IS 14955 (2001): Guidelines for Hydraulic Model Studies of Barrages and Weirs [WRD 22: River Training and Diversion Works]

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Indian Standard

GUIDELINES FOR HYDRAULIC MODEL STUDIES OF BARRAGES AND WEIRS

ICS 93.160

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

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Price Group 3

River Training and Diversion Works Sectional Committee, WRD 22

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the River Training and Diversion Works Sectional Committee had been approved by the Water Resources Division Council.

For construction of new barrages/weirs or remoulding of existing barrages/weirs, it is necessary to carry out model studies to get a comprehensive idea regarding hydraulic conditions, layout of the barrage/weir and its appurtenant structures. Many aspects of a barrage/weir are finalized after detailed study of different alternatives on a model. A need has, therefore, been felt to lay down the recommendations for various requirements for model studies so that a methodical uniform approach could be followed by all concerned.

There is no ISO Standard on the subject. This standard has been prepared based on indigenous manufacturers' data/practices prevalent in the field in India.

The composition of the committee responsible for formulating this standard is given in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, should be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

GUIDELINES FOR HYDRAULIC MODEL STUDIES OF BARRAGES AND WEIRS

1 SCOPE

This standard covers the requirements for model studies of barrages/weir. It includes types of model, selection of scale, data required for model studies and observations to be taken on the model and the parameters to be finalized from model studies.

2 REFERENCES

The Indian Standard IS 6966 (Part 1) : 1989 'Guidelines for hydraulic design of barrges and weirs: Part 1 Alluvial reaches (*first revision*)' contains provision which through reference in this text, constitutes provision of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standard.

3 TERMINOLOGY

3.0 For the purpose of this standard, the following definitions and those given in IS 6966 (Part 1) shall apply. A typical layout plan of a barrage with its appurtenant is shown in Fig. 1.

3.1 Divide Wall

A straight and long wall constructed usually at right angles to the barrages axis for separating undersluice pocket from other bays, in order to maintain deep channel infront of head regulator.

3.2 Head Regulator

A gated structure located on the upstream of the undersluices of the barrage for regulating the supplies of the canal.

3.3 Silt Excluder

A diaphragm structure constructed in the extreme undersluice bay of the barrage infront of the head regulator for excluding coarser sediment from entering into the head regulator.

3.4 River Training Works

The training works include guide bunds, afflux bunds and approach embankments, etc. River training works are required to check the out flanking of structures and to guide the river to flow axially through the barrages.

4 MODEL

4.1 Hydraulic models are mainly of two types, namely (a) geometrically similar, and (b) distorted or vertically exaggerated. In the former, all dimensions are reduced to the same scale whereas in the latter, the scales for vertical and horizontal dimensions are different.

4.2 The models may be rigid, semi-rigid or mobile according to requirement of study.

4.2.1 *Rigid Models*

In these models, the sides and bed are made rigid.

4.2.2 *Semi-rigid Models*

In these models, the sides and sometimes part of the bed are made rigid.

4.2.3 *Mobile Models*

In these models, both the bed and the sides are erodible.

4.3 Choice of Scale for Models

4.3.1 Longitudinal scale is determined from consideration of river regime, discharge and space available.

4.3.2 The depth scale should be so fixed that sufficient tractive force is developed for the general movement of bed material used in the model. The movement should start at the discharge corresponding to which bed movement occurs in the prototype. The depth of water at the lowest design discharge in model should be sufficiently large as compared to ripple height. Usually a depth of 8 to 12 cm is considered adequate at lower discharges.

4.3.3 The longitudinal and depth scales in the end decide the requirement of discharge which may be a governing factor. Various scales adopted for some typical model studies of barrages is given in Table 1.

4.3.4 The scale for sediment injection has not been developed so far. As such, the injection rate is found out by trial and error method in model itself.

4.4 Choice of Bed Material

Model bed material is generally kept finer than or the same as that of prototype, the density being almost the same. If the velocities in models are not enough to affect bed movement, lighter material such as coal dust, saw dust, etc, may be used and, if necessary, slope exaggeration may be resorted to.

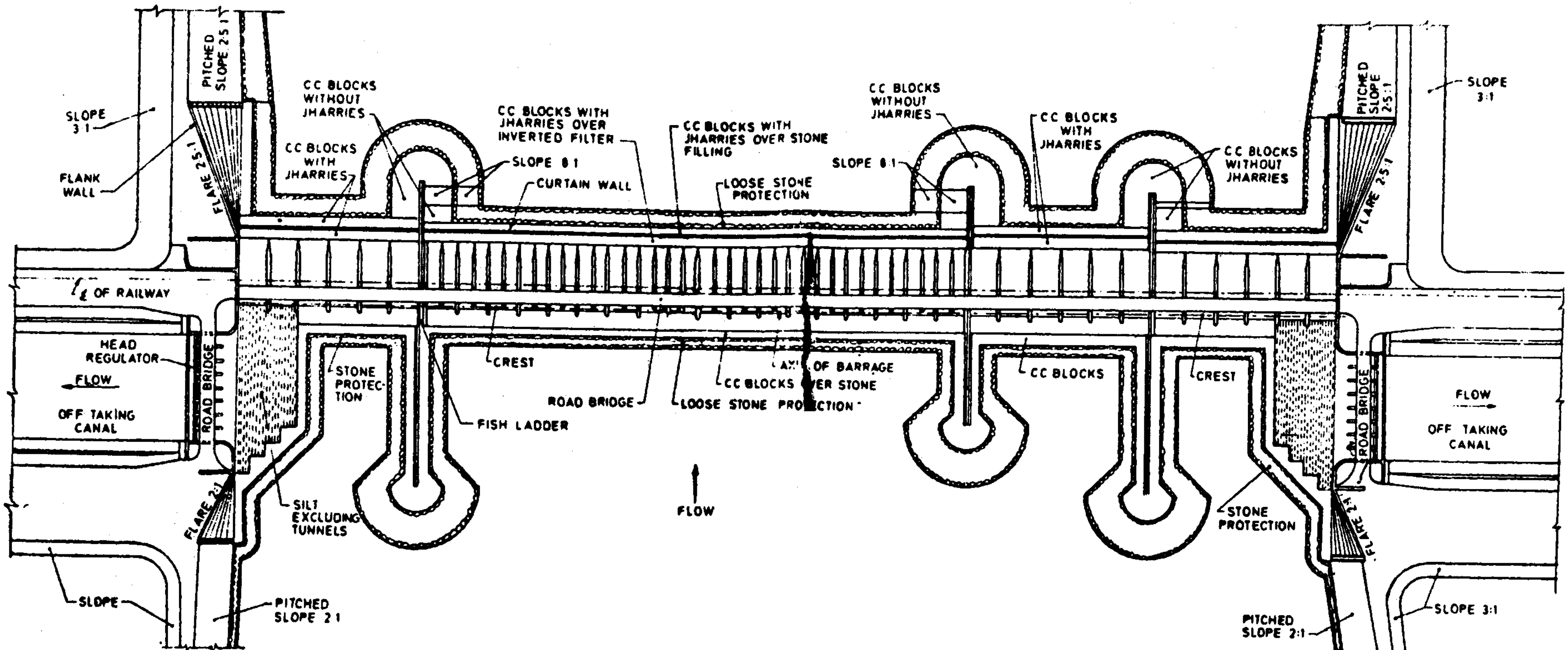

FIG. 1 TYPICAL LAYOUT OF A BARRAGE

4.5 Selection of Models

4.5.1 The model studies for the location of a barrage/ weir, orientation of its axis, waterway and required training works such as, guide bunds, afflux bunds and approach embankments, etc, are generally conducted on distorted models, wherever possible, geometrically similar models may be preferred. However the studies of other appurtenant works such as optimising the length of divide wall, width of undersluice pocket, regulation or operational sequences of gates, silt excluders and ejectors, angle of offtake of canal, etc, are conducted on geometrically similar full or part width model.

4.5.2 The model studies for deciding the profile of the undersluice and barrage bays, length of downstream floors, shape of glacis, piers, energy dissipators, etc, are generally conducted on two dimensional geometrically similar scale models.

4.5.3 In some cases, the model requires to be, tilted where consideration of correct reproduction of water surface slopes in the model and adequate bed movement would require a slope, scale to be different from the vertical exaggeration. In vertically exaggerated models, the natural river slope is magnified to the same extent as the vertical exaggeration. Thus, a scale for the slope in addition to those of length and depth come into consideration. Value of the slope exaggeration is generally equal to the vertical exaggeration. Tilting introduces complexicity in the construction and operation of the model and interpretation of results from such models would require considerable experience and skill.

5 DATA REQUIRED

5.1 General

It should include general information in respect of the project. The information may be compiled in the form of a project report which should include the following:

a) Purpose of the barrage/weir;
b) Behaviour of the river at the proposed site during last 10-20 years;
c) Photos depicting behaviour of the river during floods, if available;
d) Hydraulic design calculations for the waterway including barrage and undersluice bays; and
e) Proposed gate operation schedule of barrage.

5.2 Survey Data

The survey data of site should include the following:

a) Index plan to a scale 1:2 50 000 showing the reach under consideration with latitudes and longitudes. The state, district, important towns or villages tributaries of the river, catchment area, etc, may also be shown on the plan;
b) Survey plan preferably with contour to a scale 1:10 000 covering sufficient reach of the river to be reproduced in the model. The upstream reach should cover at least 2 meander lengths. In the downstream of the proposed site, at least one meander length reach will be sufficient. The survey plan should depict the following:
    i) Latitudes, longitudes and the north-south line;
    ii) Lean weather channel;
    iii) High flood water spread (indicating month, year and discharge);
    iv) Formation of rapids, pools, control sections, etc;
    v) Different channels in case of a braided river;
    vi) Tributaries joining the river; and
    vii) Locations of gauge — discharge sites, important towns and villages in the vicinity;

Table 1 Typical Model Scales Adopted for Various Barrages

(*Clause* 4.3.3)

Sl No.	Name of Barrage	State	River	Design Flood (cumecs)	Scales		Number of Bays		Remarks
					Hor.	Ver.	Spill-way	Under-sluice	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
i)	Hotnikund	UP/Haryana	Yamuna	22 000	1/150	1/50	10	8	One Fish ladder touching right side divide wall
ii)	Samal	Orissa	Brahmani	24 600	1/350	1/70	24	6	One Excluder on left undersluice bay
iii)	Wazirabad	Delhi	Yamuna	7 079	1/150	1/30	17	6	
iv)	Okhla	Delhi	Yamuna	8 495	1/150	1/30	22	5	
v)	Indraprastha	Delhi	Yamuna	8 495	1/150	1/30	22	10	
vi)	Naraj	Orissa	Kathjuri	29 500	1/400	1/66	33	13	

viii) Shoals and submersible land including the extent and nature of vegetation;

ix) Position of existing and proposed structures, namely, bridges, dams, weirs, barrages, ghats, spurs and revetments, etc; and

x) Cross-section lines giving its distance and orientation with respect to some fixed point and reference line;

c) *River Cross-Sections*

The cross-sections should indicate its chainages from some reference line and extend up to affluxed highest flood level. The distance between cross-sections may be kept 50-100 m in a reach of 3 km upstream to 2 km downstream of the barrage site. In the remaining reach on the upstream, the distance may be increased up to 500 m. Bed levels along cross-section should be given at interval of 5 to 10 m in the deep channel and 25 to 50 m in the remaining width. The cross-section should show HFL and LWL.

The cross-sections should be taken in such a way that all important features of the river channel and the flood plan such as mouth of an off-taking channel, their confluence, high grounds if any, less erodable or vertical banks, thick vegetation, etc, are indicated. For this purpose, the distance or orientation or both, between the consecutive sections may be suitably altered, but such alterations must be duly qualified on the survey plan; and

d) Survey plan showing past river courses for as many years as possible, or, if such data are not available, satellite imageries of dry weather channel for different years should be supplied preferably in 1:50 000 scale.

5.3 Hydraulic Data

a) *Gauge Discharge Curve* — Daily gauge and discharge data for as many years as possible for all sites existing in the study reach be given. In case a site does not exist within the above reach, install new gauge/discharge sites, one at the proposed site, one at 1.5 meander length on upstream and one at 0.5 meander length in the downstream and gauge levels at various discharges at the above sites during the first available monsoon season should be noted. The cross-sections of river at the new gauge/discharge sites indicating nature of river bed and the value of Manning's 'n' be supplied;

b) Design and high flood discharges with corresponding water levels;

c) Yearly HFL and corresponding discharge with dates of occurrence for the last 10 years;

d) Maximum flood on record with date of occurrence and corresponding HFL;

e) Discharge distribution in various channels of the river at important stages during the year for which survey plan has been supplied;

f) Proposed pond level or levels;

g) Water surface slope;

h) River discharge above which the off-taking canal/canals should be closed and all the barrage gates fully opened due to excessive sediment charge; and

j) In case of tidal reach, information regarding HTL and LTL of spring and neap tide both during freshets and dry season.

5.4 Sediment Data

a) *Bed Material* — A minimum of three representative bed material samples 1.5 kg each, across a section in the study reach, one at either end and one in the deep channel may be taken at a suitable depth below the bed level considering scour and deposition at site during flood for assessing realistic value of Lacey's silt factor 'f'.

b) *Suspended Load* — An assessment of concentration and characteristics of suspended load may be given at least at 1/3rd, 2/3rd and peak discharges experienced at the proposed site.

c) Information regarding nature of banks whether of uniform material, stratified, rock out-crops kankar, etc, along with their location marked on the plan. Gradation curve of bank material wherever protection is required should also be given.

5.5 Data of Structures

a) General arrangement of drawing showing layout plan of the barrage/weir, head regulator and its appurtenant works;

b) Longitudinal-section and cross-sections of the barrages/weir, head regulator, etc, showing details of all the works;

c) Longitudinal section and representative cross-sections of the canal in a reach of about 2 km from head; and

d) Detailed drawing and hydraulic design calculations of the appurtenant works, namely: (a) guide bunds, (b) divide wall, (c) silt excluder and silt ejector, (d) head regulator (e) fish ladder, (f) navigation locks, and (g) canal.

6 TERMS OF REFERENCE

Exact terms of reference should be stated by the sponsoring authority. The major aspects of a barrage which will be finalized in the model after studying different alternatives are:

a) Orientation and waterway of the barrage;
b) Location of the abutments with respect to the river banks;
c) Crest level and profile of spillway and undersluice bays;
d) Coefficient of discharge for various submergence ratio;
e) Alignment and length of the divide wall both upstream and downstream;
f) Position of canal off-take point and its off-taking angles;
g) Lengths and alignments of the right and left guide bunds both upstream and downstream;
h) Energy dissipation arrangements in spillway bays, undersluice bays and head regulators;
j) Type, levels and lengths of the stilling basins;
k) Silt excluder details, such as length, number of bays, etc;
m) Gate operation schedule during medium and low floods; and
n) Alignment of the afflux bunds, approach embankments, protection upstream and downstream of structures and river training works.

7 MODEL STUDIES

7.1 Proving of the River Model

After constructing the river model without barrage according to supplied data, the model is proved before taking pertinent observations in the model. The model is taken as proved if the following observations of model and prototype tally:

a) Water levels at different sections with ± 0.3 m of prototype values,
b) Curvature of flow,
c) Zone of attack by the current,
d) Tendency of scouring and deposition,
e) Overall flow pattern,
f) Sediment movement, and
g) Activation of channels at a particular discharge.

7.2 Generally the following observations are taken on the model after reproducing the barrage/weir and related structures:

a) Water levels at different locations and discharge for finding out depth of flow, water surface slope and afflux, etc;
b) Velocities at different sections and in bays for determining discharge distribution and concentration of flow including at exit of stilling basin;
c) Velocities along structures for assessing the stability;
d) Angle of approaching flow to assess the obliquity;
e) Surface and bed lines of flow for estimating curvature of flow;
f) Erosion on the upstream and downstream of the barrage;
g) Locating areas where sediment deposition or scour may take place;
h) Differential head at the piers and divide wall;
j) Bed configuration during and after running the hydrograph;
k) Afflux in the river due to structures;
m) Coefficient of discharge for sluicebays, weir bays and head regulator under free flow/critical flow and sub-merged, flow conditions;
n) Energy dissipation in hydraulic jump under different inflow and tailwater conditions. And also for different operating condition of gates;
p) Performance of the basin under oblique approach flow, if any;
q) Flushing of sediments deposited *vis-a-vis* gate operation;
r) Negative head/pressure on spillway nappe/weir glacis and at the toe of spillway near energy dissipation arrangement wherever required;
s) Selection of proper energy dissipation arrangement; and
t) Profile of undersluice and barrage bays.

7.3 Limitation of Model Studies

Model studies only help in finalization of structures. They have their own limitations like difficulties in the reproduction of silt content of water, etc. Hence for some of the studies, the results would give only qualitative idea. Therefore, the designer needs to incorporate the recommendations of the model studies only after careful consideration.

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

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