler is mounted in a frame and consists of a mouth followed by a basket of fine wire meshing (width of the mesh 300 μm).

The sharp decrease of the velocity in the wide sampling chamber causes the sediment material to settle there.

A tail fin mounted on the frame keeps the sampler in up-stream direction.

The results of the measurements are influenced by the shape of the bed (ridges, dunes, flat beds, etc.).

For a successful measurement knowledge of the relief of the bed is essential. The sampler can be discharged on board using the sample trough.

The set comprises: the sampler, the frame, measuring glasses, sample trough and spare parts.

1.1 Principle

A frame mounted sampler is pressed on the riverbottom by a leaf spring. Behind the mounth of the sampler, opening 0.085 x 0.05 m², is a basket of fine wire meshing. The form of the basket causes a low pressure behind the instrument so that water and transported bed material enter the mouth with the same velocity as if in undisturbed flow.
The bed material particles which are too coarse to pass the meshing are caught.

1.2 Characteristics

Dimensions:
Max. length of frame and rubber	1.85 m
Max. width of frame	0.81 m
Max. height of frame	0.42 m
Length of basket	0.53 m
Max. width of basket	0.15 m
Length of trough	0.75 m
Width of trough	0.53 m
Height of trough on frame	0.78 m

Weight:
frame + rudder + basket =	32 kg
trough + frame =	22 kg

Measuring range:
Material coarser than 300 μm (theoretical value of the meshes) and finer than 5 mm.

Accuracy:
With frequently repeated measurements the order of magnitude of material transport can be established. However, it should be realized that the figure obtained depends greatly on the position of the sampler in the bed form (ripples, dunes, plain bed, etc.). This implies a careful scheming of the measurements, while the results are best evaluated by comparing with results of observations under different flow conditions.

Advantages:
Robustly built for handling in the field.

Limitation:
Instrument must be handled by a davit or derrick due to its weight and dimensions.

2.   Introduction

Bedload transport is difficult to measure. Since the development of the Bedload Transport Meter Arnhem (BTMA) in 1936 and the Zurich calibration (1937) large numbers of measurements have been carried out including calibrations by the Delft Hydraulics Laboratory. Since 1936 considerably more insight is obtained into the mechanism of bedload transport and consequently into the way of measuring it.

3.   Description of the instrument

The instrument consists of a sampling body suspended from a frame by six brass chains and a stainless steel leaf spring (see also figure).
The brass sampling body has a streamlined shape and has been dimensioned in such a way, that the amount of water entering the mouth is equal to the quantity that would pass a corresponding cross section when the instrument would not be present.
The mouth is a rectangular metal pipe with a length of 0.04 m and internal dimensions of 0.050 m high and 0.085 m wide. This is connected with the actual sampling body by gradually diverging flexible tube with a length of 0.12 m, attached to the body by another rectangular metal pipe with a length of 0.021 m and internal dimensions of 0.071 m high and 0.102 m wide.

The cross section of the sampling body rapidly increasing to a height of 0.093 m and a width of 0.150 m decreases the mean velocity, which enables the sampled material to settle.
The remaining 0.30 m of the body consists of fine monel gauze, converging up to the end, which is formed by a brass tail piece with emptying plug.
A zone of low pressure surrounds the monel gauze part of the body and stimulates the velocity of the effluent water.
Bed material which is too coarse for the mesh to pass remains in the sampling body. The 51-mesh gauze has wires of 200 µm and openings of about 300 µm.
Therefore it is evident that the sampler is not suited for very fine material, which would soon clog the meshes.

The frame is constructed of steel (see figure 4 on page 7), consisting of two symmetrical halves to which a rudder may be attached. The purpose of the rudder is to keep the mouth perpendicular to the flow direction.
The rudder is fitted with a curved plate to rest on the bed. The legs are also fitted with supporting plates.
The apparatus is lowered to the bed by means of a steel cable attached to the lever arm.
The lever can move up and down although the upward movement is limited. When the frame is hoisted up or lowered, the lever is in the upwards position. When the frame rests on the bottom the lever will move towards its downward position allowing the mouth to sink with a reduced speed.
A leaf spring connects the halves of the frame, halfway supporting the mouth of the sampler.
From the foregoing description it is evident that the mouth of the sampler does not touch the bed before the three supports of the frame rest on the bed and the cable is fully released. Moreover a flexible double leaf spring connects the sampler mouth with the big leaf spring. All these provisions make it possible for the position of the mouth to be adapted to the contours of the bed.

# 4.	Mechanism of bed-load transport

## 4.1	General

Usually ripples or dunes are present at the riverbed. Therefore bedload transport fluctuates locally and temporarily.
In the trough of a dune the local transport is almost zero, whereas at the crest the transport is 2, 4 or more times the average transport. As the bedform is propagated relatively slowly the "period" of a bedwave is large.
Much larger than the two minutes measuring time which is standard for an individual BTMA observation.

## 4.2	Random sampling

When the BTMA is lowered at the riverbed, then its position with respect to the bedform can not be controlled nor measured accurately.
Depending on the depth and flow velocity the BTMA reaches the bed somewhere in a reach.

Two cases do now exist.
1.	If this reach L is large with respect to the length of the bedwave (λ), so if L is larger or equal λ, then random sampling is reached also when the survey vessel has a fixed position (fig. 1a).
2.	In all other cases random sampling is not obtained from an anchored vessel but only if the vessel takes a different position at each individual observation. (fig. 1b)

☞	**From this follows that a succesful measuring scheme with the BTMA requires a longitudinal sounding in order to get informed about the bedform present.**
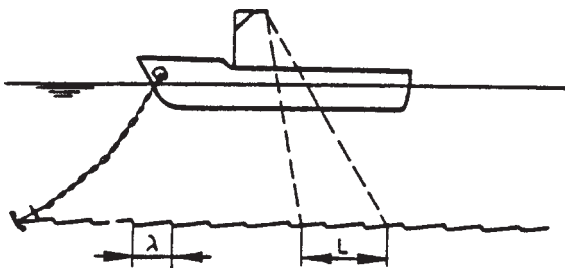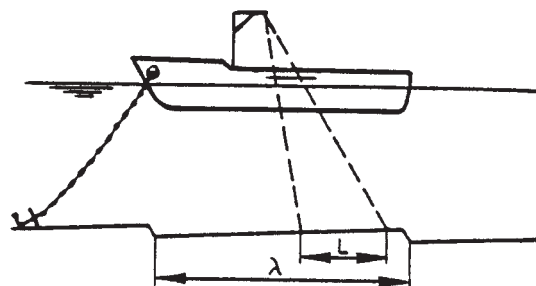

Figure 1a

Figure 1b

## 4.3	Calibration and accuracy

According to calibration the BTMA has an efficiency of 50%.
This means that the transport in the measured zone of the stream (i.e. to a distance of 0.05 m from the bed is two times higher than follows straight forward from the catches.

The instrumental error in the individual observation can be estimated at ± 30%.

However, the error due to the restricted number of observations (i.e. originating from the phenomenon) can be larger.
This sampling error amounts to (for random sampling).
for 10 observations sampling error ± 30%
for 20 observations sampling error ± 20%
for 100 observations sampling error ± 9%

5. Measuring procedure

The clean instrument is lowered from a vessel (sometimes from a bridge). The instrument has to be lowered slow enough to be sure that the frame gets its right position compared with the current.
The emptying of the instrument can be carried out in the trough. Squirt the inside of the sampler by means of a deck wash. The catch is measured volumetrically.

6. References

Calibration of BTMA (in Dutch), Report M601-I, Delft Hydraulics Laboratory, 1958, The Netherlands

Development of Bed Load Samplers (in Dutch), Report M601-II, Delft Hydraulics Laboratory, 1966, The Netherlands

Calibration of Bed Load Samplers (in Dutch), Report M601-III, Delft Hydraulics Laboratory, 1969, The Netherlands

On Measuring Discharge and Sediment Transport in River Flow, Vries, M. de, 1973, Delft Hydraulics Laboratory, Publication No. 106, The Netherlands

New Approach to Calibrating Bed Load Samplers, Hubbell, D.W., Stevens, H.H., Skinner, J.V. and Beverage, J.P., 1985, Journal of Hydraulic Engineering, Vol. 111, No. 4

TOP VIEW

FRONT VIEW

SIDE VIEW

1. WIRE MESH SAMPLER   2. SAMPLER MOUTH   3. TAIL   4. FRAME
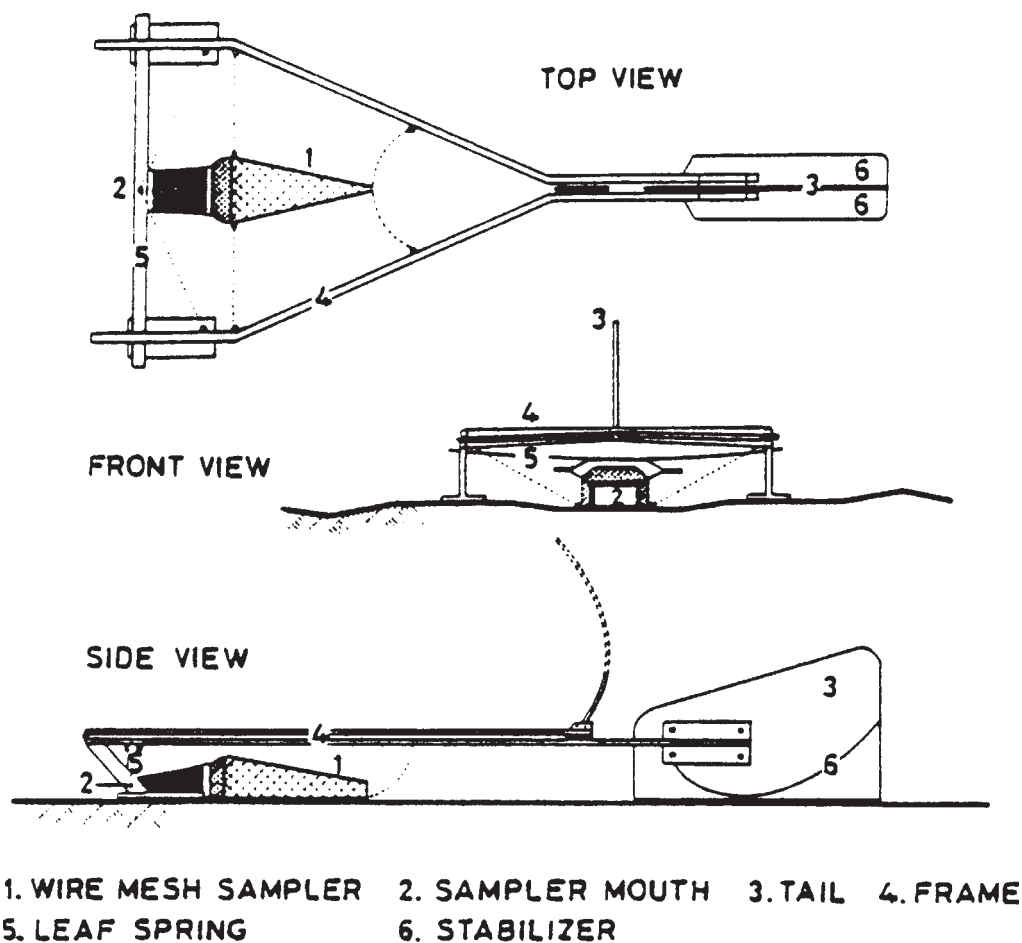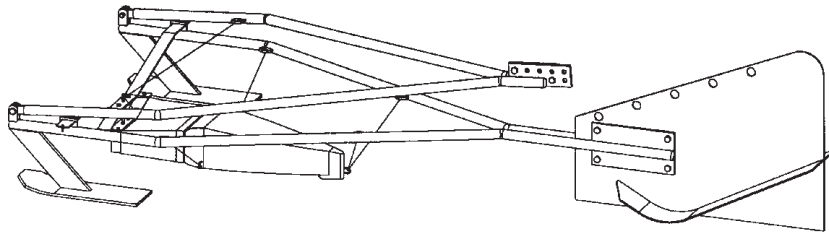5. LEAF SPRING   6. STABILIZER

Figure 2   Overview bed-load tranport meter type Arnhem
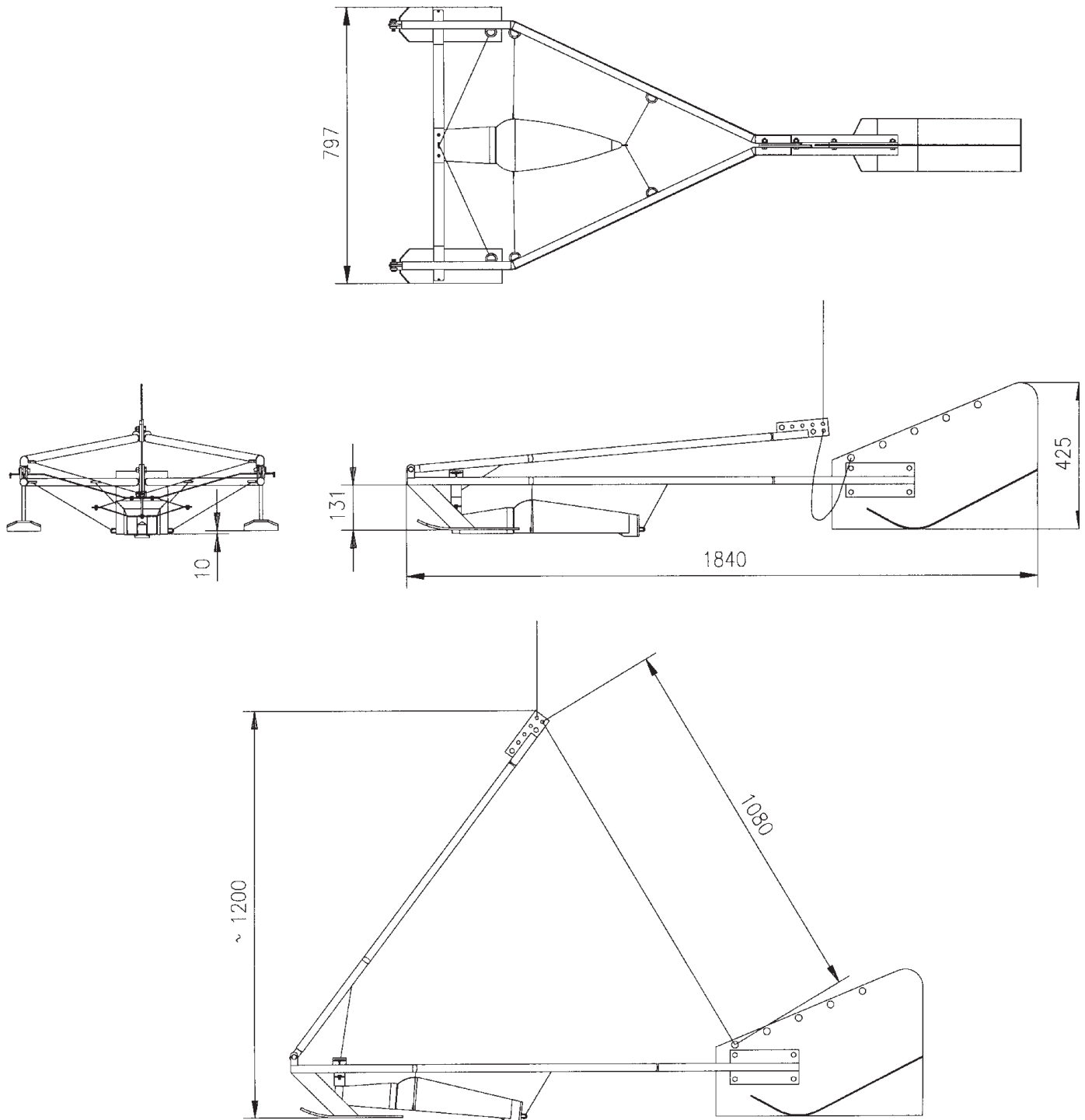
dimensions in mm
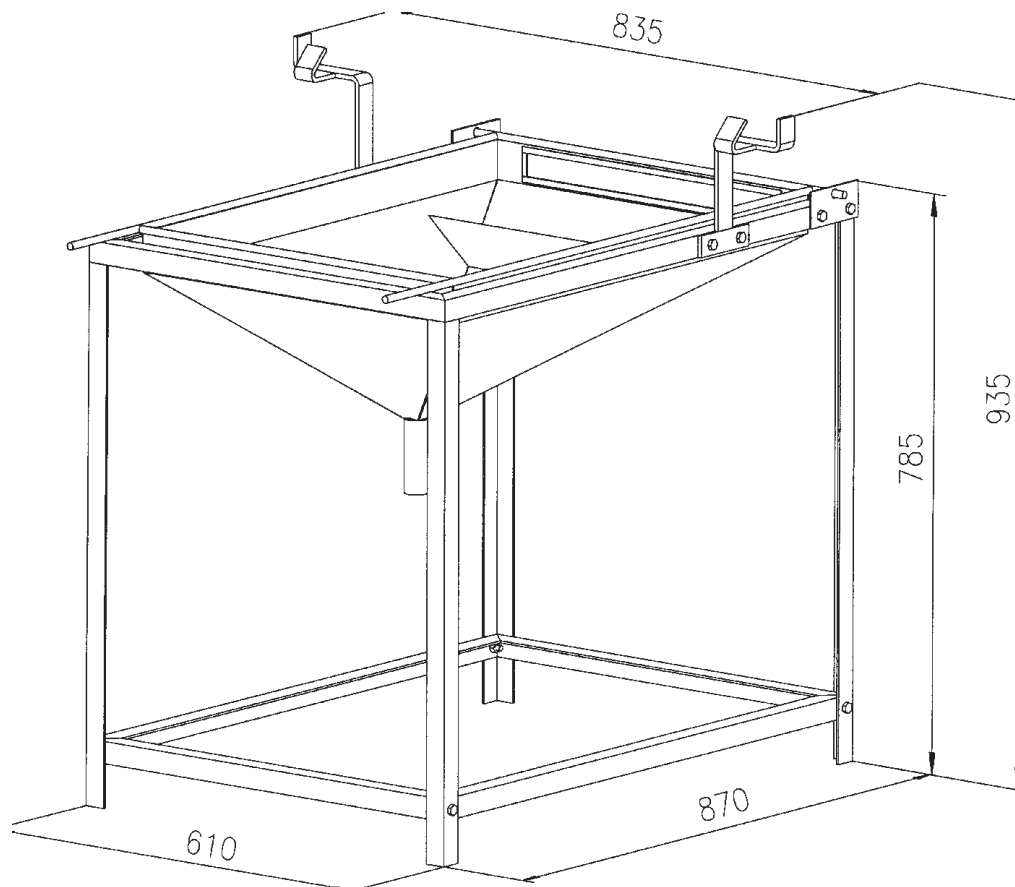
Figure 3   Dimensions bed-load tranport meter type Arnhem

Figure 4   Dimensions frame bed-load tranport meter type Arnhem

Bed Load Sampler   Delft Hydraulics Laboratory

Location	•	
Date	•	
Survey vessel	•	
Observer	•	
Weather	•	
Wind speed	•	m/s
Wind direction	•	
Wave height	•	m

Water temperature	•	°C
Instrument type	•	
Opening width	•	m
Correction factor	•	
Porosity factor	•	
Sediment density	• .	kg/m^3

Local time (hours)	Sample no.	Water depth (m)	Sampling period (min)	Sediment catch immersed volume (cm^3)	Sediment catch dry weight (kg)	Sediment catch bed load (kg/ms)	Particle size D_{10} (µm)	Particle size D_{50} (µm)	Particle size D_{90} (µm)	Remarks

Figure 5   Example of maesuring form for bed load transport meter type Arnhem