Equipment for Engineering Education

Experiment Instructions

HM 160.29 Adjustable Undershot Weir

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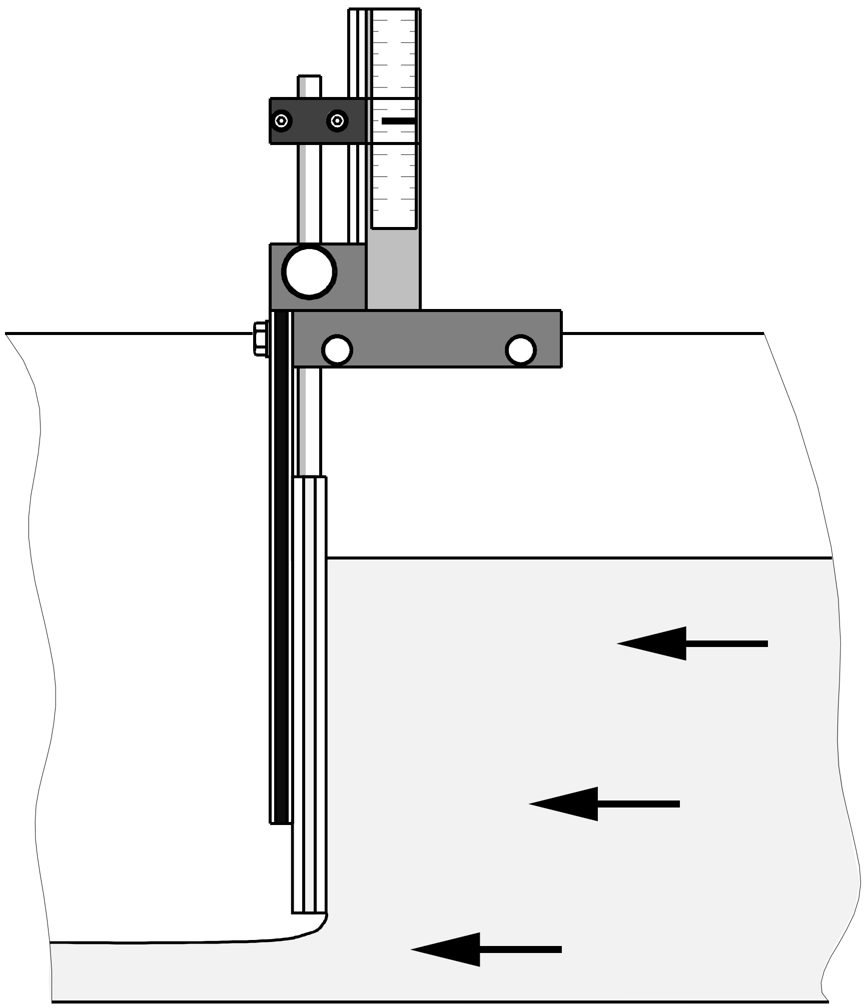
HM 160.29 Adjustable Undershot Weir for Multi-Purpose Teaching Flume



Experiment Instructions

Please read and follow the safety comments before the first installation!

This apparatus is ment to be used only for Education, Teaching or Research.

Publication.no: 917.00029A160 12 02/97

Table of Contents

HM 160.29 Adjustable Undershot Weir for Multi-Purpose Teaching Flume

1 Introduction

The **HM 160.29 adjustable undershot weir** accessory unit**,** in combination with the HM 160 multi-purpose teaching flume, aids the investigation of flow conditions on a sluice weir. The sluice weir is adjustable across a broad range. A scale with mm units precisely shows the set height of the outflow opening.

The sluice weir is mounted at any point on the side walls of the HM 160 flow channel. Fixing screws ensure secure positioning of the sluice weir even under severe water pressure or in case of extreme inclination of the flow channel.

The accessory unit is made of corrosion-proof, black anodised aluminium. It is of robust construction and thus extremely well suited to day-to-day use.

The unit is designed for use in conjunction with the HM 160 multi-purpose teaching flume, and it can be used to investigate the following **topics**:

- Outflow processes under a sluice weir
- "Migration" of sheath rollings
- Hydraulic jumps in open waterways
- Hydrostatic pressure on a weir

2 Unit description

The **HM 160.29 adjustable undershot weir accessory unit** is designed for installation in the HM 160 multi-purpose teaching flume. The height of the outflow cross-section is adjustable, and is displayed on a scale in mm units.

2.1 Components

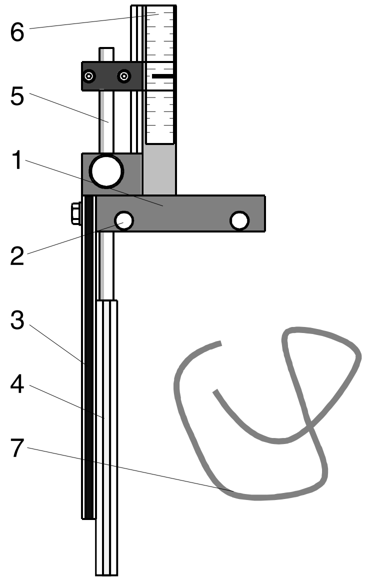


Fig. 2.1

The adjustable undershot weir comprises the following components:

- **Holder plate** (1) with **fixing screws** (2) and **steadier** (3)
- Movable **sluice weir** (4) with **guide rod** (5) and **scale with mm units** (6)
- **Plastic sealing tube** (7)

2.2 Assembly

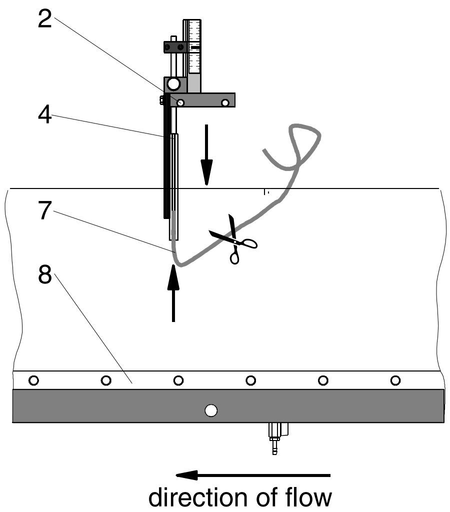


Fig. 2.2

- Insert the plastic sealing tubes (7) in the two grooves on the sluice weir (4); shorten them as necessary
- Mount the sluice weir from above onto the side walls of the laboratory flow channel (8) (pay attention to direction of flow!)
- Secure the sluice weir in position by tightening the plastic fixing screws (2)

Important! Do not perform the assembly when water is flowing, to prevent screws and sealing tubes from being swept away by the flow.

2.3 Function

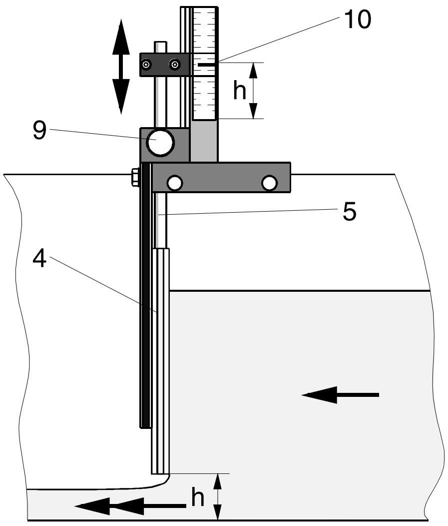


Fig. 2.3 Moving the sluice weir

The sluice weir (4) is movable by means of a guide rod (5). This enables setting of freely adjustable outflow cross-sections in a range 0- 80 mm:

- Slightly loosen the knurled screw (9)
- Move the weir (4) together with the guide rod (5) to the desired position
- Retighten the knurled screw

The height h of the outflow cross-section can be read from the scale underneath the black marking (10) of the plastic lug.

3 Safety

3.1 Protection of the unit

ATTENTION

- **IMPORTANT! After assembly or disassembly do not leave any tools or tubes lying in the flow channel!**
  They will be swept away by the flow and may get into the pump!

ATTENTION

- **IMPORTANT! Do not perform assembly and disassembly when water is flowing!**
  Screws or the like may be swept away by the flow and get into the pump.

ATTENTION

- **IMPORTANT! Before moving the sluice weir loosen the fixing screws!**
  The Plexiglas panels may be scratched.

ATTENTION

- **IMPORTANT! Always tighten the fixing screws firmly!**
  The sluice weir may be moved by the water pressure and damaged.

4 Theory and experiments

4.1 Categorisation of weirs

Weirs can be categorised as **fixed weirs** and **movable weirs**. Movable weirs are used whenever as constant a head water level as possible is required, and when a certain height of damming must not be exceeded with the highest of high waters.

In the case of rivers with heavy bed load, a movable weir may be used in addition to a fixed weir, to prevent bed load colmation upstream of the fixed weir and to be able to conduct the bed load into the downstream water.

The sluice weir dealt with here is a movable weir. In terms of its function, the weir is a **sluice**, i.e. the water does not flow over it, but **under it**.

4.2 Features of a sluice weir

The sluice weir is a relatively simply constructed, and so economical, type of weir. In its simplest form, it consists of beams (1) aligned transverse to the flow which are borne in U-shaped locators (2) on the pillars or abutments, and which absorb the water pressure (slide gates).

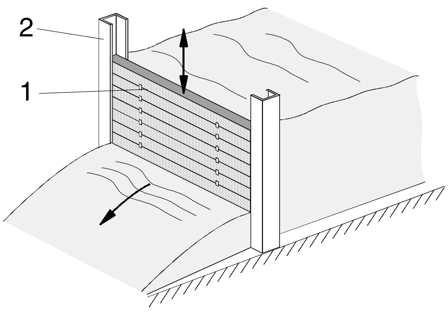


Fig. 4.1 Actual sluice weir

The sluice weir can be raised, and the water flows under it. Bed load can thus be transported away without substantial loss of water, in contrast to overfall weirs. Side sealing is not usually necessary, because the water pressure presses the weir onto the sliding surface of the side locators, i.e. the sluice weir seals itself.

Unfortunately, the water pressure creates severe friction in the locators when the sluice weir is moved; the result is high suction force. Design modifications can be made to reduce the friction, and special forms of sluice weir (Stoney sluice, dual sluice etc.) are created.

If the entire height of the raceway is to be opened up, the sluice weir must be drawn a very long way up, requiring an extremely high structure.

4.3 Outflow under a sluice weir

Because the sluice weir is of great importance in water engineering, researchers have investigated the hydraulic conditions in great detail.

Firstly, qualitative features are to be demonstrated. When the sluice weir is opened the water runs out through a gap, and a so-called **base stream** is created. If there is no damming, and so the outflow rate is not influenced by the downstream water, a **complete base stream** occurs (Fig.4.2), in the same manner as a complete overfall.

When the downstream water is dammed, an **incomplete base stream** occurs.

The most interesting aspect is that, shortly after passing through the outflow opening, a **stream contraction** $\delta \cdot s$ with gap height s is produced, which then disappears again in the subsequent run of the stream. The contraction is greater the smaller the gap height s in relation to the water level h in the head water. The contraction influences the outflow rate: the greater the contraction, the lower the outflow rate of the sluice weir.

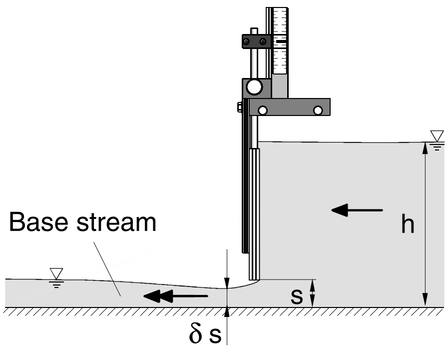


Fig. 4.2 Undeflowed sluice weir

In the case of the base stream the water emerges from the sluice weir in a **shoot**, before transforming into a flowing discharge in the form of a hydraulic jump with sheath rolling.

4.4 Water pressure calculation

The water pressure acting on the sluice weir generates a counterforce on it. The size and position of this counterforce is to be ascertained for the **complete base stream** (without damming).

The flow speed of the water is usually quite low, so the inherent **impetus** in the water is ignored.

4.4.1 Amount of counterforce

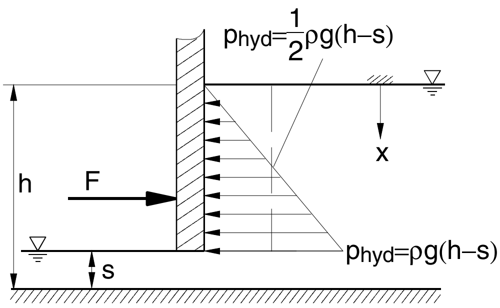


Fig. 4.3 Counterforce onto the sluice weir

The water pressure acts on the sluice weir as hydrostatic pressure p_{hyd} and is a **linear** functon of the water level x. The pressure distribution on the body of the weir from the upper water level h to the bottom edge s is produced as

$$p_{hyd} = \rho \cdot g \cdot x \tag{4.1}$$

and corresponds to a delta shape. The hydrostatic pressure determined by way of the weir height is thus

$$p_{hyd} = \frac{1}{2} \cdot \rho \cdot g \cdot (h-s) \tag{4.2}$$

with

- ρ - Density of water (=1 kg/dm^3)
- g - Acceleration due to gravity (=9.81 m/s^2)
- b - Width of the sluice weir

p_{hyd} acts on a surface area A of

$$A=(h-s) \cdot b \;. \tag{4.3}$$

The resulting counterforce F is then

$$F = p_{hyd} \cdot A = \frac{1}{2} \cdot b \cdot \rho \cdot g \cdot (h-s)^2 \tag{4.4}$$

Example:

Measured values with Q=5.9 m^3/h flow:

h=117.5 mm
s=30 mm
b=86 mm

The counterforce F is calculated as

$$F = 3.2 \text{ N} .$$

4.4.2 Position of counterforce

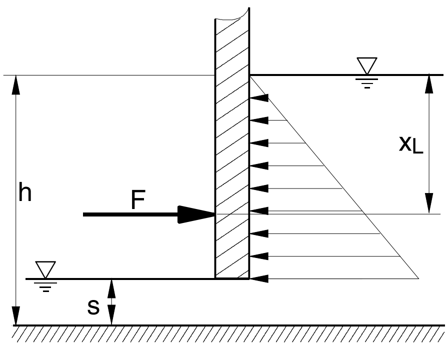


Fig. 4.4 Position of the counter-force

Application of a balance of moments between the water pressure and the counterforce shows that the counterforce F leads through the **area centre of gravity** of the pressure distribution delta as per Fig. 4.3 (the derivation is not shown here). In the case of a delta it is **2/3 of the overall height**:

$$x_L = \tfrac{2}{3} \cdot (h - s) \qquad (4.5)$$

4.5 Indications of additional experiments

We **recommend using the HM 160.52 level gauge** for precise gauging of water levels!

- Damming in the downstream water: Interesting observations can be made by creating a dam in the downstream water. An incomplete base stream under the sluice weir can then be observed.

5 Appendix

5.1 Technical data

Material:	Aluminium alloy, black anodised	
Dimensions: (L x W x H)	130 x 120 x 400	mm
Opening range:	0-80	mm
Scale:	0-80	mm
Accuracy:	1	mm