INTERNATIONAL STANDARD

ISO 4362

First edition
1992-09-15

Measurement of liquid flow in open channels — Trapezoidal profile weirs

Mesure de débit des liquides dans les canaux découverts — Déversoirs à profil trapézoïdal

Reference number
ISO 4362:1992(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 4362 was prepared by Technical Committee ISO/TC 113, *Measurement of liquid flow in open channels*, Sub-Committee SC 2, *Notches, weirs and flumes*.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Measurement of liquid flow in open channels — Trapezoidal profile weirs

1 Scope

This International Standard specifies methods of liquid flow measurement in open channels under steady flow conditions using trapezoidal profile weirs. It applies to free flows, which depend on the upstream head only, and drowned flows, which depend on both the upstream and the downstream heads.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 772:1988, *Liquid flow measurement in open channels — Vocabulary and symbols.*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 772 apply.

4 Installation — General considerations

NOTE 1 Particular requirements for trapezoidal profile weirs are given in clause 7.

4.1 Selection of site

A preliminary survey shall be made of the physical and hydraulic features of the proposed site, to check that it conforms (or may be made to conform) with the requirements necessary for discharge measurement by a weir.

Particular attention shall be paid to the following features in selecting the site:

a) the availability of an adequate length of channel of regular cross-section;

b) the existing velocity distribution;

c) the avoidance of a steep channel, if possible;

d) the effects of an excessive increase in upstream water level owing to installation of the measuring structure;

e) the sediment content of the stream and whether heavy deposition just upstream of the weir is likely to occur;

f) the impermeability of the ground on which the structure is to be founded and the necessity for piling, grouting or other means of controlling seepage;

g) the necessity for flood banks to confine the maximum discharge to the channel;

h) the stability of the banks and the necessity for trimming and/or revetment in natural channels;

i) the need for clearance of rocks or boulders from the bed of the approach channel;

j) the effect of wind on the flow over the weir, especially when the weir is wide and the head is small and when the prevailing wind is in a direction transverse to the direction of flow.

If the site does not possess the characteristics necessary for satisfactory measurements, it shall not be used unless suitable improvements are practicable.

The existing velocity distribution in the approach channel shall be checked by inspection and measurement using, for example, current-meters, velocity rods and floats.

NOTES

2 Concentrations of dye are also useful to check the conditions at the bottom of the channel.

3 A complete and quantitative assessment of the velocity distribution may be made by using a current-meter. More information on the use of current-meters is given in ISO 748[1].

If an inspection of the stream shows that the existing velocity distribution is regular, then it may be assumed that the velocity distribution will remain satisfactory after the weir has been constructed.

If the existing velocity distribution is irregular and no other site for a weir is feasible, due consideration shall be given to checking the distribution after the installation of the weir and to improving it if necessary.

4.2 Installation conditions

4.2.1 General

The complete measuring installation consists of an approach channel, a measuring structure and a downstream channel. The condition of each of these components affects the overall accuracy of the measurements.

In addition, features such as the surface finish of the weir, the cross-sectional shape of the channel and its roughness, and the influences of the control section and devices upstream or downstream of the gauging structure shall be taken into consideration.

These features together determine the distribution and direction of velocity, which have an important influence on the performance of a weir.

Once an installation has been designed and constructed, the user shall prevent or rectify any physical changes in the installation which could affect the discharge characteristics.

4.2.2 Approach channel

The flow in the approach channel shall be smooth, free from disturbances and shall have a velocity distribution as symmetrical as possible over the cross-sectional area.

NOTE 4 This can usually be verified by inspection or measurement.

In the case of natural streams or rivers, these flow conditions can only be attained by having a long straight approach channel of uniform cross-section, free from projections at the side or on the bottom.

Unless otherwise specified, the following general requirements shall be met.

After construction of the weir the flow conditions in the approach channel may be altered owing to the build-up of shoals of debris upstream of the structure. The likely consequential changes in the water level shall be taken into account in the design of the structure.

In an artificial channel the cross-section shall be uniform and the channel shall be straight for a length equal to at least 10 times its width.

If the entry of the approach channel is through a bend or if the flow is discharged into the channel either through a conduit of smaller cross-section or at an angle, then a greater length of straight approach channel will be required to achieve a regular velocity distribution. There shall be no baffle nearer to the points of measurement than 10 times the maximum head to be measured.

Under certain conditions, a standing wave may occur upstream of the gauging device, for example if the approach channel is steep. Provided that this wave is at a distance upstream of not less than 30 times the maximum head, flow measurement will be feasible, subject to confirmation that a regular velocity distribution exists at the gauging station. If a standing wave occurs within this distance, the approach conditions and/or the gauging device shall be modified.

4.2.3 Weir structure

The structure shall be rigid and watertight and capable of withstanding flood-flow conditions without displacement, distortion or fracture. It shall be at right angles to the direction of flow and the geometry of the weir shall conform with the dimensions given in this International Standard.

4.2.4 Downstream channel

The channel downstream of the structure is usually of no importance if the weir has been designed to operate under free-flow conditions. If the weir is designed to operate under drowned conditions also, the downstream channel shall be straight for a length of at least eight times the maximum head to be measured.

A downstream gauge shall be provided to determine the submergence ratio.

1) ISO 748:1979, *Liquid flow measurement in open channels — Velocity-area methods.*

5 Maintenance

Maintenance of the measuring structure and the approach channel is important to secure accurate continuous measurements.

It is essential that, as far as practicable, the approach channel to the weir be kept clean and free from silt and vegetation for the minimum distance specified in 4.2.2. The float well and the entry from the approach channel shall also be kept clean and free from deposits. The weir structure shall be kept clean and free from clinging debris and care shall be taken in the process of cleaning to avoid damage to the weir crest.

6 Measurement of water levels

6.1 General

Where spot measurements are required, water levels (heads) upstream and downstream of the measuring structure may be measured by using a hook gauge, a point gauge or a staff gauge. Where continuous records are required, a float-operated recording gauge may be used; however, to reduce the effects of water surface irregularities, it is preferable to measure water levels in a separate stilling well. Other head-measuring methods may be used provided that sufficient accuracy is obtainable.

The discharges calculated using the working equations given in this International Standard are volumetric figures. The liquid density does not affect the volumetric discharge for a given water level provided that the operative level is gauged in liquid of identical density. If the gauging is carried out in a separate well, a correction for the difference in density may be necessary if the temperature of the liquid in the well is significantly different from that of the flowing liquid. However, it is assumed herein that the densities are equal.

6.2 Stilling or float well

Where provided, the stilling well shall be vertical and shall be 0,6 m higher than the maximum water level to be recorded in the well. The bottom of the well shall be lower than the elevation of the weir crest.

The well shall be connected to the channel by an inlet pipe or slot, which is large enough to permit the water in the well to follow the rise and fall of head without significant delay.

The connecting pipe or slot shall, however, be as small as possible consistent with ease of maintenance, or shall alternatively be fitted with a constriction to damp out oscillations due to short-period waves.

The well and the connecting pipe or slot shall be watertight. Where provided for the accommodation of the float of a level recorder, the well shall be of adequate diameter and depth to give clearance around and beneath the float at all stages. Adequate additional depth shall be provided in wells to avoid the danger of floats grounding on any accumulation of silt or debris. The float well arrangement may include an intermediate chamber of similar size and proportions between the stilling well and the approach channel to enable silt and other debris to settle out where they may be readily removed.

6.3 Zero setting

An accurate means of checking the zero setting of the water level measuring device shall be provided. For this purpose, a pointer, set exactly level with the crest of the weir and fixed permanently in the approach channel or alternatively in the stilling well or float well where provided, may be used.

A zero check based on the level of the water when the flow either ceases or just begins is liable to serious errors due to surface tension effects and shall not be used.

With decreasing size of the weir and the water level, small errors in construction and in the zero setting and reading of the water-level measuring device become of greater importance.

7 Particular requirements for trapezoidal weirs

7.1 Specification for the standard weir

The weir comprises an upstream slope of $1{:}Z_1$, a horizontal crest, and a downstream slope of $1{:}Z_2$ (see figure 1).

The values of Z_1 and Z_2 for standard trapezoidal profile weirs in accordance with this International Standard are specified in table 1.

Table 1 — Upstream and downstream slope combinations

Upstream slope $1{:}Z_1$	Downstream slope $1{:}Z_2$
1:1	1:5
1:2	1:2
1:2	1:3
1:2	1:5
1:3	1:3
1:3	1:5

The intersection of the surfaces of the upstream and downstream slopes with the horizontal crest shall form a well-defined straight sharp corner which shall be horizontal and at right angles to the direction of flow in the approach channel. The crest shall be horizontal and shall have a rectangular plane surface. The surfaces of the crest and the slopes shall be smooth. The width b of the crest perpendicular to the direction of flow shall be equal to the width of the channel in which the weir is located.

A sketch of a typical trapezoidal profile weir is given in figure 1.

7.2 Location of head measurement section

Piezometers or a point-gauge station for the measurement of the head on the weir shall be located at a sufficient distance upstream from the weir to avoid the region of surface drawdown. However, they (it) shall be close enough to the weir to ensure that the energy loss between the section of measurement and the control section on the weir is negligible.

It is recommended that the head measurement section be located at a distance equal to three to four times the maximum head (i.e. $3h_{max}$ to $4h_{max}$) upstream from the toe of the upstream face of the weir, as shown in figure 1.

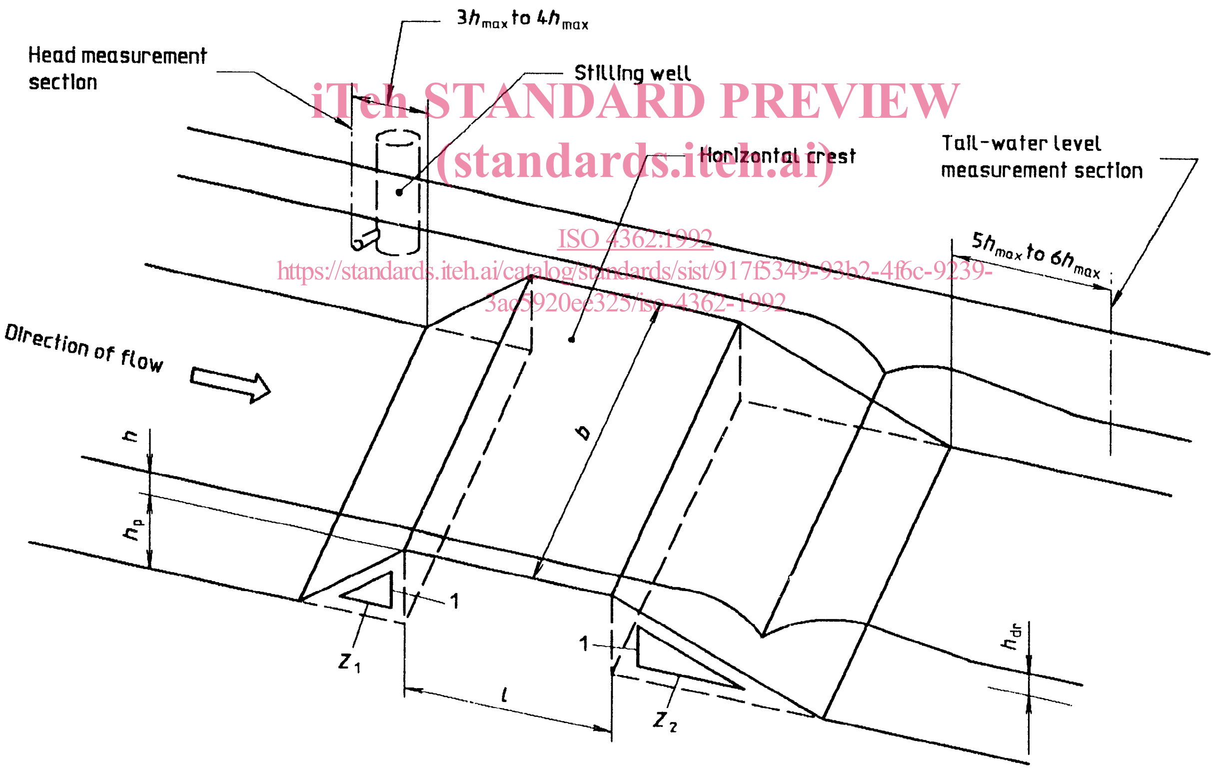

Figure 1 — Trapezoidal profile weir

7.3 Location of tail-water level measurement section

Piezometers or a point-gauge station for the measurement of the tail-water level shall be located at a sufficient distance downstream from the weir to avoid regions of fluctuation.

Generally, it is recommended that the tail-water level measurement section be located at a distance of five to six times the maximum head (i.e. $5h_{max}$ to $6h_{max}$) downstream from the toe of the downstream face of the weir, so that the measurement is downstream of any unstable water surface or jump.

7.4 Conditions for free-flow

Flow is free-flow when it is independent of variations in the tail-water level. For each upstream and downstream slope combination of the weir, correlations for the modular limit σ_c are given in 8.2.3. The tail-water head shall not rise more than σ_c times the upstream head above the crest level, if the flow is not to be affected by more than 1 % for subcritical conditions in the tail-water.

8 Discharge relationships

8.1 Discharge equation

The discharge equation for trapezoidal profile weirs is as follows:

$$Q = \left(\frac{2}{3}\right)^{3/2} C_D C_v C_{dr} \sqrt{g}\, b h^{3/2}$$

where

- b is the width of the weir perpendicular to the direction of flow, in metres;
- C_{dr} is the submerged- or drowned-flow coefficient, which is non-dimensional;
- C_D is the coefficient of discharge, which is non-dimensional;
- C_v is the approach velocity coefficient, which is non-dimensional [$= (H/h)^{3/2}$, where H is the total head, in metres];
- g is the acceleration due to gravity, in metres per second squared;
- h is the measured head, in metres;
- Q is the discharge across the weir, in cubic metres per second.

8.2 Coefficients

8.2.1 Approach velocity coefficient, C_v

C_v is given by the following implicit equation:

$$C_v = \left[1 + \frac{4}{27} C_v^2 \left(\frac{C_D bh}{A}\right)^2\right]^{3/2}$$

Values of C_v may be determined from figure 2 which gives C_v as a function of $C_D bh/A$, where A is the cross-sectional area of the channel at the head measurement section, in square metres.

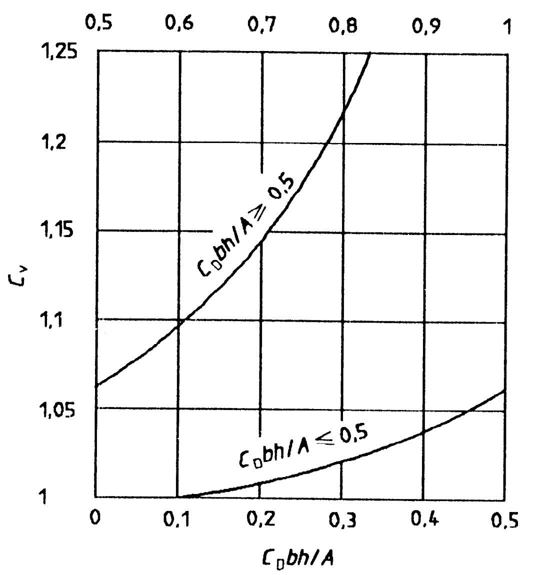

Figure 2 — Approach velocity coefficient, C_v

8.2.2 Coefficient of discharge, C_D

Values of C_D as a function of h/l are given in figures 3 and 4, and table 2 for the upstream and downstream slope combinations given in table 1.

8.2.3 Modular limit, σ_c

The modular limit is a function of h/l and the upstream and downstream slopes. It is taken to be equal to the value of the submergence ratio $\sigma = h_{dr}/h$ (where h_{dr} is the tail-water head above the crest) above which the reduction in discharge exceeds 1 % of the free-flow (or modular flow) discharge. Values of σ_c as a function of h/l are given in figures 5 to 10 for the various slope combinations specified in table 1.

8.2.4 Drowned-flow coefficient, C_{dr}

C_{dr} is a function of h/l and the upstream and downstream slopes. For free-flow and submerged-flow conditions where the submergence ratio is less than the modular limit specified in 8.2.3, the drowned-flow coefficient C_{dr} may be taken to be unity.

For flow conditions where the submergence ratio is greater than the modular limit, the value of C_{dr} may be determined from figures 11 to 16, where C_{dr} is given as a function of h/l and σ for the various slope combinations specified in table 1.

Table 2 — Variation in the coefficient of discharge C_D

h/l	C_D for the following upstream and downstream slope combinations					
	$Z_1 = 1$, $Z_2 = 5$	$Z_1 = 2$, $Z_2 = 2$	$Z_1 = 2$, $Z_2 = 3$	$Z_1 = 2$, $Z_2 = 5$	$Z_1 = 3$, $Z_2 = 3$	$Z_1 = 3$, $Z_2 = 5$
0,1	0,908	0,936	0,936	0,936	0,946	0,946
0,2	0,920	0,952	0,952	0,952	0,963	0,963
0,3	0,928	0,964	0,964	0,964	0,974	0,974
0,4	0,938	0,974	0,974	0,974	0,984	0,984
0,5	0,949	0,985	0,985	0,985	0,992	0,992
0,6	0,962	1,000	0,999	0,998	1,003	1,003
0,7	0,976	1,018	1,014	1,012	1,014	1,012
0,8	0,988	1,036	1,029	1,025	1,028	1,022
0,9	1,002	1,052	1,042	1,035	1,041	1,032
1,0	1,014	1,066	1,054	1,046	1,054	1,042
1,1	1,026	1,080	1,067	1,056	1,066	1,050
1,2	1,038	1,094	1,080	1,066	1,076	1,058
1,3	1,049	1,106	1,092	1,076	1,086	1,064
1,4	1,060	1,120	1,102	1,085	1,096	1,071
1,5	1,072	1,130	1,112	1,092	1,103	1,078
1,6	1,082	1,140	1,121	1,098	1,110	1,084
1,7	1,090	1,150	1,130	1,104	1,116	1,090
1,8	1,098	1,158	1,138	1,109	1,122	1,096
1,9	1,103	1,165	1,145	1,114	1,128	1,102
2,0	1,108	1,173	1,152	1,119	1,133	1,106
2,1	1,113	1,180	1,158	1,123	1,138	1,110
2,2	1,116	1,187	1,164	1,127	1,142	1,114
2,3	1,119	1,194	1,168	1,130	1,146	1,116
2,4	1,121	1,200	1,171	1,133	1,149	1,120
2,5	1,124	1,206	1,174	1,136	1,152	1,122
2,6	1,126	1,212	1,176	1,139	1,156	1,126
2,7	1,128	1,216	1,178	1,140	1,160	1,128
2,8	1,130	1,220	1,181	1,142	1,164	1,132
2,9	1,132	1,222	1,183	1,143	1,166	1,134
3,0	1,134	1,224	1,185	1,144	1,168	1,135

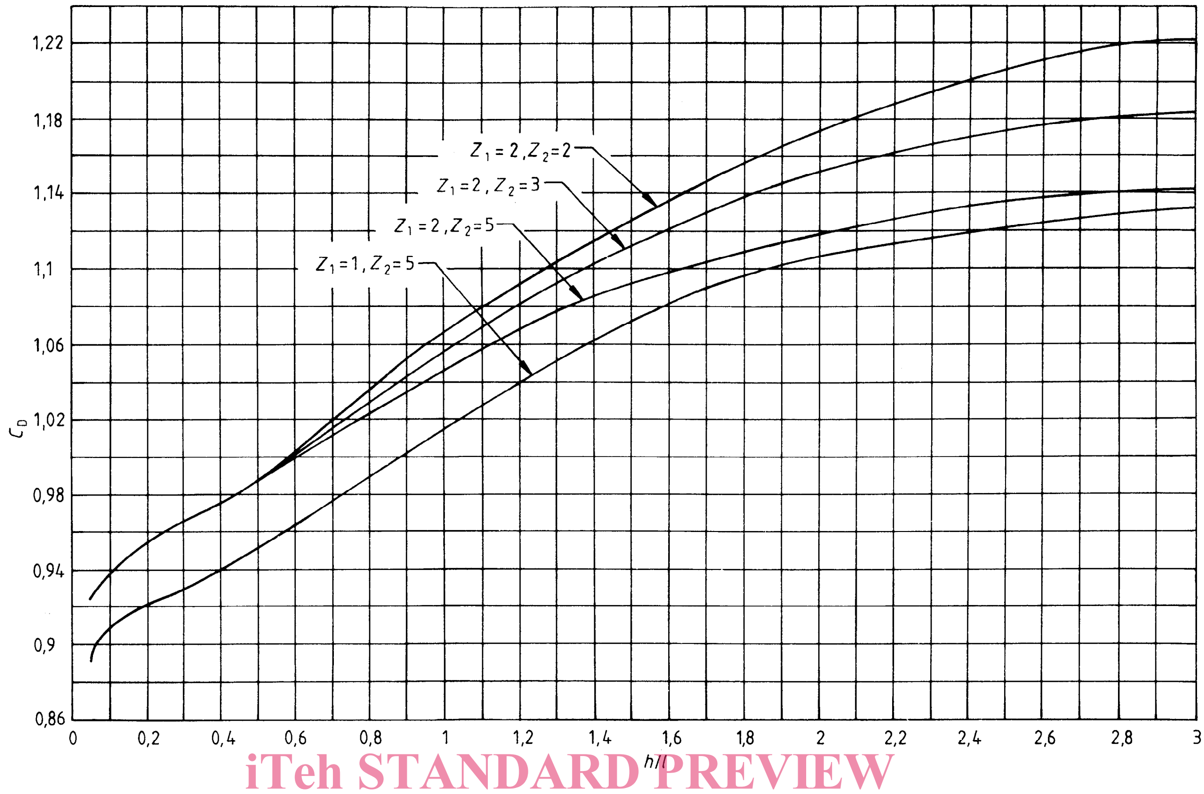

Figure 3 — Variation in the coefficient of discharge for $Z_1 = 1$ and $Z_1 = 2$

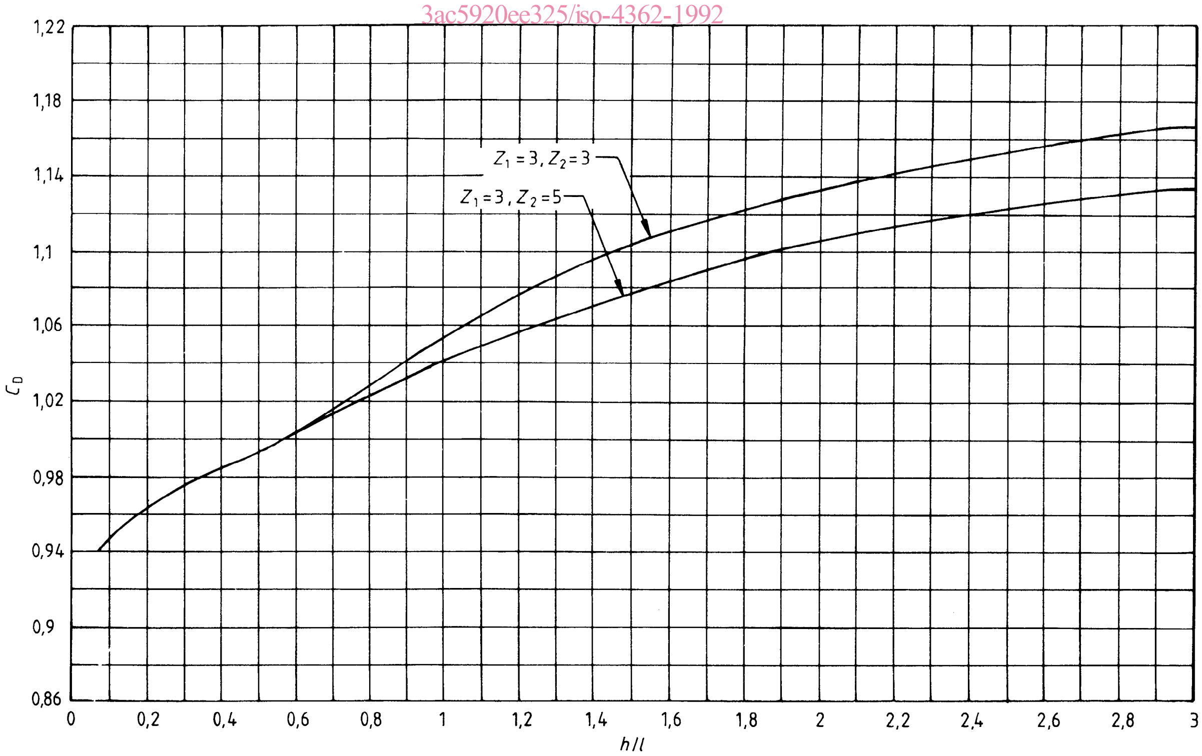

Figure 4 — Variation in the coefficient of discharge for $Z_1 = 3$

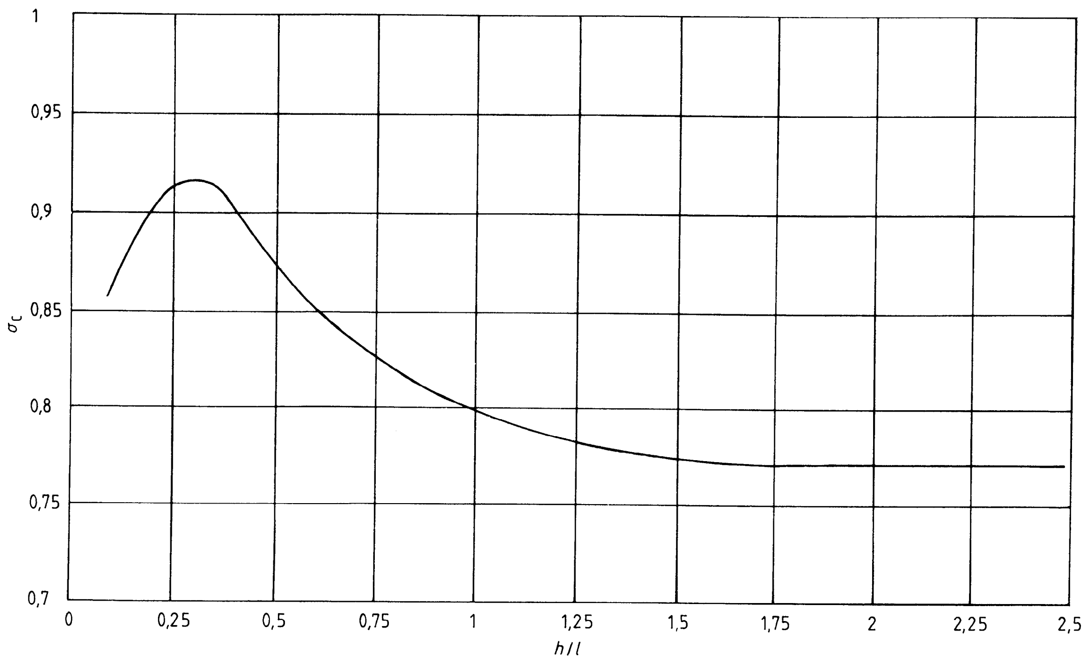

Figure 5 — Variation in the modular limit σ_c for $Z_1 = 1$ and $Z_2 = 5$

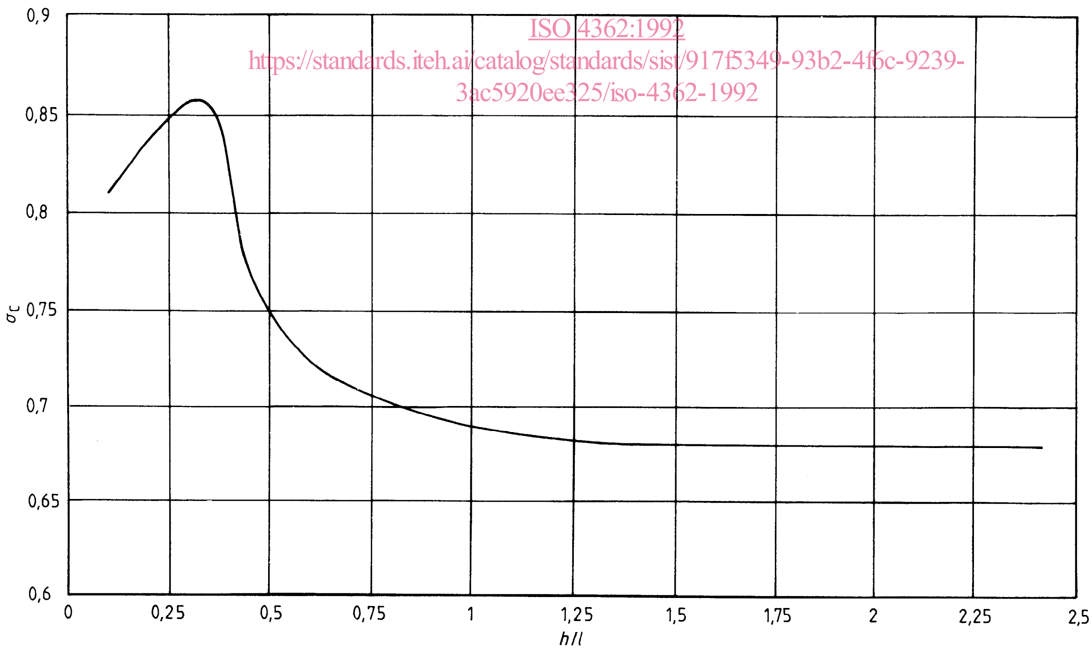

Figure 6 — Variation in the modular limit σ_c for $Z_1 = 2$ and $Z_2 = 2$

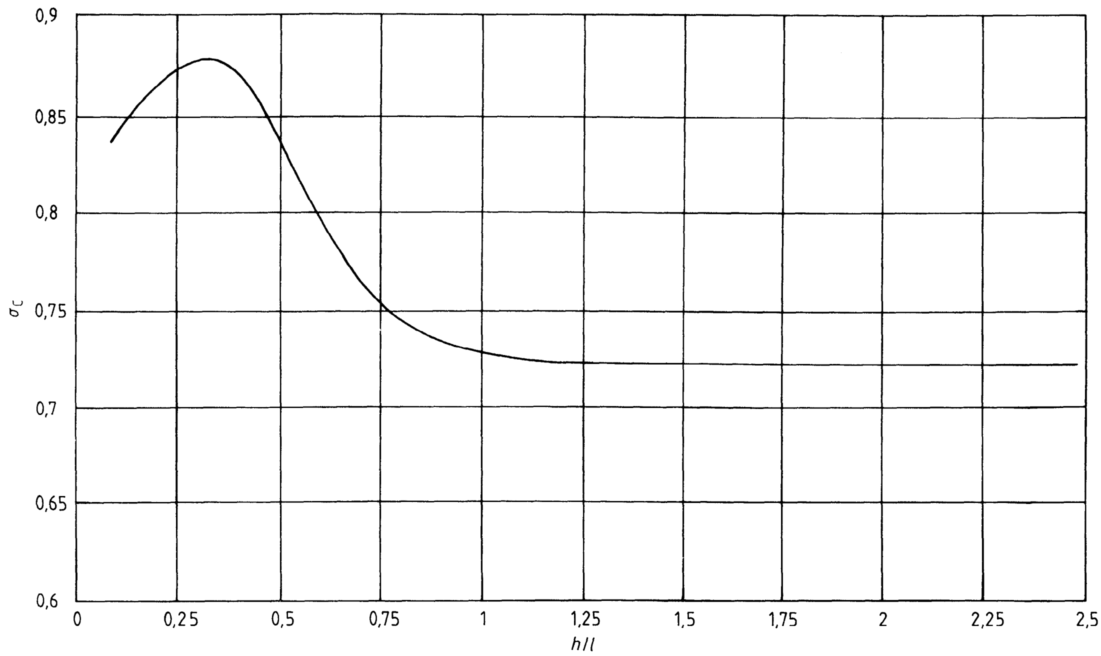

Figure 7 — Variation in the modular limit σ_c for $Z_1 = 2$ and $Z_2 = 3$

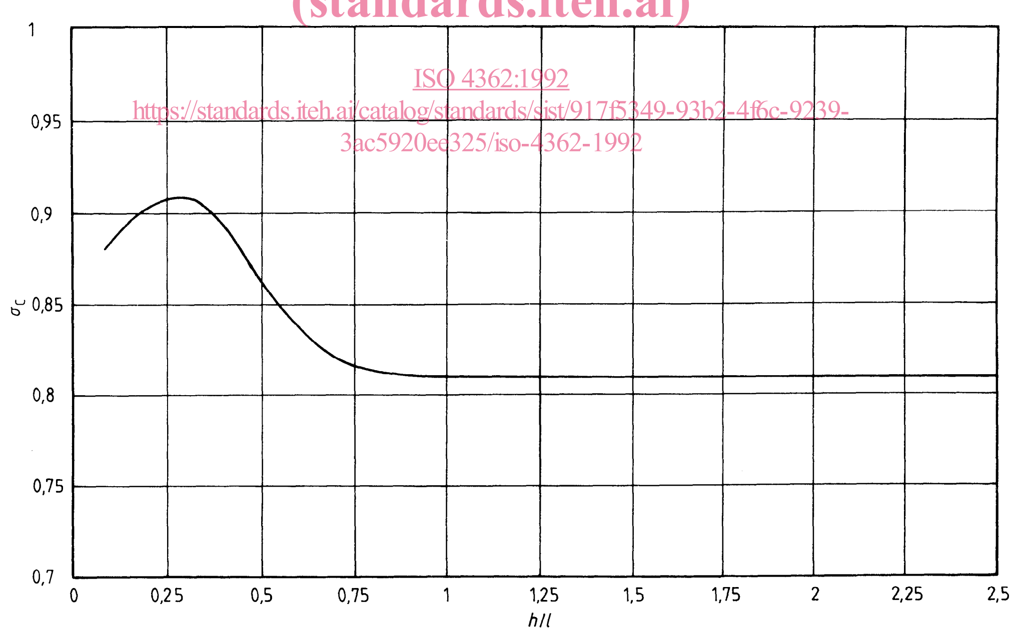

Figure 8 — Variation in the modular limit σ_c for $Z_1 = 2$ and $Z_2 = 5$