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भारतीय मानक

पथान्तर कार्यों के लिये मापदन्ड

भाग 2 बांध के ढांचे में पथान्तर चैनल और खुला कटाव अथवा नलिका

Indian Standard

DESIGN OF DIVERSION WORKS — CRITERIA

PART 2 DIVERSION CHANNEL AND OPEN CUT OR CONDUIT IN THE BODY OF DAM

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Diversion Works Sectional Committee, RVD 7

FOREWORD

This Indian Standard (Part 2) was adopted by the Bureau of Indian Standards, after the draft finalized by the Diversion Works Sectional Committee had been approved by the River Valley Division Council.

Prior to the commencement of actual construction of any work in the bed of a natural river, it becomes obligatory in most cases to exclude temporarily the river flow away from the proposed work area during the construction period, so as to permit the work to be done in the dry or semi-dry areas. Diversion works provide working area free from water and river flow for constructing hydraulic structures. These works, as far as possible, are so designed that when the diversion needs are over, these may be utilised partially or fully in the main projects as spillways, bottom outlets, irrigation outlets, head race or tail race tunnels. The method and magnitude of diversion works will depend primarily upon the cross section of the valley, the type of dam, diversion discharge and the bed material in the river. However, in some specific cases, the choice of a dam may depend on diversion arrangement, for example an earth dam is not feasible where diversion works cannot prevent overtopping of the dam.

Part 1 of this standard covers the criteria for design of coffer dams of different types, namely masonry/concrete/colloidal concrete, earthen, rockfill, steel and timber coffer dams. The passage for diversion of water can be broadly classified into three categories, namely open channel, open cut or conduit in the permanent works and tunnels. Part 2 of this standard has been prepared to cover the design criteria for diversion channel and open cut or conduit in the body of the dam. Part 3 of this standard will cover the design criteria for tunnels.

Indian Standard

DESIGN OF DIVERSION WORKS — CRITERIA

PART 2 DIVERSION CHANNEL AND OPEN CUT OR CONDUIT IN THE BODY OF DAM

1 SCOPE

This standard covers the criteria for design of open channel and open cut or conduit in the body of the dam as diversion works.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
4410 (Part 12) : 1973	Glossary of terms relating to river valley projects : Part 12 Diversion works
12966 (Part 2) : 1990	Code of practice for galleries and other openings in dams: Part 2 Structural design
13912 : 1993	Closure of diversion channel and open cut or conduit in the body of the dam — Code of practice

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 4410 (Part 12) : 1973 shall apply.

4 OPEN CHANNEL

4.1 At sites where diversion of flow through tunnels or close conduits is not possible (due to topographical considerations) or proves to be uneconomical, diversion through excavated channels called diversion channels is effected. Diversion channels are often classified according to the type of diversion namely, single stage or multiple stage diversion scheme. In the former which is more suitable for narrow valleys, the same set of diversion channel and coffer dams is utilised throughout the period of construction. In the latter, which is generally suitable for wide valleys, the channels and coffer dams are shifted from place to place in accordance with phasing of the work. A more useful classification, however, is based on the type of the dam to be constructed namely diversion channel for masonry or concrete dams and that for the earth or rockfill dams. The following guidelines are followed for their design.

4.1.1 *Diversion Channels for Masonry/Concrete Dams*

Concrete or masonry dams could be allowed to get overtopped during floods when construction activity is not in progress. The resulting damage is either negligible or could be tolerated without much concern. Therefore, it is customary to adopt diversion flood which is just adequate to be handled during non-monsoon season, when construction activity of the dam is continued. Generally the largest observed non-monsoon flood or non-monsoon flood of 100 year return period is adopted as a diversion flood. This is generally a small fraction of the design flood of the spillway and, therefore, diversion channel required to handle this flood is obviously small. Advantage is also taken of passing the floods over partly completed dam or spillway blocks, thereby keeping the diversion channel of relatively smaller size. In such a case a small excavated channel either in the available width of the river or one of the banks of the river proves to be adequate. Construction sluices are located in such excavated channels which allow passage of non-monsoon flows without hindrance to the construction activity. Such sluices are subsequently plugged when the dam has been raised to adequate height. If the pondage is not allowed even when the dam has been raised to sufficient height, the river outlets are often provided in the body of the non-overflow or overflow dam to pass the non-monsoon flows which later on are kept for permanent use after completion of construction. If the diversion channel is excavated on one of the river banks, it is possible to use the same for locating an irrigation outlet, a power house or a spillway depending upon the magnitude and purpose of the project. Figures 1 and 2 show typical layouts of diversion channel for masonry/concrete dams in narrow and wide rivers.

4.1.2 *Diversion Channel for Earth/Rockfill Dams*

4.1.2.1 Earth or rockfill dams should not normally be allowed to be overtopped by floods during construction. Therefore, it is imperative to ensure that the highest water level, either during diversion of non-monsoon flows

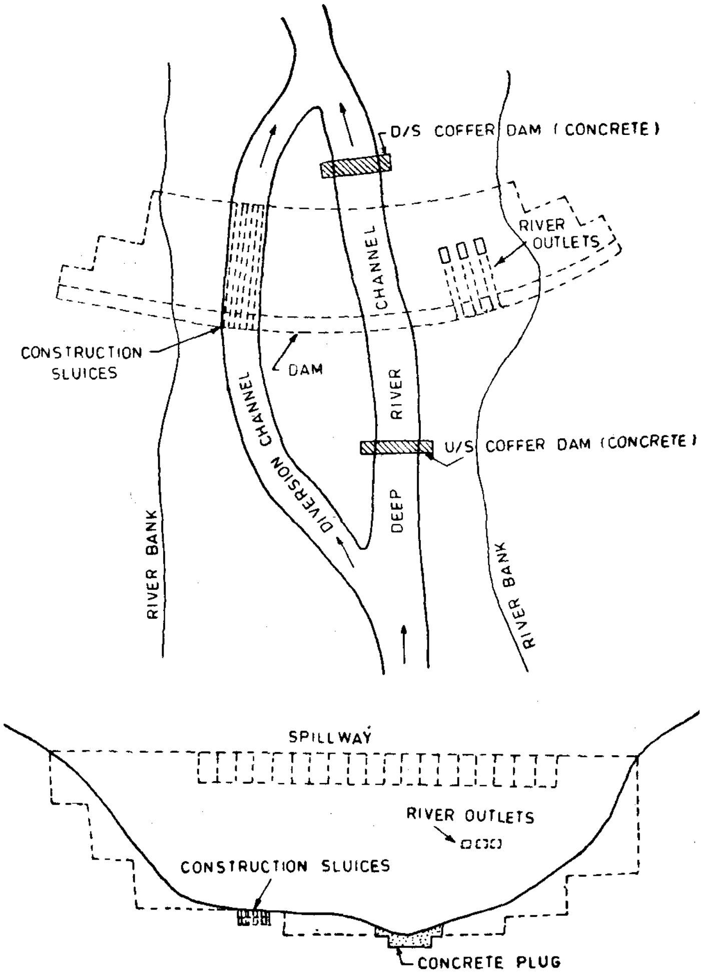

FIG. 1 DIVERSION CHANNEL FOR CONCRETE/MASONRY DAM IN A WIDE RIVER

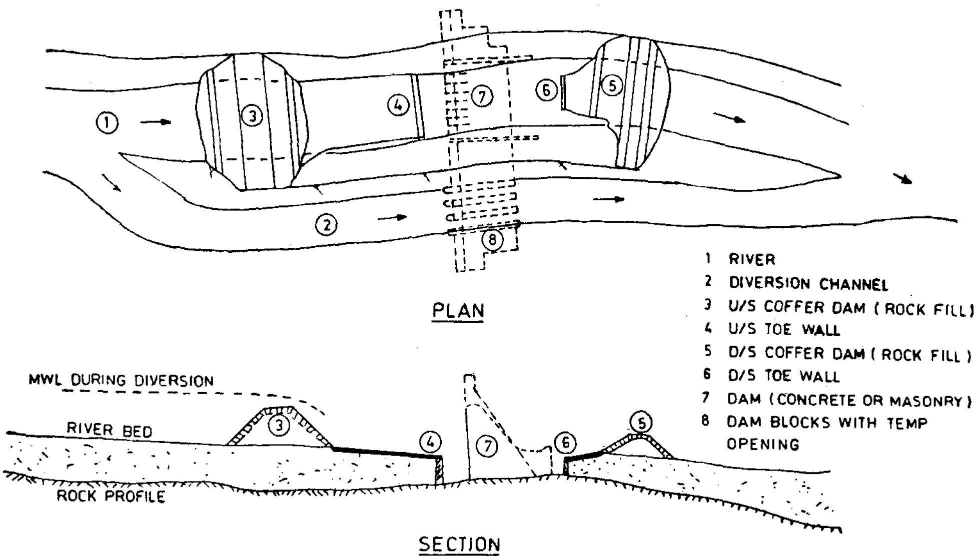

FIG. 2 DIVERSION CHANNEL FOR CONCRETE/MASONRY DAM IN A NARROW RIVER

or passage of monsoon floods is lower than top level of the dam during construction. Capacity of the diversion flood should be worked out on the basis of the standard 'Design Flood for River Diversion Works—Guidelines (*under preparation*)'. Because of the large volume of flood to be negotiated and the fact that earth dams are generally located in the main river gorge, diversion channels have to be excavated on one of the river banks in the case of narrow valleys. The layout and principal dimensions, specially the cross-section of the diversion channel is governed by several considerations such as topography, volume of flood to be handled, water levels during passage of monsoon and non-monsoon floods in consonance with raising of the dam and requirement of excavated material from diversion channel for use in constructing earth dam, etc. The coffer dams in such a case which form integral part of the earth or rockfill dam in the finally completed stage, are also not allowed to be overtopped (though a few examples exist when earth or rockfill dams have been allowed to be overtopped during diversion with special protection on their slopes with concrete blocks or gabions, etc). Because of the considerable expenditure and time involved in the construction of diversion channel for earth dams, these channels are designed to be useful for other purpose also such as spillway tail channel or power house tail channel. Although, initially such channels may be without protective lining on the sides, they are protected at a subsequenr stage when utilised for spillway or power house tail race channel. Figure 3 shows typical example of diversion channels for earth/rock fill dam project, in a narrow river channel.

4.1.2.2 In a wide river channel, provided the height of the earth dam is small enough, diversion could be managed by a temporary channel involving a gap through earthfill dam while the remainder of the embankment is being constructed (*see* Fig. 4). Before the stream is diverted, the foundation required for the dam should be completed in the area where the temporary opening will be left through embankment. This preparation would include excavation and refilling of a cut-off trench, if one is to be constructed. The stream is then channelised through this area after which the foundation work in the remainder of the stream bed is completed. The portion of the embankment on either side of the diversion opening may then be completed. The side slopes of the opening should not be steeper than 4 vertical to 1 horizontal to facilitate filling up of the gap at the end of the construction period and to decrease the danger of cracking of the embankment due to differential settlement. The flat slope also provides a good bonding surface between the previously constructed embankment and the material to be placed. The bottom level of the temporary channel

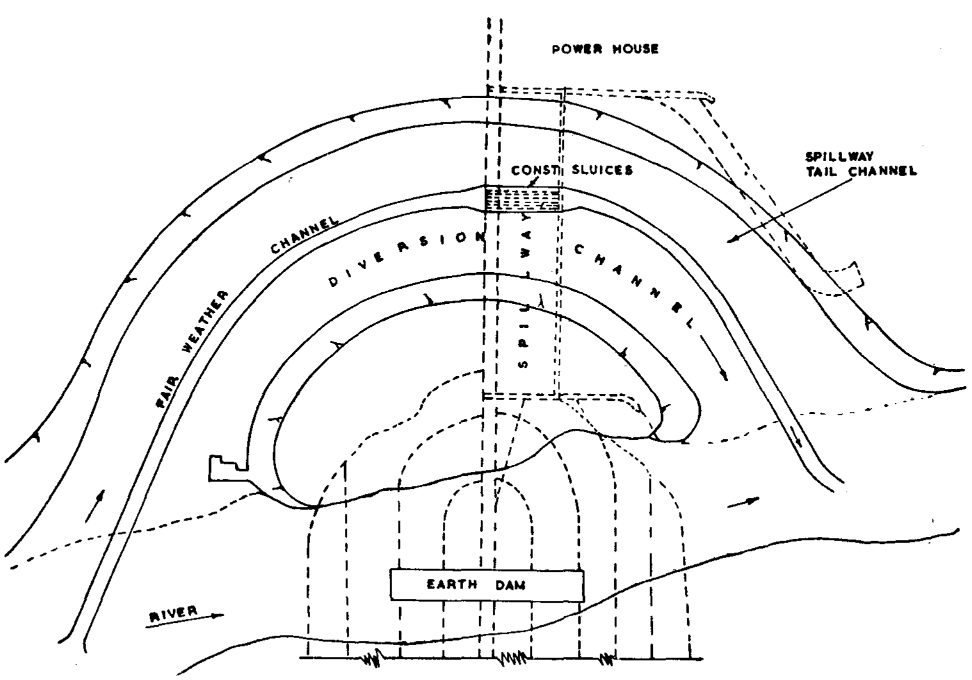

FIG. 3 DIVERSION CHANNEL FOR EARTH/ROCKFILL DAM IN A NARROW RIVER CHANNEL

through embankment should be the same as the original stream bed, so that erosion in the channel will be minimised. The width of the opening will depend on the magnitude of the diversion flood and consideration of the equipment capabilities for filling the gap which would be available. The average rate of embankment placement should be such that the gap could be filled faster than the water rise in the reservoir. Care should be exercised during filling of the gap so that the quality of the work is not sacrificed due to exigencies of the situation. This is of great importance because frequently the diversion gap is in the area where the dam would be of maximum height. Special attention should also be given to bonding of the newly placed material with earthfill previously placed.

4.2 Design Considerations

The following points should be considered in the design of open channel for diversion:

a) Although the alignment of the diversion channel is governed by topography, circular alignment is by far the most efficient alignment. The radius of the circle should be 3 to 5 times the bed width of the channel to obtain equitable flow across the channel. However, radius as small as twice the bed width may also be adopted because of the restraints due to other considerations.

b) Channels are designed on the basis of Manning's formula, after adopting suitable value of rugosity coefficient depending on site conditions. The velocity in the unlined section should not exceed 5 m/s. In lined channels velocity may go up to 15 m/s.

c) It is also advantageous to provide a fair weather flow channel within the diversion channel so as to restrict the non-monsoon flow through the fair weather channel thus keeping the rest of the diversion channel high and dry to enable the work to continue uninterruptedly. Provision of a fair weather channel also facilitates placing construction sluices within the dam body so that diversion of the fair weather flow could be conveniently handled even after raising of the dam to a considerable height (*see* Fig. 3). Likelihood of silting up of the fair weather channel by the monsoon floods should, however, be kept in mind.

d) When the dam is raised and operation of construction sluices becomes difficult, diversion of non-monsoon flows could be effected through river outlets provided in the body of the spillway or dam. Often these outlets are used for irrigation outlets after completion of the dam.

e) Although diversion of flow through open channel is for temporary use, the requirement of diversion continues for some years. In such a condition, it becomes necessary to ensure equitable distribution of discharge across the width of the diversion channel. For this purpose groynes or spurs could be effectively used to ensure satisfactory flow conditions in the diversion channel (*see* Fig. 3).

f) For the diversion channel excavated in overburden, it is also necessary to ensure that the banks are not eroded due to flood flows. While provision of a spur could help ensuring concentration of discharge in the central portion of the channel with minimum velocities along the banks, it nevertheless requires protection to avoid erosion of the banks. If the diversion channel is to be utilised as spillway channel or power house tail race channel, the protection measures are designed such that those could be useful during permanent stage also. In other cases, pitching with stones, rip rap or gabions is normally adopted.

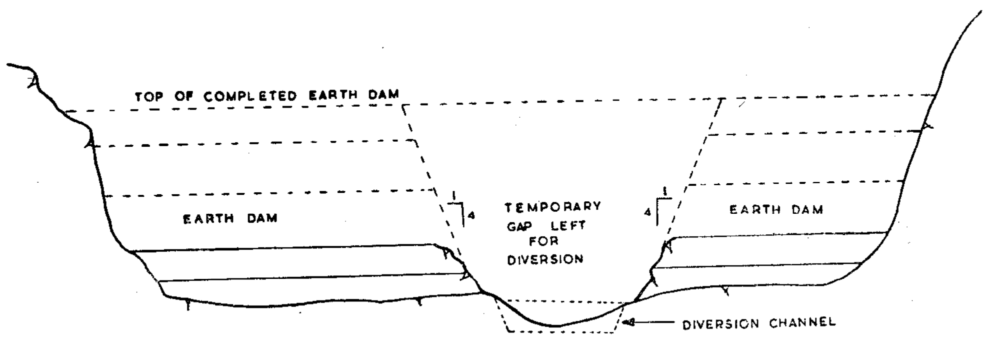

FIG. 4 DIVERSION THROUGH A GAP IN THE EARTH DAM IN A WIDE RIVER CHANNEL

4.3 Model Studies

4.3.1 Hydraulic model studies for evolving suitable arrangement of the diversion through open channel are almost indispensable. The model studies help deciding the most efficient alignment of the diversion channel, heights of the upstream and downstream coffer dams, protection measures for the coffer dams if they are to be overtopped, flow conditions in the diversion channel and protection measures for the diversion channel depending on its utility during diversion as well as during permanent stage. The discharging capacity of partly constructed spillway blocks could only be assessed through model studies as no accurate theoretical approach is still available for such a complex three dimensional flow situation.

5 OPEN CUT OR CONDUIT

5.1 The river floods may be so large that provision of diversion passages even for average floods may be highly expensive. The only alternative is to have them passed over or through the dam, although this does apply mostly to concrete dams. Smaller floods occurring during non-monsoon period are handled by temporary low level outlets works, permanent outlets works or other diversion arrangements while the monsoon floods are passed by over topping certain dam blocks purposely left at low level than others.

5.2 The capacity of diversion arrangement should be worked out on the basis of the standard 'Design Flood for River Diversion Works—Guidelines (*under preparation*)'. The conduit for diversion arrangement has to be designed normally as an outlet sluice in the body of the dam, that is, the reinforcement details should be worked out according to standard design criteria. The diversion conduit would normally be a rectangular conduit with height/width ratio of 1·5/1·0 to 2·0/1·0. It would be desirable to flare the downstream end of the conduit to reduce the discharge intensity. Structural design of conduit should be done according to IS 12966 (Part 2) : 1990.

If the conduit/sluice is used as a permanent structure, permanent gates and hoisting arrangement should be provided. In case the conduit/sluice is to be closed after diversion, there is no necessity of providing a gate in the body of the sluice but a bulk-head gate on the upstream with proper guidance for closing purposes may be provided. The permissible velocity in the conduit may be limited to 20 m/s. It is necessary to see that diversion channels and diversion tunnels are steel lined from intake to end of transition to avoid damage to the invert and sides due to rolling boulders, if carried in rivers.

The pressure fluctuations under transient flow conditions should be examined closely. It should also be ensured that change from free surface to pressure flow take place smoothly.

The conduit should preferably be in the non-overflow block of the dam close to the spillway portion. Proper care should be taken for the dissipation of the energy at the outlet of the diversion conduit.

6 CLOSURE

When diversion channel and open or conduit in the body of the dam are no longer required for construction purpose, they should be closed as recommended in IS 13912 : 1993.

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