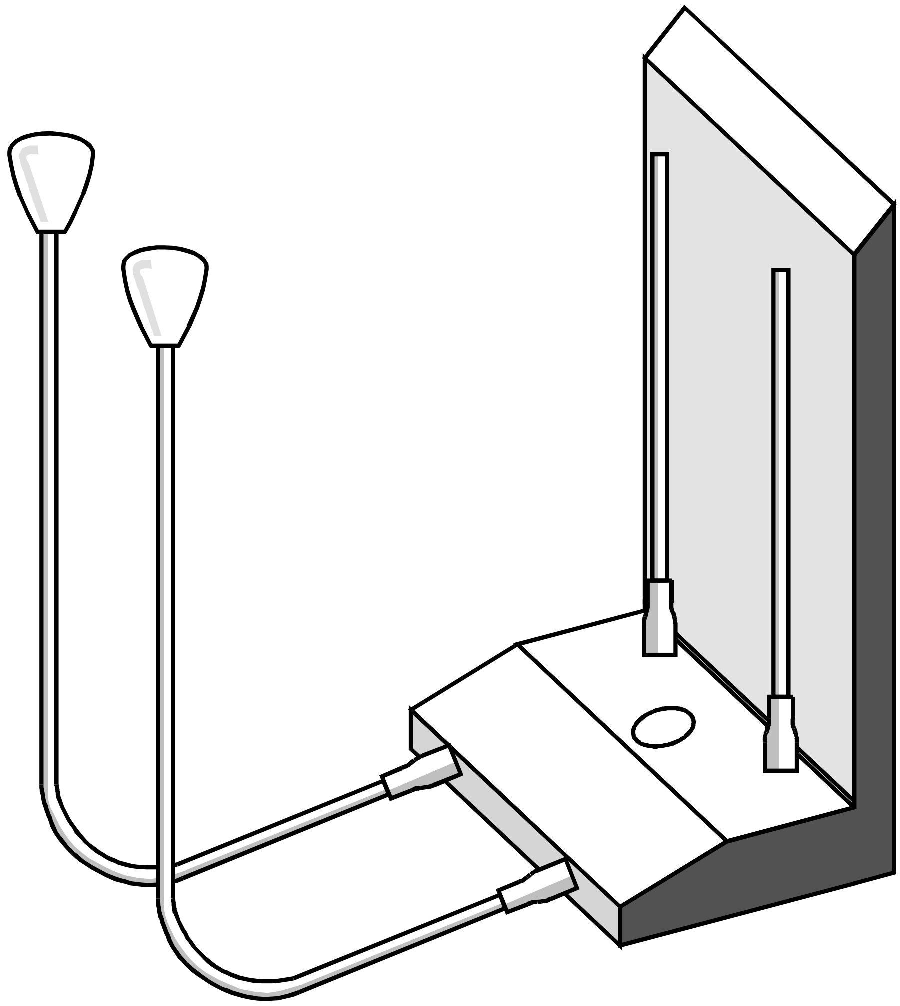
Experiment Instructions

HM 160.30 Overshot Weir for Teaching Flume

HM 160.30 Overshot 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.

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HM 160.30 Overshot Weir for Multi-Purpose Teaching Flume

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1 Introduction

The **HM 160.30 overshot weir** accessory unit is used to demonstrate the hydraulic processes in weir and dam installations in connection with overflow weirs (complete overflows), but can also be used to observe the processes occurring in overflowed underwater weirs (incomplete overflows). Reproducible experiments of a qualitative and quantitative nature can be performed.

The overshot weir consists of a square-edged panel weir with internal ventilation. The internal ventilation is provided by brass tubes, which can also be closed off in order to demonstrate an non-ventilated overflow.

The HM 160.30 overshot weir accessory unit is designed for installation in the HM 160 multi-purpose teaching flume.

The following **topics** can be covered with the accessory unit:

- Outflow processes on the ventilated and non-ventilated overflow
- Flow rate measurement on the measuring weir
- Signs of detachment on the square-edged weir
- Flow rates from a underwater weir

2 Unit description

The **HM 160.30 overshot weir accessory unit** is designed for installation in the HM 160 multi-purpose teaching flume.

It is an ventilated weir with a horizontal edge. The ventilation is provided by sealable tubes. Caps can be used to close off the tubes and operate the weir as an non-ventilated weir.

2.1 Components

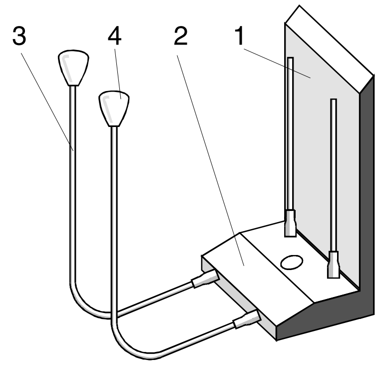


Fig. 2.1

The overshot weir comprises the following components:

- Square-edged **weir panel** (1)
- **Fixture** (2)
- **Ventilating tubes** (3)
- **Sealing caps** (4) for unaerated operation
- Hexagon socket screw M8 and sealing hose

2.2 Assembly

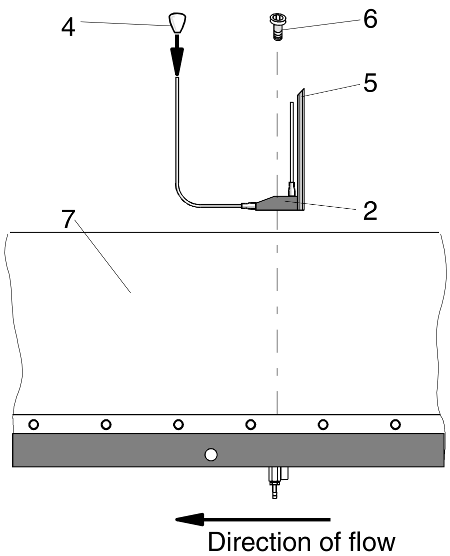


Fig. 2.2

- Insert the weir in the flow channel (7), paying attention to the direction of flow!
- Insert sealing hoses (5), shortened as appropriate, into the two grooves on the weir panel
- Secure the fixture (2) in the measuring holes of the channel bed with M8 hexagon socket screw (6)
- Fit the sealing caps (4) if required

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

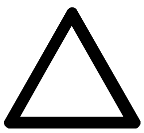
3 Safety

3.1 Dangers to life and limb

DANGER

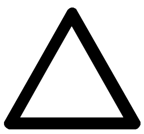
- **DANGER! Take care when handling the ventilating tubes!**
  There is danger of serious injury to the eyes!

3.2 Protection of the unit



ATTENTION

- **IMPORTANT Take care when handling the thin ventilating tubes!**
  They may be bent and thus rendered useless!



ATTENTION

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

4 Theory and experiments

As in the case of all G.U.N.T. instructions, the presentation of the theoretical background and possible experiments is intended as an incentive to encourage students, teachers or researchers to experiment and learn themselves. Accordingly, we make no claim to completeness, although we do of course consider the details given to be correct.

4.1 Terms

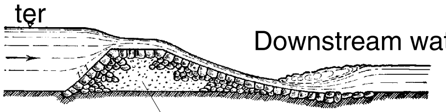


Fig.: 4.1

The term **weir or dam** r covers all installations in the bed of a water course intended to bring about an artificial raising of the head water level. **Upstream water** is the segment of the water course between the dam and the inlet; the segment downstream of the dam installation is termed the **downstream water**.

A barrier serving primarily to raise the head water level is termed a **weir**. If it is constructed to hold water and to compensate for the outflow, it is termed a **dam** or barrage.

4.2 Purpose of dams

- Increase water depth of the natural river course

This is primarily for the benefit of **shipping**, to provide sufficient water depth even at low water on the river. The speed of flow of the water is also reduced, which helps to conserve energy resources when travelling upstream.

Increasing water depth is, however, also necessary when taking out water, in order to attain a hydraulically favourable outflow cross-section (small width, large depth).

- Concentrate the natural river gradient at one point

This purpose is important wherever the natural gradient of the river is to be exploited for **power generation** (e.g. hydroelectric power stations, turbines) or draining off at a higher level is required for artificial irrigation.

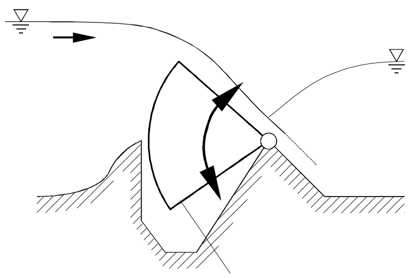
- Reduce fluctuation of the water level

If water is conducted away from the course of the river in artificial channels (e.g. for irrigation purposes), fluctuations in the natural water level are to be prevented from affecting the channels, in order to ensure the **amount of water removed** is kept as **constant** as possible. To this end, movable weirs or weir bodies aligned at an offset to the course of the river are usually used.

- High-water protection

Dams and barrages offer the possibility of equalising the seasonal fluctuations in flow of a river and storing surplus water (e.g. in reservoirs). This offers an effective protection against high water.

4.3 Weirs


Movable weir

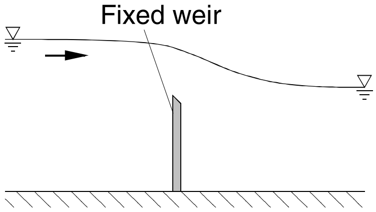
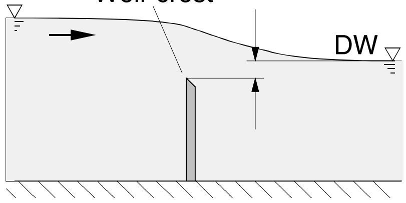


Fig.: 4.2



underwater weir (incomplete overflow)

overflow weir (complete overflow)

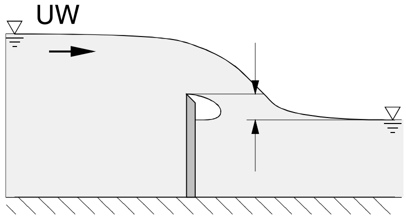


Fig.: 4.3

As already mentioned, the main purpose of a weir is to raise the upstream water level.

A distinction is made between a number of different kinds of weir. They can firstly be differentiated in terms of **design** as **fixed weirs** and **movable weirs**.

Fixed weirs are considerably cheaper and can be used where a possibly higher level of backpressure (at high water) in the upstream water does not harm the environment. Movable weirs must be used wherever precise and variable regulation of the upstream water level is decisive, and also wherever a certain water level must not be exceeded at the highest of high waters.

A further important differentiation between weirs is their classification according to the **height of the crest of the weir relative to the downstream water level**. A distinction is made between **overflow weirs** and **underwater weirs**.

Depending on the outflow volume, one and the same weir may in fact be of both categories. With a low outflow the weir acts as a overflow weir, but when the outflow is high it acts as an underwater weir, because as the outflow increases the water depth in the downstream water can rise much more quickly than in the upstream water.

In a overflow weir **complete overfall** occurs; in a underwater weir **incomplete overfall**.

4.3.1 Design of weir

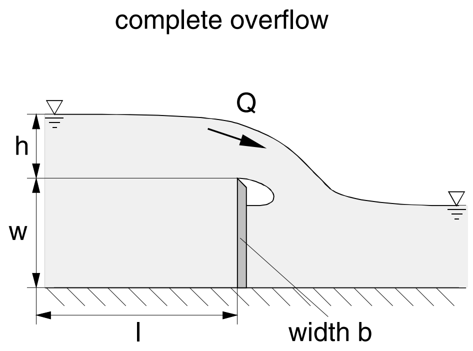


Fig.: 4.4

In an actual case, the decisive factor in constructing a **fixed weir** in a river course will be the overflow level h of the weir (always measured from the upstream water level). h must be measured at a sufficient distance l from the weir (l>4h). If the structure height w and the weir opening width b are fixed, the hydraulic calculation is reduced to the equation h = f(Q). The flow rate Q indicates the **efficiency of the overflow** at an overflow level h.

The efficiency of an overflow is impaired by dammed-up downstream water. Therefore, in designing an overflow a distinction must be made between complete and incomplete overflow.

For the complete overflow, neglecting the inflow speed in the upstream water, an overflow formula is produced which indicates the flow rate Q (estimation formula)

$$Q = \frac{2}{3}\mu b\sqrt{2g}\cdot h^{3/2} \qquad (4.1)$$

The symbols have the following meanings:

μ Overflow coefficient, dependent on shape of structure
(approx. $0.45<\mu<0.8$)

b Width of the weir (in m!)

g Acceleration due to gravity g=9.81 m/s^2

h Overflow height (in m!)

4.3.2 Measuring weirs

To ascertain the flow rate in a reproducible manner (they are, after all, only estimation formulae), the overflow coefficient, and thus the flow rate, are determined in the experiment with the aid of so-called **measuring weirs** . These are weirs with pre-defined geometries, such as deltoid or trapezoidal weirs, or also, as here, the panel weir with horizontal overfall edge.

To determine the overflow coefficient of any given weir, the overflow must first be calibrated using a flowmeter . Then, from a number of different measured values, an overflow coefficient can be determined for the weir in question.

A number of researchers have in the past ascertained the overflow coefficients of some measuring weirs, or have even determined approximation formulae for the flow rate.

4.3.2.1 Vented overfall

As early as around 1929, Rehbock had investigated square-edged **vented overflow** (Fig.4.5) u and determined the overflow coefficient. Based on an equivalent height h_E

$$h_E = h + 0.0011 \text{ (in m)} \qquad (4.2)$$

and the overflow coefficient

$$\mu = 0.6035 + 0.0813 \frac{h_E}{w} \qquad (4.3)$$

the flow rate can be determined as

$$Q = \frac{2}{3} \mu \, b \sqrt{2g} \, h_E^{3/2} \text{ . } [m^3/s] \qquad (4.4)$$

The prerequisite, however, is an even flow with no lateral effects and an absolutely horizontal overflow edge.

h and b must be given in m; the flow rate Q is produced in m^3/s.

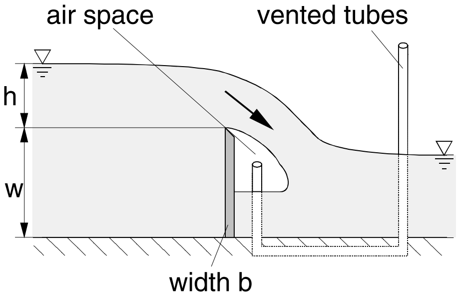


Fig.: 4.5

Why is an vented overfall needed?

In the cavity between the overflowing stream and the weir body (Fig.4.5) the air being dragged along forms an under pressure**.** This presses the stream more closely onto the weir and consequently, as a result of the dispersion and break-up of the stream, air is introduced again and a pressure equalisation occurs, which allows the stream to return to its natural position. The process begins all over again and a highly undesirable vibration of the weir locks is caused. To prevent this, it is therefore necessary to connect the area behind the stream with the outside air and thus establish a "vented stream".

The experiment can therefore use different flow rates to demonstrate these occurrences. For this, the two tubes protruding out of the water must be closed off using the caps.

4.3.2.2 Overfall coefficient of a vented overflow

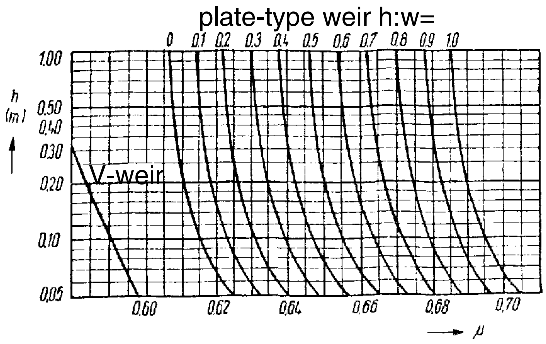


Fig.: 4.6

Rehbock plotted a graph from which the corresponding **overflow coefficients** μ for equation (4.1) for a straight plate-type weir (such as the overshot weir HM 160.30) can be read.

Example of a reading: For a plate-type weir with overflow height h=65 mm and structural height w=200 mm a h:w ratio of 0.325 and a coefficient μ of 0.655 is produced.

Using the formula (4.1), the efficiency of each square-edged plate-type weir can now be calculated.

4.3.3 Evaluating the experiment

Evaluation of an experiment with the vented overflow is presented as an example:

A value of Q_{system}=3.8 m^3/h was set on the system flowmeter. On the overshot weir the following variables were measured:

Weir height:	w = 175 mm
Overflow height:	h = 34 mm
Channel width:	b = 86 mm

(We recommend gauging the water levels with the **HM 160.52** level gauge.)

Thus, equation (4.3) produces an overflow coefficient of

$$\mu = 0.620 \;.$$

Equation (4.4) produces a theoretical flow rate of:

$$Q_{theo} = 1.83 \cdot 0.086 \cdot 0.0351^{\;1,5}$$

$$= 0.00104 \; m^3/s$$

$$\text{or } Q_{theo} = 3.73 \; m^3/h$$

The deviation from the displayed value is

$$Dev = \frac{Q_{theo} - Q_{system}}{Q_{system}} \cdot 100\% = \mathbf{2\%}$$

This is an excellent value! Do not be disappointed if your theoretical values show somewhat greater deviations; even illustrious scientists such as Thomson and Rehbock didn't always measure ideal values, despite their great wisdom!

5 Appendix

5.1 Technical Data

Main Dimensions:

(L x W x H)	220 x 175 x 84	mm
Distance of the weir crest above bottom of the flume:	175	mm
Angle weir crest:	45	°