IS 10084-1 (1982): Criteria for design of diversion works, Part 1: Coffer dams [WRD 22: River Training and Diversion Works]

BLANK PAGE

IS : 10084 (Part I) - 1982
(Reaffirmed 2012)

Indian Standard

CRITERIA FOR DESIGN OF DIVERSION WORKS

PART I COFFER DAMS

UDC 627·47 : 624·04

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 5

December 1982

Indian Standard

CRITERIA FOR DESIGN OF DIVERSION WORKS

PART I COFFER DAMS

Diversion Works Sectional Committee, BDC 51

Chairman	*Representing*
SHRI O. P. DATTA	Beas Dam Project, Talwara Township
Members	
SHRI R. N. BANSAL (*Alternate* to Shri O. P. Datta)	
CHIEF ENGINEER (PROJECT)	Irrigation Department, Government of Punjab
SUPERINTENDING ENGINEER (*Alternate*)	
DIRECTOR (B & CD-I)	Central Water Commission, New Delhi
DEPUTY DIRECTOR (B & CD-I) (*Alternate*)	
SHRI V. K. GUPTA	Engineer-in-Chief's Branch, Ministry of Defence
SHRI J. R. D'GAMA (*Alternate*)	
SHRI S. L. GUPTA	National Hydroelectric Power Corporation Ltd, New Delhi
SHRI HARI MOHAN	Irrigation Department, Government of Uttar Pradesh, Lucknow
SHRI N. K. GUPTA (*Alternate*)	
SHRI Y. K. MEHTA	Concrete Association of India, Bombay
SHRI M. G. DANDAVATE (*Alternate*)	
SHRI T. S. MURTHY	National Projects Construction Corporation Ltd, New Delhi
SHRI S. K. MURTHY (*Alternate*)	
SHRI P. V. NAIK	The Hindustan Construction Co Ltd, Bombay
SHRI M. V. S. IYENGAR (*Alternate*)	
SHRI C. B. PATEL	M. N. Dastur & Co Pvt Ltd, Calcutta
SHRI S. R. PINHEIRO	M/s Gammon India Ltd, Bombay
SHRI S. V. CHOUKULKAR (*Alternate*)	
SHRI P. V. RAGHAVENDRA RAO	Andhra Pradesh Engineering Research Laboratories, Hyderabad
SHRI M. A. RAHEEM (*Alternate*)	
SHRI K. RAMACHANDRAN	Public Works and Electricity Department, Government of Karnataka, Bangalore
SHRI S. R. SUBBA RAO (*Alternate*)	
SHRI P. C. SAXENA	Central Water & Power Research Station, Pune
SHRI N. V. PRAHLAD (*Alternate*)	

(*Continued on page* 2)

(*Continued from page* 1)

Members	*Representing*
SENIOR ENGINEER	Ministry of Railways, New Delhi
SHRI R. C. SINGH	Public Works Department, Government of Himachal Pradesh, Simla
SUPERINTENDING ENGINEER	Irrigation Department, Government of Maharashtra, Bombay
SUPERINTENDING ENGINEER	Public Works Department, Government of Tamil Nadu, Madras
EXECUTIVE ENGINEER (*Alternate*)	
SHRI G. VENKATESULU	Ministry of Shipping and Transport (Roads Wing), New Delhi
SHRI M. V. SHASTRI (*Alternate*)	
SHRI J. C. VERMA	Bhakra Management Board, Nangal Township
SHRI JAMIT SINGH (*Alternate*)	
SHRI G. RAMAN, Director (Civ Engg)	Director General, ISI (*Ex-officio Member*)

Secretary

SHRI V. KALYANASUNDARAM
Assistant Director (Civ Engg), ISI

Indian Standard

CRITERIA FOR DESIGN OF DIVERSION WORKS

PART I COFFER DAMS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 29 January 1982, 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 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. An efficient scheme of diverting the river flow away from the work area should be capable of 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 of 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.

Reference may be made to IS : 9795 (Part I)-1980* for the proper choice of the type of coffer dam after considering all the relevant aspects mentioned in the standard.

*Guidelines for choice of the type of diversion works: Part I Coffer dams.

0.4 The successful planning and construction of any major project depends on the proper design and execution of the coffer dam selected for the purpose of temporary river diversion. Hence, a safe design of coffer dam in order to avoid unanticipated/uncalculated risks and calamities during construction of the project is very important. However, it is paradoxical to note that in the design of a coffer dam, which is a temporary structure, certain calculated risks may have to be taken to effect economy on the overall cost of the project.

0.5 This standard is among a group of standards covering the choice, design and construction of coffer dams. The standards already published in this series are IS : 9461-1980* and IS : 9795 (Part I)-1980†.

0.6 In the formulation of this standard, due weightage has been given to the practices prevailing in the field in this country. Assistance has also been derived from the publications given below:

1. White (L) and Prentis (E A). Coffer dams. Columbia University Press, New York 1950.
2. Packshaw (S). Coffer dams. Journal of Institution of Civil Engineers, Vol. 21, pp. 367-398, Feb 1962.
3. Cummings (E M). Cellular coffer dams and docks. ASCE, Vol. 83 (WW3), Proc. Paper 1366, Sept 1957.
4. Swatek (E P). Cellular coffer dams, design and practice. ASCE, Proc. Paper 5398, Aug 1967, WW3, p. 109.
5. Tomlinson (M J). Foundation design and construction. English Language Book Society and Pitman, 1975.
6. Teng (W C). Foundation design. Prentice Hall of India Private Ltd. 1962.
7. Jumkis (A R). Soil Mechanics. D. Van Nostrand Co, Inc., New York 1969.
8. Steel sheet piling cellular coffer dams on rocks. TVA Technical Monograph No. 75, Vol. 1, Dec 1957.
9. Karl Terzaghi. Stability and stiffness of cellular coffer dams. Trans ASCE, Vol. 110, pp 1083-1119, 1945.
10. Williams P. Creager, Joel D. Justin and Julian Hinds. Engineering for dams. Vol. III. John Wiley & Sons Inc. 1945.
11. Design of pile structures and foundations. U.S. Army Corps of Engineers – EM 1110-2-2906. 1958.

*Guidelines for data required for design of temporary river diversion works.
†Guidelines for choice of type of diversion works: Part I Coffer dams.

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

---

1. SCOPE

1.1 This standard covers the criteria for the design of coffer dams of different types, namely, masonry/concrete/colloidal concrete, earthen, rockfill, steel and timber coffer dams.

2. TERMINOLOGY

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

3. DATA REQUIRED

3.1 Data required shall be collected in accordance with IS : 9461-1980‡.

4. GENERAL DESIGN REQUIREMENTS

4.1 General — The safety of the coffer dam against failures depends on proper hydraulic and structural designs. The hydraulic design relates to the behaviour of the river during the different seasons of the year, bed profiles, scouring, silting, velocity, afflux, etc. The structural design relates to the overall stability and safety of the coffer dam structure as a whole and also of each one of its members. Since a wrong hydraulic design and/or a faulty structural design may lead to structural failure and consequential costly and time-consuming remedial measures, the correct estimation of the river hydrology and other design data is very important. These are listed below.

4.1.1 *Design Flood* — The coffer dam being a temporary structure is normally designed for a flood with frequency less than that for the design of the main structure. The choice of a particular frequency shall be made on practical judgement keeping in view the construction period and the stage of construction of the main structure and its importance. Accordingly, the design flood is chosen.

---

*Rules for rounding off numerical values (*revised*).
†Glossary of terms relating to river valley projects: Part XII Diversion works.
‡Guidelines for data required for design of temporary river diversion works.

For seasonal coffer dams and the initial construction stages of the main structure, a flood frequency of 20 years or more can be adopted. For coffer dams to be retained for more than one season and for the advanced construction stage of the main structure, a flood of 100 year frequency may be adopted*.

4.1.2 *Effect of Wind* — While fixing up the top level of the coffer dam, adequate free board shall be kept, so that over-topping of the coffer dam due to waves created by wind action is avoided.

The height of the waves may be calculated by the formula,

$$h_w = 0{\cdot}0322\sqrt{FV} + 0{\cdot}763 - 0{\cdot}271\sqrt[4]{F}$$

where

h_w = height of waves in 'm' measured between trough and crest.

F = Fetch of reservoir in km.

V = velocity of wind on the water surface in km per hour.

For fetches more than 32 km,

h_w may taken as $0{\cdot}0322\sqrt{FV}$

A free board of $1{\cdot}5\ h_w$ may be provided.

4.1.3 *Effect of Earthquake* — As coffer dams are temporary structures, generally earthquake factor need not be considered in the designs.

4.1.4 *Seepage* — Although the area enclosed by the coffer dam is supposed to be dry, nevertheless seepage takes place through the body and foundation of the coffer dam. This may be kept to the minimum by suitably treating the foundations by grouting, sheet piling, diaphragm, etc, if considered necessary and by proper selection of construction materials and methods.

4.1.5 *Scouring* — In the design of coffer dams, it becomes essential to consider various possible and feasible alternative sequences of construction. A preliminary and quick design of the various alternatives has to be done to assess whether the sequence conceived is feasible hydraulically and to choose the best scheme of construction from among them. For this purpose, an estimation of the scouring by any of the available standard method may be done.

---

*Specific comments are invited on this clause about the flood frequency adopted in the respective project.

4.1.6 *Obstruction to River Flow During Working and Monsoon Seasons* — An idea of the waterway available in the river section after the construction of the coffer dam as compared to what was originally available needs to be obtained for some selected discharges and for all construction stages during both working and monsoon seasons. It has to be ensured that sufficient waterway (including allowance of discharges over constructed portion of the main structure) has been provided for the flow, so that problems due to excess velocities, scours, etc may not arise.

5. PRELIMINARY LAYOUT PROPOSALS OF COFFER DAM

5.0 Having selected the type of coffer dam based on the guidelines given in IS : 9795 (Part I)-1981*, it is necessary to consider all feasible layout proposals with the types of coffer dams chosen. The following criteria may be useful while formulating the coffer dam layout proposals.

5.1 Length of Coffer Dam — The length of the coffer dam will depend upon the length and width of the area to be enclosed.

5.2 Working Space — For all layout proposals of coffer dams, criterion of suitable working space shall be kept in view.

5.3 Width of Unobstructed River — The quantum of construction and the cross-section of the coffer dam will govern the width of unobstructed river. For all the layout proposals, suitable preliminary dimensions may be assumed. It should be ensured, however, that high afflux is not created, as otherwise high scouring velocities at the toe of the coffer dams may be generated and the surrounding areas may be submerged requiring compensation.

5.4 Clear Length of the Structure — The clear length of the main structure which is proposed to be taken up in stages and the clear length of the structure already constructed will also govern the coffer dam layout proposals.

5.5 Passage of Floods through Structure — The coffer dam layout proposals will be governed by the clear length of the completed structure through which the river discharge is allowed to flow.

5.6 The criteria enunciated in **5.1** to **5.5** may be applied to the different proposals for all the selected discharges and for all the construction stages. Based on the results of such a study from hydraulic considerations, one or two schemes of the various layout proposals may be chosen for final detailed study.

---

*Guidelines for choice of type of diversion works: Part I Coffer dams.

6. FINAL SELECTION OF COFFER DAM LAYOUT PROPOSALS

6.1 After selecting one or two layout proposals based on the criteria enunciated in **4**, the final choice of coffer dam layout to be taken up for detailed designs shall be done depending upon (a) detailed hydraulic computation and hydraulic model studies wherever required (b) requirement and availability of machinery and equipment, (c) construction feasibility, and (d) economy. Subject to the limitations of the model studies, qualitative results of scour, velocity, intensity of discharge, flow pattern, etc shall be obtained and critical areas of the coffer dam needing extra precautions and provisions in the designs shall be ascertained.

7. DESIGN CRITERIA FOR DIFFERENT TYPES OF COFFER DAMS

7.1 Having made the final selection of the coffer dam and its layout to be adopted, the detailed designs shall be taken up. The criteria to be generally adopted for each type of coffer dam are given in **7.2** to **7.6**.

7.2 Masonry/In situ Concrete/Colloidal Concrete Coffer Dam

7.2.1 The criteria for the design of solid gravity coffer dam made up of masonry or concrete or both, constructed in situ are as follows: Reference may also be made to IS : 6512-1972*.

7.2.2 *Requirements of Stability*

7.2.2.1 The design shall specify the following requirements of stability:

a) The coffer dam shall be safe against overturning at any plane within the dam, at the base, or at any plane below the base.
b) The coffer dam shall be safe against sliding on any plane or combination of planes within the dam, at the foundation or within the foundation.
c) The unit stresses developed in the masonry or concrete of the coffer dam or in the foundation material shall not exceed the permissible values.
d) For compressive stresses, the permissible stress shall be increased by 20 percent of the provisions contained in **5.12.2.2**a) of IS : 6512 -1972*. On the tension side, a stress equal to 1/15 of the permissible compressive stress may be allowed.

7.2.3 *Forces to be Considered in the Analysis of Stability*

*Criteria for design of solid gravity dams.

7.2.3.1 The following forces are to be considered in the design of gravity coffer dam:

a) Dead load;
b) Hydrostatic pressure, including velocity head;
c) Uplift pressures;
d) Earth and silt pressures; and
e) Reaction of foundation.

7.2.3.2 The forces to be considered in the stability analysis of the coffer dam which fall into two categories are as given below:

a) Forces, such as self weight, weight of the water and water pressures which are directly calculable from the unit weights of the materials and properties of fluid pressures; and
b) Forces, such as uplift, silt pressure, etc, which can be assumed only on the basis of the data available for existing structures, experience and judgement.

7.2.3.3 For consideration of stability certain assumptions are made for which reference may be made to clause **3.3** of IS : 6512-1972*.

7.2.4 *Free Board* — Free board for the coffer dam may be adopted as per provisions given in **4.1.2**.

7.2.5 *Foundation Conditions* — The structural competency of the foundation should be examined carefully before the foundation grade is decided upon. When the quality of foundation material approaches or falls below that of the masonry/concrete of the structure on it, the stresses developed at the foundation will have to be based on the strength properties of the foundation rock. Correct evaluation of the strength properties of the rock is necessary in the design of a gravity coffer dam. Wherever necessary, proper foundation treatment has to be ensured.

7.2.6 *Load Combinations*

7.2.6.1 *General* — Design of coffer dam shall be based on the most adverse combination of the probable load conditions which are most likely to occur. Combinations of transient loads which have little or no probability of occurrence are not generally considered in the design of coffer dam.

7.2.6.2 *Loading condition* — The gravity coffer dam design shall be based on the loading condition given below using the factor of safety suggested in **7.2.9.3**.

*Criteria for design of solid gravity dams.

Loading Condition — Maximum water elevation on the upstream face, uplift and silt pressure (if applicable) with no tail water.

7.2.7 *Design Criteria* — The dead load, upstream and downstream water loads, uplift, etc considered in the design of coffer dam, are generally calculated in conformity with the provisions given in IS : 6512-1972*. If the coffer dam is to be built as part of the main dam, the unit weight of the material of the coffer dam shall be based on actual test data. The water level on the upstream side shall correspond to the flood of the frequency for which the coffer dam is being designed (refer **4.1.1**). The uplift shall be taken as varying linearly from the appropraite upstream water level to the downstream water level acting on full area, since uplift relief arrangements are not generally made in coffer dam.

7.2.7.1 *Resistance against overturning*

7.2.7.1.1 Before the coffer dam overturns bodily, other types of failures may occur, such as cracking of the upstream material due to tension, crushing of toe material and sliding. A gravity coffer dam is, therefore, considered safe against overturning if the following criteria are satisfied.

a) The resultant of all forces shall normally fall within the middle third of the base.

b) The maximum compressive stresses at any point within the coffer dam and in the foundation below for the worst combination of loading shall be within the permissible values for the dam and foundation materials respectively.

7.2.7.2 *Resistance against sliding*

7.2.7.2.1 Many of the loads on the coffer dam are horizontal or have horizontal components which are resisted by frictional or shearing resistance along the horizontal or nearly horizontal planes in the body of the coffer dam and on the foundation. The stability of a coffer dam against sliding is evaluated by comparing the minimum total available resistance along the critical plane of sliding to the total magnitude of the forces tending to induce sliding.

7.2.7.2.2 The factor of safety against sliding may be computed by the following equation:

*Criteria for design of solid gravity dams.

$$F = \frac{(W-U)\tan\phi + CA}{P}$$

where

F = factor of safety;

W = total weight of the dam;

U = total uplift force;

$\tan\phi$ = coefficient of internal friction of the material;

C = cohesion of the material at the plane considered, if existing

A = area under compression; and

P = total horizontal force, including earthquake forces, considered, if any.

The values of cohesion and internal friction of the materials along the plane considered for analysis may be assumed, based on the available data on similar or comparable materials.

7.2.9.3 The factor of safety shall not be less than 3·0 for the load condition mentioned in **7.2.6.2**.

7.3 Earthen Coffer Dam

7.3.1 While designing an earthfill coffer dam, it has to be ensured that it shall remain safe and stable during all phases of construction and its existence in the river. The following criteria shall be generally observed:

a) Sufficient free board (*see* **4.1.2**) shall be provided for the coffer dam, so that no overtopping occurs due to the anticipated design construction flood and wave action;

b) The seepage flow passing through the earthfill coffer dam and its foundation shall be so controlled as to avoid damages due to piping, sloughing and removal of material by solution and to keep it as minimum as possible; and

c) The slopes of the embankment, on both water and dry sides, shall be stable under all conditions of construction and after completion including sudden draw down of the pond created.

7.3.2 *Preliminary Dimensions*

7.3.2.1 Preliminary dimensions of parameters, such as free board, top width and side slopes, may be assumed to get an approximate section of the earthfill coffer dam. The assumed slopes of the coffer dam shall be analysed for their stability for possible drawdown conditions, etc and modified if found necessary. Guidelines for fixing these preliminary dimensions are given below.

7.3.2.2 *Free board* — Free board for the coffer dam may be adopted as per provisions given in **4.1.2**. While fixing the freeboard, the possible settlement of the fill should be kept in view.

7.3.2.3 *Top width* — The top width of the coffer dam normally depends on stability and practical requirements for safe passage of all heavy earth moving equipment used in the construction of the main work and practicability of construction.

7.3.2.4 *Side slopes* — The side slopes of the earthen coffer dam depend on the height of the coffer dam and the nature of the soil. Since coffer dams are built as temporary structures and the desirable compaction may not always be possible as in the case of the main structure, generally flatter slopes are adopted for the sides. Slopes of 2·5 : 1 to 3 : 1 on the upstream side (water side) and 2 : 1 to 2·5 : 1 on the downstream side (dry side) if constructed in dry condition and flatter slopes for under-water construction may have to be adopted, depending upon the foundations, construction materials and type of construction.

7.3.3 *Design Analysis* — The design analysis of earthfill coffer dam shall be carried out similar to the analysis of an earthfill dam. For detailed analysis, references may be made to IS : 7894-1975* and IS : 8826-1978†.

7.3.3.1 The factor of safety under worst loading conditions shall be greater than unity.

7.4 Rockfill Coffer Dam

7.4.1 *Design Criteria* — For a safe and stable rockfill coffer dam, the following criteria shall generally be observed:

a) Sufficient free board (*see* **4.1.2**) shall be provided for the coffer dam so that no overtopping occurs due to the anticipated design construction flood and wave action. However, where an over-topping type of rockfill coffer dam is proposed, adequate crated protection shall be provided;

b) The foundation shall not be subjected to material settlement or to erosion from seepage passing through or/and under it;

c) The upstream and downstream slopes of the rockfill coffer dam shall be suitable for the material proposed to be used in the construction of the coffer dam;

d) The rockfill coffer dam shall be safe against sliding;

*Code of practice for stability analysis of earth dams.

†Guidelines for design of large earth and rockfill dams.

e) For minimising the seepage through the body of the coffer dam, an impervious central earth core or upstream impervious membrane formed of (i) earth (ii) wood, (iii) bituminous concrete, or (iv) concrete shall be provided. If concrete facing is proposed to be used as an upstream impervious membrane, all the specifications and precautions for reinforced concrete laid down in the relevant Indian Standards shall be observed; and

f) Adequate provision for passage of the diverted river discharge shall be made.

7.4.2 *Preliminary Dimensions*

7.4.2.1 Certain preliminary dimensions of parameters, such as free board, top width, side slopes, and impervious central core/upstream impervious facing, may be assumed to get an approximate section of the rockfill dam which shall be further analysed for stability of slopes. If the analysis indicates any modifications to be done to the assumed section, these may be incorporated for further review and adoption for construction. Guidelines for fixing these preliminary dimensions are given below.

7.4.2.2 *Free board* — The free board for the coffer dam may be adopted as per provisions given in **4.1.2**; while fixing the free board, the possible settlement of the fill should be kept in view.

7.4.2.3 *Top width* — The top width of the rockfill coffer dam normally depends on stability and practical requirements for safe passage of all heavy equipment moving over the coffer dam and practicability of construction.

7.4.2.4 *Side slopes* — The upstream slope generally varies from 1·5:1 to 1:1, depending on the position of the impervious material used in the section, that is, upstream membrane or central core and conditions of construction, that is, under water or in dry condition. The downstream slope may vary between 1·25:1 and 1·5:1.

7.4.2.5 *Impervious central core/upstream facing* — The rockfill coffer dam may be made watertight by provision of an impervious central core/impervious facing on the upstream slope placed in such a manner as to obtain some degree of flexibility up to the cut-off wall at the upstream toe. The facing may be of earth, wood, concrete or bituminous concrete, etc.

7.4.3 *Design Analysis*

7.4.3.1 *Sliding* — Rockfill coffer dam with an impervious central core/upstream face would have a relatively high factor of safety against sliding because of the large mass involved. Adequacy of the foundation shall also be checked. However, the factor of safety against sliding between the rockfill material and the impervious core/membrane shall invariably be checked, as this is very important.

7.5 Steel Coffer Dam — The steel coffer dams discussed in this standard refer to the direct strutted and cantilever types [*see* IS : 4410 (Part VIII)-1968*] and the steel sheet pile coffer dams of double walled and cellular types.

7.5.1 *Direct Strutted and Cantilever Types* — The general theory for the design of direct strutted and cantilever types of steel coffer dam is same as that for hollow concrete dams.

7.5.1.1 *Slope of face* — The upstream of the steel coffer dam shall not be kept flatter than 1:1 and it may vary up to 1:1·5.

7.5.1.2 *Face plates* — The deck shall be made up of cylindrically curved plates, placed concave to the water. These plates may be either rivetted and caulked or welded to make a perfectly watertight face. To allow for a reasonable amount of corrosion, suitable allowance should be made in the design.

7.5.2 *Double Wall Steel Sheet Pile Type*

7.5.2.1 A double wall steel sheet pile coffer dam consists of two parallel sheet pile walls with a good solid fill in between them. To obtain more security and stability, the two-sheet pile walls are sometimes connected by steel ties.

7.5.2.2 *Design criteria* — Design of a double wall sheet pile coffer dam involves the design of the sheet piles and the width of the coffer dam. These are outlined below.

7.5.2.3 *Design of sheet piles* — The inner and outer sheet piles shall be designed individually as single wall coffer dam. The inner sheet pile is subjected to the pressures from the wall fill and the ground pressures. Reckoning these forces, the required section modulus Z and also the minimum penetration depth P for resisting the forces shall be calculated for the inner sheet pile. The outer sheet pile is subjected to the water pressure and pressure from the wall fill plus the ground pressures with estimated scour on the upstream side having occurred. The section modulus Z and the minimum penetration depth $P1$ of the sheet pile to resist the forces shall be calculated, as done for the inner sheet pile.

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

Knowing the values of the two section moduli and minimum penetration depth, if the differences between the two sets of values are not considerable, the same type of sheet piles with the same lengths shall be adopted.

Where the two rows of sheet piles are connected by tie rods, the design of tie rods shall be done to transmit the loadings from one component to the other of the bulk head. Use of more tie rods results in lesser bending moments in sheet pile and lesser anchor pull.

7.5.2.4 *Design of width of coffer dam* — For designing the width of the double wall sheet pile coffer dam, it shall be treated as a self-supporting gravity structure. The width of the coffer dam shall be the minimum satisfying these requirements consistent with safety and economy.

Selection of the width — The minimum width of the coffer dam is given by the equation:

$$b_{min} = \sqrt{\frac{6\,M}{\gamma_1 H_w + \gamma_2 P}}$$

where

M = net moment,
H_w = depth of water,
P = penetration depth,
γ_1 = unit weight of soil above bed level, and
γ_2 = unit weight of soil below bed level.

The values of moments for different values of P and hence b_{min} shall be computed and the minimum of the different values of b_{min} shall be adopted as the base width of the double wall sheetpile coffer dam. For calculations of the value of M, the sheet pile is generally treated as a fixed cantilever wall without anchorages.

However, if the width 'b' is fixed from any other considerations, it shall be checked that the base pressures developed are less than the allowable stresses. If the allowable stresses in the sheet piles are assumed with a good margin of safety, the possibility of secondary stresses developing in the inner face of sheet pile wall may generally be ignored.

7.5.2.5 *Forces acting on the coffer dam* — The following forces acting on the double wall coffer dam shall be considered (*see* Fig. 1):

a) the net water pressure on the outer face, F_4;
b) the active earth pressure on the outer face, F_1;
c) the passive earth pressure on the inner face, F_2;
d) weight of the wall fill, G; and
e) horizontal frictional force at the foot of the sheet piles, F_3.

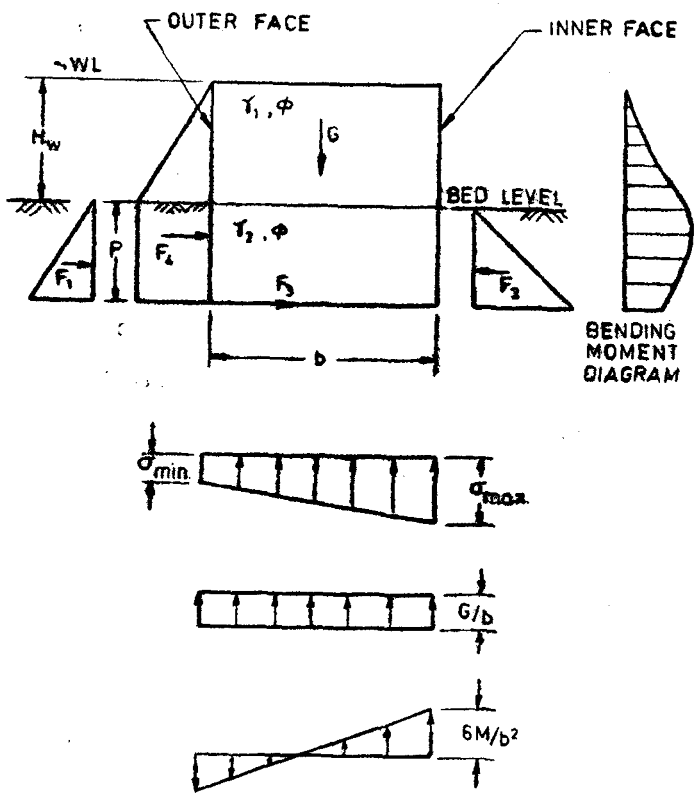

FIG. 1 FORCES ACTING ON A DOUBLE WALL COFFER DAM

7.5.2.6 *Design requirements* — The design of double wall coffer dam shall satisfy the following conditions of equilibrium:

a) Σ horizontal forces $=0$
b) Σ moments $=0$
c) $(F_4+F_1-F_2) \leqslant G \tan \phi \; (F_3)$

Further, the resultant of all forces shall lie within the middle third of the base, since earth cannot take any tensile force. The compressive stresses developed at the foot of the sheet pile shall be within the bearing capacity of the foundation soil.

7.5.3 *Cellular Steel Sheet Pile Coffer Dam* — Cellular steel sheet pile coffer dams are of two types, namely, circular type and diaphragm type. In the circular type, each cell can be constructed independently and forms stable unit by itself. Hence, circular type provides high safety during construction and high structural stability. But the wall width is limited by interlock tension of the steel sheet piling. In the diaphragm type of sheet pile coffer dam, the wall width can be enlarged without increasing the interlock tension of the steel sheet piling. Unlike circular type, each cell is not independent and failure of one cell affects the other.

7.5.3.1 The design of cellular steel sheet pile coffer dam comprises two parts: (a) layout and (b) stability analysis of the cellular coffer dam.

7.5.3.2 *Layout of cellular steel sheet pile coffer dam* — For details of the layout of circular type and diaphragm type of cellular steel sheet pile coffer dams, reference may be made to IS : 9527 (Part IV)-1980*.

7.5.3.3 The following forces shall be considered in the design of the cell structures:

a) Active lateral earth pressure at the backside of the wall,
b) Passive lateral earth pressure at the front of the wall,
c) Lateral earth pressure of the fill,
d) Residual water pressure,
e) Mass of the fill,
f) Wave force,
g) Seismic force, and
h) Any other force peculiar to a particular situation.

7.5.3.3.1 For the various other design considerations of cellular steel sheet pile coffer dam, reference may be made to IS : 9527 (Part IV)-1980*.

7.5.3.4 *Stability requirements* — The stability of the cellular steel sheet pile coffer dam shall be checked for:

a) cell shear,
b) sliding,
c) tilting,
d) bursting of cell, and
e) soil support.

7.5.3.4.1 Regarding the analysis and details of stability requirements, reference may be made to IS : 9527 (Part IV)-1980*.

---

*Code of practice for design and construction of port and harbour structures: Part IV Cellular steel pile structures.

7.5.3.4.2 The cellular sheet pile coffer dam shall be designed as a gravity structure well founded on rock, concrete or any other hard strata. For sand, clay or any other pervious foundation the required depth of penetration of the sheet piles shall be determined by the condition that the bearing capacity of the sheet piles per unit of width should be equal at least to 1.5 times the shearing force which acts per unit of width between the fill and the length rows of sheet piles at maximum over-turning moment. Since the vertical forces that act on the sheet piles can be estimated in advance, the required depth of sheet pile penetration can be determined by means of pulling tests on test sheet piles in the field. Alternatively the sheet piles have to be driven minimum to a depth of at least 2/3 H into the sandy/clayey foundation where H is the height of the coffer dam above the river bed.

7.6 Timber Coffer Dam

7.6.1 *Design Considerations* — The use of timber coffer dam is very much limited due to its non-suitability for great depths, frequent leakages and maintenance problems. However, where timber coffer dams are selected as per criteria laid down in IS : 9795 (Part I)-1981*, their stability has to be ensured against sliding overturning and strength of timber. Where timber coffer dams are adopted over alluvial foundations, they have to be protected against erosion also.

7.6.1.1 *Stability against sliding* — The theory of the design of masonry dams is applicable for all types of timber coffer dams also. In timber coffer dam, uplift is not present. Only the effective weight of the rockfill allowing for submergence below the tail water if any and the percentage of voids in the fill in the case of rockfilled timber crib type shall be considered. For stability against sliding, the effective weight of a rockfilled crib coffer dam on a rock foundation, including the vertical water pressure on the upstream face, usually ranges from 2·5 times the horizontal pressure of water for structures on rough foundations to 4 times the horizontal pressure on smooth foundations. As A-frame and beaver types of timber coffer dams have no rockfill to prevent sliding, their stability depends entirely upon the strength of the pins which fasten the dams to rock foundation, unless the foundation is so rough as to permit a horizontal support for the bottom timbers. The friction of wet timber on stone shall be neglected, as it is very small.

7.6.1.2 *Stability against overturning* — The dimensions of the rockfilled crib type coffer dams shall be so fixed as to prevent overturning.

---

*Guidelines for choice of type of diversion works: Part I Coffer dams.

7.6.1.3 *Strength of timber* — The timbers of the dam shall be investigated for strength to transmit the loads to the foundations. However, in the case of rockfilled crib type of coffer dam, advantage may be taken of the transmission of much of the load through the rockfill which may relieve the stress on the lower timbers.

7.6.1.4 *Protection against erosion* — If the timber coffer dam is to be constructed over alluvial foundations, necessary protection against erosion by the provision of loose stone apron and short piling needed may be ensured.

7.6.1.5 *Prevention of leakage* — If the timber coffer dam rests on a rock foundation, the lagging at the upstream toe shall be framed as closely as possible to the rock and the junction properly sealed, by depositing a layer of concrete against the toe or depositing a fill of impervious earth against the upstream face of the coffer dam where velocities of flow are not high to disturb it. Wherever indicated, necessary foundation treatment may be adopted.

INDIAN STANDARDS

ON

DIVERSION WORKS

IS:

9461-1980 Guidelines for data required for design of temporary river diversion works

9795 (Part I)-1981 Criteria for the choice of type of diversion works: Part I Coffer dams