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GUIDELINES FOR THE CHOICE OF THE TYPE OF DIVERSION WORKS

PART I COFFER DAMS

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GUIDELINES FOR THE CHOICE OF THE TYPE OF DIVERSION WORKS

PART I COFFER DAMS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 4 March 1981 after the draft finalized by the Diversion Works Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Prior to the commencement of construction of any work in the bed of a river, it becomes obligatory to exclude temporarily the river flow from the proposed work area during the construction period, so as to permit the work to be done in dry or semi-dry conditions. An efficient scheme of diverting the river flow away from the work area should aim at limiting the seepage into the work area to a minimum, so that the work area can be kept dry with minimum pumping capacity.

0.3 A temporary river diversion scheme essentially consists of:

a) coffer dam(s) built across a part or full width of the river to divert the flowing water away from the work area, and

b) works to transfer the diverted water from upstream to the downstream of the work area without affecting the same, such as :

   1) diversion through (construction) sluices in the main work;

   2) diversion by one or more tunnels along the side of the main work area;

   3) diversion through low-level blocks of the main structure left for the purpose or through channels excavated outside the main structure; and

   4) secluding part of the work area for construction and allowing the river to flow through the remaining work area.

0.4 There are different types of coffer dams in vogue, such as masonry/concrete/colloidal concrete/earthfill/rockfill, and steel and timber coffer dams. The suitability of the particular type of coffer dam will depend on a number of factors such as the availability of space and materials, construction programme, rate of construction, incorporation of the coffer dam as a part of main structure, foundation characteristics, and river flow conditions. The proper choice of the type of coffer dam shall be made after considering all the relevant aspects.

0.5 This standard on guidelines for choice of type of diversion works is proposed to be formulated in four parts, of which this is Part I. The other parts are listed below:

Part II Diversion channel and open cuts,

Part III Conduits, and

Part IV Utilization of permanent structures for diversion.

1. SCOPE

1.1 This standard lays down the guidelines for the choice of the different types of coffer dams (such as masonary/concrete/colloidal concrete, earthfill/rockfill, steel and timber coffer dams).

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 6461 (Part IV)-1972*, IS : 4410 (Part VIII)-1968† and IS : 4410 (Part XII)-1973‡ shall apply.

3. TYPES OF COFFER DAMS

3.1 The different types of coffer dams, the guidelines for choice of which have been discussed in this standard, are (i) masonry/concrete/colloidal concrete coffer dams, (ii) earthfill/rockfill coffer dams, (iii) steel coffer dams, and (iv) timber coffer dams.

3.1.1 *Masonry/Concrete/Colloidal Concrete Coffer Dam* — A masonry/concrete coffer dam on a rocky foundation is similar to a masonry/concrete dam constructed at site. This can be of gravity or arch type, usually the former. A brief description of a colloidal concrete coffer dam generally adopted for river diversion works is given below.

3.1.1.1 A colloidal concrete coffer dam consists of two rows of piles of 1 to 1·25 m diameter, spaced suitably apart and having inter-locking points. Cylindrical steel liners are driven penetrating into the bed rock

*Glossary of terms relating to cement concrete : Part IV Types of concrete.

†Glossary of terms relating to river valley projects : Part VIII Dams and dam section.

‡Glossary of terms relating to river valley projects : Part XII Diversion works.

by about 1 m. The overburden of sand and gravel in front of and in the immediate vicinity of the inter-locking points is grouted to make the points more effective. After placement of suitable reinforcement inside the cylindrical liner, the same is concreted to form an RCC pile. To facilitate rubble dumping and grouting simultaneously with piling work, the coffer dam is divided into cells by providing cross-rows of piles, penetrating in the overburden to a short depth. Horizontal bracings connecting the two rows are also provided for ensuring stability of piles. Later, the space between the two rows of piles is filled with rubble and concreted so that the whole structure is stable as one unit and prevents seepage into the work area. For typical plan, section and details of such a colloidal concrete coffer dam, *see* Fig. 1.

3.1.2 *Earthfill/Rockfill Coffer Dam* — In addition to the usual type of earthfill/rockfill coffer dam with a central core of impervious soil, a coffer dam with single sheet pile at the centre, backed by earthfill/rockfill on either side of it is also used. A typical section of such a coffer dam is shown in Fig. 2. Sometimes, a coffer dam with a single sheet pile at the centre, backed on either side by sand bags, caged suitably by G. I. wire mesh of appropriate gauge, is also adopted. However, due to the possibility of rotting of gunny bags and sand spreading thereby, this type of coffer dam can be suitable only for short durations.

3.1.2.1 Where the height of the coffer dam is not more than 3 m and the foundations are impervious, a simpler type of coffer dam with two rows of parallel walls of sand bags with the space between them filled with impervious soil can also be adopted.

3.1.3 *Steel Coffer Dams*

3.1.3.1 Steel coffer dams suitable for rocky foundations at very shallow depths are generally of two types, viz, direct strutted steel dam and cantilevered steel dam [refer IS : 4410 (Part VIII)-1968* for definitions]. However, these steel dams are very rarely used as coffer dams.

3.1.3.2 In alluvial reaches, where only limited area is available for construction of a coffer dam, sometimes single steel sheet pile coffer dams of the cantilever type, shown in Fig. 3A may also be used. However, where the bed is rocky, single sheet pile coffer dams of strutted type, shown in Fig. 3B, may be useful.

3.1.3.3 In alluvial reaches, the steel coffer dam used in diversion works of river valley projects mainly refers to steel sheet pile coffer dam. There are two types of such steel sheet pile coffer dams generally in use. They are (i) double wall sheet pile with earth/sand filling type, and (ii) cellular sheet pile with earth/sand filling type.

*Glossary of terms relating to river valley projects : Part VIII Dams and dam section.

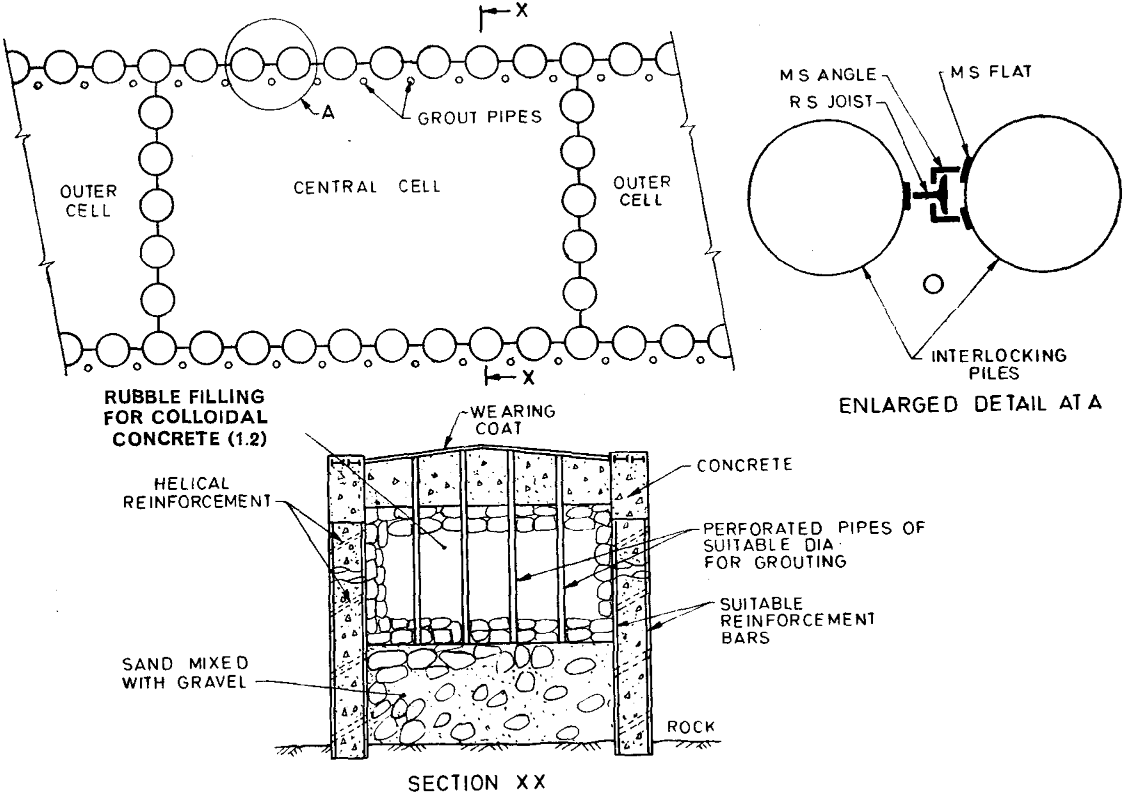


FIG. 1 COLLOIDAL CONCRETE COFFER DAM

3.1.3.3.1 *Double wall sheet pile coffer dam* — For typical section of a double wall sheet pile coffer dam with earth/sand filling, *see* Fig. 3C.

3.1.3.3.2 *Cellular sheet pile coffer dam* — For typical plan of a cellular sheet pile coffer dam with earth/sand filling, *see* Fig. 3D.

3.1.4 *Timber Coffer Dams* — Timber coffer dams suitable for rocky foundations at very shallow depths made of framed members are generally of three types, viz., (i) A-frame type, (ii) rockfilled crib type, and (iii) Beaver type. In view of the high cost of timber in India, this type of coffer dam is not likely to be economical, except in circumstances for low height coffer dams.

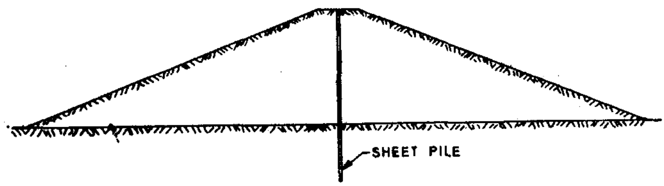
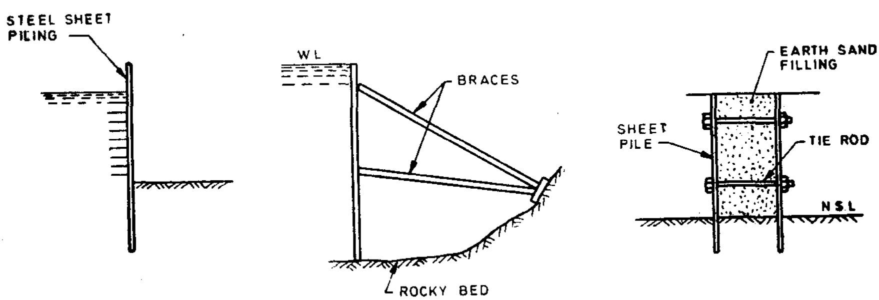


FIG. 2 EARTHFILL/ROCKFILL COFFER DAM WITH SINGLE SHEET PILE AT THE CENTRE

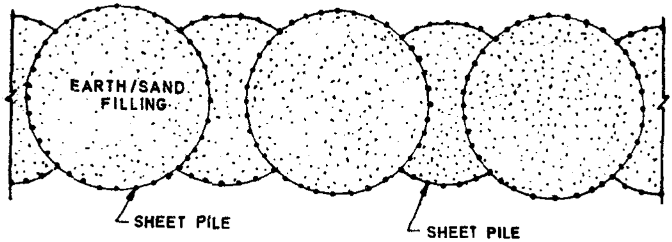


3A Single Sheet Pile Coffer Dam Cantilever Type

3B Single Sheet Pile Coffer Dam Strutted Type

3C Double Wall Sheet Pile Coffer Dam with Earth/Sand Filling

FIG. 3 STEEL COFFER DAM — *Contd*



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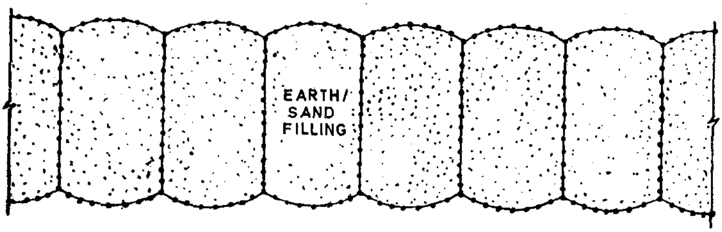

DIAPHRAGM

3D Typical Plan of Cellular Sheet Pile Coffer Dam with Earth/Sand Filling

FIG. 3 STEEL COFFER DAM

4. GUIDELINES FOR SELECTION

4.1 In addition to the criteria of the cost of the structure and the overall economy of the project, there are some specific guidelines which dictate the selection of a particular type of coffer dam. Among these are the availability of space and materials, construction programme, rate of construction, incorporation of coffer dam(s) as part of the main dam, foundation characteristics, river flow conditions and passing of floods. The choice of the different types of coffer dams with reference to these guidelines is given in the following paras. The final choice of the type of coffer dam may be made based on a study of relevant criteria and commensurate with economy.

4.2 Availability of Space

4.2.1 An earthfill/rockfill coffer dam requires more space due to its wider base. For the sites where only limited area is available for construction of the coffer dam over rocky foundations, in addition to masonry/

concrete/colloidal concrete coffer dams, steel and timber coffer dams are also suitable. However, since the latter types can be considered only for depths up to 2 m, for conditions of limited area and rocky foundations, a masonry/concrete coffer dam is better suited than other types.

4.2.2 However, where there is no problem of space for the location of the coffer dam(s), an earthfill/rockfill coffer dam may be the suitable choice.

4.2.3 In alluvial foundations, where limited space is available for construction of coffer dam(s) due to the construction of certain structures like navigation facilities, etc, a double wall steel sheet pile coffer dam with proper earth/sand backing may be preferable.

4.3 Availability of Materials

4.3.1 Where construction materials like earth, rockfill, steel and timber for the construction of coffer dam (s) are not easily available, if foundation conditions and other relevant criteria are satisfied, a masonry/concrete/colloidal concrete coffer dam may be chosen.

4.3.2 However, where sufficient quantities of embankment materials and equipment for the construction of the embankment(s) are easily available an earthfill/rockfill coffer dam is preferable.

4.3.3 The selection of a steel coffer dam will depend on the easy availability of the required steel sections and the necessary accessories in sufficient quantity, besides satisfying the other criteria like depth of water, foundation conditions, etc. In the alluvial reaches, the suitability of steel sheet pile coffer dam will depend on the easy availability of the required sheet pile sections, its quantity and driving equipment and transportation thereof to the site. The availability of the required amount of foreign exchange needed for procurement of sheet piles and their driving equipment is also a factor to be taken note of.

4.3.4 Subject to satisfying other criteria, a timber coffer dam may be chosen where timber is cheap and available in plenty.

4.4 Construction Programme

4.4.1 Where the coffer dam needs to be retained for more than one working season, a masonry/concrete/colloidal concrete coffer dam is preferable, as it can be made to withstand overtopping with proper protection.

4.4.2 However, with the recent advancement in construction techniques, rockfill coffer dams are also sometimes allowed to be overtopped by provision of adequate crated protection. Under such circumstances, rockfill coffer dams may also be considered where they are required to be retained for more than one working season.

4.4.3 Where a cellular type of steel sheet pile coffer dam is preferred due to other criteria, proper protection against overtopping needs to be provided in addition to increased depth of driving and other protective works.

4.5 Incorporation of Coffer Dam as Part of the Main Structure — Where a diversion coffer dam of appreciable volume is to be built up, it can be economically incorporated in the main dam with proper care taken in the design of the main structure. This type of construction is more suitable for earthfill/rockfill dams, than for masonry/concrete/colloidal concrete coffer dams.

4.6 Rate of Construction

4.6.1 As the progress of construction of an earthfill/rockfill coffer dam can be maintained at comparatively higher rates, this type of coffer dam is preferable where the time available for the construction of coffer dam is very limited, subject to availability of space.

4.6.2 As it takes comparatively more time for the construction of a masonry/concrete/colloidal concrete dam than for the other types of coffer dams, the availability of construction time for the coffer dams needs to be kept in view while selecting this type of coffer dam. However, in underwater works, either a earthfill/rockfill coffer dam or a concrete coffer dam may be preferred. The choice of any of these types depends on the different relevant aspects outlined in this standard.

4.7 Foundation Characteristics

4.7.1 Where a rocky foundation is available at the bed level of the river or at very shallow depths, masonry/concrete/colloidal concrete coffer dam, steel and timber coffer dams may be preferable for certain considerations. However, from considerations of depth of water, availability of materials, etc, generally steel and timber coffer dams may not find favour.

4.7.2 An earthfill/rockfill coffer dam is suitable for almost any kind of foundation.

4.7.3 Steel sheet pile coffer dams are preferable for rivers with alluvial beds of great depths and with higher depths of flow in the lean period.

4.8 River Flow Conditions

4.8.1 Where the depth of flowing water in the lean season is low and suitable rocky foundations are available at shallow depths, masonry/

concrete/colloidal concrete coffer dams and steel and timber coffer dams may be preferable. However, subject to the availability of materials, steel and timber coffer dams are not generally useful for depths of water more than 2 m.

4.8.1.1 However, where suitable rocky or boulder foundations are available at shallow depths, but the depth of flowing water in the lean season is more, concrete coffer dams may be useful.

4.8.2 In alluvial reaches, for construction of structures across rivers where the flow during lean period would not go down low at any time, steel pile coffer dams are preferable.

4.8.2.1 For depths of water up to 6 to 8 m, double wall steel sheet pile coffer dams are suitable. Where the depth of water exceeds this value, cellular coffer dams are preferable.

4.8.3 In alluvial reaches, where the estimated scour is of the order of 6 m and more below the river bed during the period of construction and the coffer dam has to remain in position for more than one season, it is preferable to adopt a cellular sheet pile coffer dam.

4.9 The various guidelines and requirements for choosing the type of coffer dam to be adopted have been listed is Table 1 for ready reference.

TABLE 1 GUIDELINES FOR CHOICE OF TYPE OF COFFER DAM

(*Clause* 4.9)

SL No.	TYPE OF COFFER DAM	REQUIREMENT OF SPACE	REQUIREMENT MATERIALS	CONSTRUCTION PROGRAMME	INCORPORATION OF COFFER DAM AS PART OF MAIN STRUCTURE	RATE OF CONSTRUCTION	REQUIREMENT OF FOUNDATION CHARACTERISTICS	REQUIREMENT OF RIVER FLOW CONDITIONS	REMARKS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1.	Earthfill/Rockfill coffer dam	Larger space due to wider base	Sufficient quantities of embankment materials	Any*	More suitable	High	Any kind	Any depth	
2.	Masonry/concrete/colloidal concrete coffer dam	Limited over rocky foundations	Limited over rocky foundations	Any	Suitable	More time required	Rocky bed at bed level or very shallow depths	Any depth	
3.	Steel coffer dam:								
	(a) Single sheet pile with fill on both sides	Larger space due to wider base	Sufficient quantities of embankment materials	One working season	—	More time required	Alluvial bed of great depth	Depth of flow up to 2 m	

(b) Double-wall sheet pile	Limited over alluvial foundation	Sufficient quantities of required sheet-pile section	Any*	—	More time required	Alluvial bed of great depth	Depth of flow up to 6 to 8 m
(c) Cellular sheet pile	Larger space	Sufficient quantities of required sheet-pile sections	Any*	—	More time required	Alluvial bed of great depth	Depth of flow up to 8 m and estimated scour of the order of 6 m or more below bed level
4. Timber coffer dam	Limited over rocky foundations but depths of water up to 2 m only	Sufficient quantities of timber at cheap rates	One working season	—	More time required	Rocky bed at bed level or very shallow depths	Depth of flow up to 2 m

*When coffer dams are required to be retained for more than one working season, special protection measures/treatment shall have to be provided to withstand overlopping during floods.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Definition
Force	newton	N	1 N = 1 $kg.m/s^2$
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	H	1 H = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2