IS 11223 (1985): Guidelines for Fixing Spillway Capacity
[WRD 9: Dams and Spillways]

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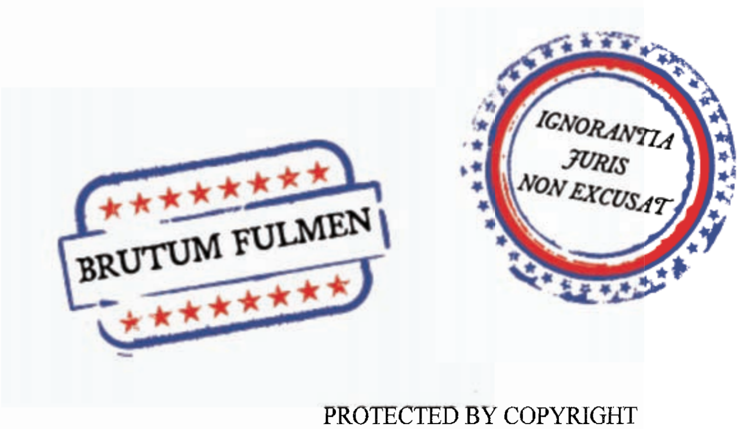

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Indian Standard

GUIDELINES FOR FIXING SPILLWAY CAPACITY

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GUIDELINES FOR FIXING SPILLWAY CAPACITY

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Indian Standard
GUIDELINES FOR FIXING SPILLWAY CAPACITY

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 13 February 1985, after the draft finalized by the Spillways Including Energy Dissipators Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 An essential component of any river valley project, the spillway, performs a very important function of disposing off safely the flood waters that enter the reservoir and which are found surplus to the requirements. The determination of adequate spillway capacity and surcharge storage is of paramount importance since upon it depends the maximum flood level attained and the consequent safety of the dam itself as also the pattern of flooding upstream and downstream of the reservoir.

0.3 Every artificial storage can be a potential hazard to downstream life and property and also cause upstream submergence. Primary purpose of the spillway is to reduce this hazard to negligible or acceptable level. In operational terms, the spillway capacity should be such as to safely pass a pre-determined inflow design flood without irreparable damage to the spillway structure and other components of the dam. Apart from this primary purpose, the capacity of the spillway may be so fixed as to fulfil one or more of the following additional purposes:

a) to provide a small surcharge storage to compensate the effect of the reservoir in decreasing the naturally available valley storage and in decreasing the travel time of the flood waves from the natural condition so as not to change the natural flood regime on the downstream in a detrimental manner.

b) to change the flood regime downstream to reduce the frequency of flood damage, through provision of surcharge storage.

c) to control the floods on the downstream by using a permanent flood control capacity or a joint use capacity in the reservoir.

d) to control the backwater upstream of the reservoir so that the frequency of flooding of an upstream structure or property is reduced to acceptable limits.

e) to economize the dam design by adopting an appropriate combination of surcharge storage versus spillway capacity.

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1. SCOPE

1.1 This standard lays down guidelines for fixing the spillway capacity consistent with the safety of the dam.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions in addition to those given in IS:4410* shall apply.

2.1 Probable Maximum Flood (PMF) — It is the flood that may be expected from the most severe combination of critical meteorological and hydrological condition that are reasonably possible in the region and is computed by using the Probable Maximum Storm which is an estimate of the physical upper limit to maximum precipitation for the basin. This is obtained from transposition studies of the storms that have occurred over the region and maximising them for the most critical atmospheric conditions.

2.2 Return Period Flood — A flood with a return period of 'T' year ('T' year flood) is defined as a flood that is expected, on the average, to be equalled or exceeded once in 'T' years. Thus the probability of occurrence of a flood equalling or exceeding the 'T' year flood is 1/T.

NOTE — The T year flood should specify the flood element (for example peak discharge volume, volume above a threshold, etc) which is considered in the probability analysis. While using this concept in application, the flood element to be used in the analysis is to be decided with reference to the engineering design requirements.

2.3 Spillway Capacity — Capability of the spillway, as determined by its dimensions, crest level and hydraulic characteristics in disposing off water at any specific level.

2.4 Standard Project Flood (SPF) — It is the flood that may be expected from the most severe combination of hydrological and meteorological factors that are considered reasonably characteristic of the region and is computed by using the Standard Project Storm (SPS). While transposition of storms from outside the basin is permissible, very rare storms which are 'not characteristic' of the region concerned are excluded in arriving at the SPS rainfall for the basin.

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*Glossary of terms relating to river valley projects.

2.5 Surcharge Storage — It is the storage between the full reservoir level and the maximum water level.

3. FACTORS GOVERNING SPILLWAY CAPACITY

3.0 The performance of a spillway under a flood situation is affected by the following:

a) Inflow flood.

b) Reservoir and outflow conditions at the beginning of the flood.

c) Hydraulic characteristics of the spillway including those for the approach and the tail channel geometry.

d) Storage characteristics or the reservoir geometry.

e) Rules for operation of the spillway gates.

f) Actual functioning of the spillway including mechanical and human failures.

3.0.1 The acceptability of resulting performance in a flood would then be decided by:

a) The highest water level reached in the flood studies, that is, in particular:

1) Free board available at this level,

2) Clearances of gates available at this level,

3) Upstream submergence corresponding to this level, and

4) Structural safety considerations.

b) The largest outflow during this flood situation and in particular:

1) behaviour of the spillway, energy dissipation arrangement and downstream channel for this outflow, and

2) acceptability of the outflow from the consideration of downstream damage in the valley.

3.1 Inflow Design Flood

3.1.1 Corresponding to the primary and additional purposes of the spillway enumerated in **0.3**, various inflow design floods may be considered, namely:

a) *Inflow design flood for the safety of the dam* — It is the flood for which, when used with standard specifications of other factors as mentioned in subsequent clauses, the performance of the dam should be safe against overtopping, structural failure and the spillway and its energy dissipation arrangements, if provided for a lower flood, should function reasonably well.

b) *Inflow design flood for efficient operation of energy dissipation works* — It is a flood which may be lower than the inflow design flood for the safety of the dam. When this flood is used with standard specifications or other factors affecting the performance, the energy dissipation arrangements are expected to work most efficiently. No damage/breaches in the breaching section, fuse plug, etc, are contemplated during this flood.

c) Inflow design flood for checking acceptability of extent of upstream submergence.

d) Inflow design flood for checking acceptability of extent of downstream damage in the valley.

3.1.2 The dams may be classified according to size by using the hydraulic head (from normal or annual average flood level on the downstream to the maximum water level) and the gross storage behind the dam as given below. The overall size classification for the dam would be the greater of that indicated by either of the following two parameters:

Classification	*Gross Storage*	*Hydraulic Head*
Small	Between 0·5 and 10 million m^3	Between 7·5 m and 12 m.
Intermediate	Between 10 and 60 million m^3	Between 12 m and 30 m.
Large	Greater than 60 million m^3	Greater than 30 m.

3.1.3 The inflow design flood for safety of the dam would be as follows:

Size as Determined in **3.1.2**	*Inflow Design Flood for Safety of Dam*
Small	100 year flood
Intermediate	SPF
Large	PMF

Floods of larger or smaller magnitude may be used if the hazard involved in the eventuality of a failure is particularly high or low. The relevant parameters to be considered in judging the hazard in addition to the size would be:

i) distance to and location of the human habitations on the downstream after considering the likely future developments.

ii) maximum hydraulic capacity of the downstream channel at a level at which catastrophic damage is not expected.

For more important projects dam break studies may be done as an aid to the judgement in deciding whether PMF needs to be used. Where the studies or judgement indicate an imminent danger to present or future human settlements, the PMF should be used. Any departure from the general criteria as above on account of larger or smaller hazard should be clearly brought out and recorded.

3.1.4 Inflow design flood for efficient operation of energy dissipation work — For some dams, inflow design flood for the safety of the dam may not undermine the dam foundation and endanger its safety. Also for some dams, breaching sections or auxillary spillways may be provided such that the breach of this breaching section or operation of the auxillary spillway also may not undermine the dam foundation and endanger its safety and in addition these may not lead to uncontrolled widening of the breach or loss of life. Under these conditions the energy dissipation arrangements for the main spillway may be designed for best efficiency for a smaller inflow flood than the inflow design flood for the safety of the dam.

3.1.5 For the two types of inflow design floods (*see* **3.1.3** and **3.1.4**) for intermediate and large dams the design situation would consist of the flood followed or preceded by a 25 year flood, if two large floods have occurred in close succession in the region in the past. The period between the floods, or between the two storms if the floods are generated through storm rainfall, may be reasonably small and may be decided after the analysis of the past data.

The duration of the standard project or maximum probable storm to be considered depends on the storm characteristics of the region, basin characteristics and characteristics of the proposed engineering work. For attaining the highest possible peak discharge, the rainfall period should not be less than the base period of the unit hydrograph where a considerable reduction in the peak through the dam is envisaged, the volume of the flood in the routed portion becomes important, and longer duration rainfall would have to be considered.

Where a 'T' year flood is to be used through probability analysis, any value between and including the expected value of the flood, as indicated by the analysis to be 95 percent upper confidence band value, may be used depending on the importance of the structure, length of data, etc.

3.2 Initial Level and Outflow — For routing of the inflow design floods (*see* **3.1.3** and **3.1.4**) following conditions shall be used:

a) The initial level, when the flood impinges, would be the top of conservation pool level. For ungated spillways this would correspond to the spillway crest or a little above this [*see* **3.2** (c)]. For reservoirs not having a permanent flood control pool this will correspond to top of gate level. Where by rule-curve operation, a part of the conservation capacity is proposed to be used as a joint use capacity towards flood control also, the top of conservation level will be used and not the rule-curve level. For projects having permanent flood control pool, the actual initial level may be in between the top of conservation pool and top of flood pool depending on the flow sequences before the flood. A sequence of 25 year and design flood should be adopted. Where such sequence is used, it would be admissible to use the top of conservation pool as the initial level. However, where the sequence is not used, the initial level may correspond to the level at which 50 percent of the permanent flood control storage is occupied.

b) For some projects, it may be possible to pre-deplete the reservoir by using a flood forecast. However, this pre-depletion by using forecasts need not be considered in the initial level determination for the present purpose.

c) The initial outflow from the reservoir should correspond to the initial inflow so that the steady pool is the initial condition. For ungated spillways, this outflow may require a consideration of an initial level little above the spillway crest. For flood control reservoirs, where 50 percent initial filling of the flood pool is assumed, the initial outflow would correspond to the operation schedule for flood control purposes and may be governed by downstream constraints.

3.3 Hydraulic Characteristics of the Spillway — Outflow from outlets provided for conservation used need not be considered in deciding discharging capacity. Care should be taken to adopt appropriate elevation-outflow curve for the spillway. For hydraulic characteristics of high ogee spillways, reference may be made to IS:6934-1973*.

NOTE — For ungated waste weirs, common on small projects, sufficient slope to maintain critical flow at spillway crest may not be available on the downstream.

3.4 Reservoir Geometry — The elevation area capacity characteristics as expected after 100 years of sedimentation (*see* draft Indian Standard Methods for determination of life of reservoirs, *under preparation*) may be used in the routing of the design floods.

3.5 Rules of Operation — It is necessary that the rules of the gate operation as used in flood routing should be similar to those that can be used in practice.

3.5.1 If surcharging operation, involving maintenance of a steady pool above the full reservoir level is contemplated, thus using up the controlled surcharge storage of the total surcharge pool, this should be reflected in flood routing.

*Recommendations for hydraulic design of high ogee overflow spillways.

3.5.2 Whether or not flood control is a stated purpose, rules for operation under normal floods may initially provide a restriction on the outflow or on its rate of change. Only at a later stage of a larger flood, the flood would be recognized as a large one, and emergency schedule permitting unrestricted outflow may come into force. These possibilities should be reflected in the computations of reservoir simulation under both the design floods (*see* **3.1.3** and **3.1.4**).

3.6 Mechanical and Human Failures

3.6.1 For gated spillways, the contingency of at least 10 percent of the gates with a minimum of one gate being inoperative may be considered as an emergency condition (like earthquake) for both types of design floods (*see* **3.1.3** and **3.1.4**), for safety of the dam and for design of energy dissipation works.

3.6.2 Human failures in the operation of a high capacity spillway may cause a downstream flood larger than the inflow flood and may endanger downstream interest. Although it is preferable to restrict the outflow capacity, if possible, to reduce this possibility, explicit consideration of such situations is not necessary (*see also* **5.2.1**).

4. CHECKING ACCEPTABILITY OF THE PERFORMANCE

4.0 With the two design floods (*see* **3.1.3** and **3.1.4**), four design conditions would result:

Design Condition I : Under inflow design flood for safety of dams and with inoperative gates as in **3.6.1**.

Design Condition II : Under inflow design flood for safety of dams and with all gates operative.

Design Condition III : Under inflow design flood for energy dissipation works and with inoperative gates as in **3.6.1**.

Design Condition IV : Under inflow design flood for energy dissipation works and with all gates operative.

4.1 Free-Board and Clearances — The free-board as specified in relevant Indian Standards (*see* IS : 6512-1984* and IS : 10635-1983†) should be available at FRL as also at MWL which would correspond to Design Condition II.

4.1.1 A reduced free-board may be acceptable under Design Condition I assumed as an emergency condition (like earthquake).

4.1.2 Similarly, normal clearance from and clearance in the energy dissipation structure should be available for Design Condition II and lower acceptable clearances for Design Condition I.

*Criteria for design and solid gravity dams (*first revision*).

†Guidelines for freeboard requirements in embankment dams.

4.2 Upstream Submergence Consideration — This depends on local condition, type of property and effects of its submergence. Except for very important structures upstream like power houses, mines, etc, for which levels corresponding to SPF or PMF may be used; smaller design floods and levels attained under these may suffice. In general a 25-year flood for land acquisition and 50-year flood for built up property acquisition may be adopted.

4.3 Downstream Submergence Consideration — This depends on local conditions, the type of property and effects of its submergence. Except for very important facilities like power houses, for which outflows obtained under condition II or of that order may be relevant. Normally the discharge relevant to check the acceptability of downstream submergence condition may be smaller than those for power houses at or near the toe of the dam. Normally damage due to physical flooding may not be allowed for Design Condition II, but disruption of operation may be allowed.

5. GENERAL CONSIDERATIONS

5.1 Breaching Sections — If a suitable site is available in a separate saddle, a breaching section may be provided. The top level of the earth dam provided in the saddle should be kept lower than the top level of the main dam so that the earth dam in the saddle gets breached due to overtopping in the event of high water level. This would relieve the pressure on the main dam. It should be seen that no habitation or valuable property exists downstream of the saddle and the damage caused by way of the breach is minimum.

5.2 Although the primary purpose of the spillway as stated in **0.3**, that is to eliminate or reduce the artificial hazard due to failure of dam forms the main scope of the standard other purposes as mentioned in **0.4** also require careful considerations.

5.2.1 It seems preferable to provide at least a small surcharge storage so that the maximum water level reached even under the design floods with all gates functioning is higher than the full reservoir level (or the maximum controlled water level in case surcharging is planned). This would allow a moderation of the high floods so that the hydrologic effects of the reservoir in reducing valley storage and travel times are countered. Such a margin would also give a slight flexibility in gate operation and reduce the effects of human failures.

5.2.2 Where flood control downstream of the dam is proposed to be achieved, it is necessary to have a rigorous study based on simulation of the reservoir under a number of floods.

5.2.3 Techno-economic studies for sizing of spillway *vis-a-vis* sizing of surcharge capacity need to be done for all important dams.

AMENDMENT NO. 1 DECEMBER 1990
TO
IS 11223 : 1985 GUIDELINES FOR FIXING SPILLWAY CAPACITY

(*Page* 9, *clause* 4.1.1) — Insert following at the end :

'Provide minimum of 1m height above maximum water level to top of dam in case of masonry dams.'

(RVD 10)

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AMENDMENT NO. 2 SEPTEMBER 1991
TO
IS 11223 : 1985 GUIDELINES FOR FIXING SPILLWAY CAPACITY

(*Page* 6, *clause* 3.1.2, *first sentence*) — Substitute the following for the existing sentence :

'The dams may be classified according to size by using the static head at FRL (from FRL to the minimum tail water level) and the gross storage behind the dam as given below :'

(*Page* 6, *clause* 3.1.2, *line* 6) — Substitute '*Static Head at FRL*' for '*Hydraulic Head*'.

(RVD 10)

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