इंटरनेट मानक

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IS 10751 (1994): Planning and Design of Guide Banks for Alluvial Rivers - Guidelines [WRD 22: River Training and Diversion Works]

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भारतीय मानक

जलीद नदियों के लिए पक्ष-निर्धारक किनारों की योजना तथा डिज़ाईन — मार्गदर्शी सिद्धान्त

(पहला पुनरीक्षण)

Indian Standard

PLANNINGANDDESIGNOFGUIDEBANKS FORALLUVIALRIVERS-GUIDELINES

(First Revision)

UDC 627·41 : 624·04

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

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River Training and Control Works Sectional Committee, RVD 22

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the River Training and Control Works Sectional Committee had been approved by the River Valley Division Council.

Indian rivers in plains are often shallow and flow in a wide alluvial belt, with meandering and/or braiding characteristics. To construct an engineering structure across rivers, it is necessary to narrow down its section and restrict its course of flow centrally through the structure built over it. This is achieved by construction of heavy embankments, called 'Guide Banks'.

Guide banks are thus meant to confine and guide the river flow through the structure without causing damage to it and its approaches. They also prevent the outflanking of the structure.

Guide banks form one of the major and vital constituent of river training works and often a substantial amount of cost of project is spent on them. Thus it is imperative that they must be designed in the most economic and efficient manner.

As a result of researches conducted by various organizations in India and by the knowledge and experience gained from the banks constructed in the past, attempt has been made in this standard to evolve more rational criteria of design for guide banks. A number of factors, which have an important bearing in the design and are still in investigation stage or are not yet universally accepted, have been kept out of the purview of this standard and should be incorporated in subsequent modifications and revisions, thereto. Thus the provisions laid down in this standard are recommendatory in nature, and are intended to lay down guidelines for design, where much depends on the experience and ingenuity of engineers involved in design.

This standard was first published in 1983 under the title Criteria for Design of Guide Banks for Alluvial Rivers'. The revision of the standard has been undertaken to incorporate the latest practices being followed in the field. The important changes in this revision are in respect of design requirements of pitching stone and incorporation of use of filter fabric. The details regarding construction and maintenance of guide banks have been covered in IS 12926 : 1990 'Construction of guide banks in alluvial rivers — Guidelines (under revision)'.

Indian Standard

PLANNING AND DESIGN OF GUIDE BANKS FOR ALLUVIAL RIVERS — GUIDELINES

(First Revision)

1 SCOPE

This standard covers the planning and design of guide banks used for the various engineering structures constructed on the alluvial rivers.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
4410 (Part 3): 1988	Glossary of terms relating to river valley projects: Part 3 River and river training (*first revision)*
8237 : *1985*	Code of practice for protection of slope for reservoir embankment (*first revision)*

3 TERMINOLOGY

For the purpose of this standard, the terms defined in IS 4410 (Part 3): 1988 shall apply.

4 GENERAL DESIGN FEATURES

4.1 Guide banks are constructed in the direction of flow both upstream and downstream of structure, on one or both flanks as required.

4.2 Alignment

4.2.1 The alignment, should be such that the pattern of flow is uniform with minimum return currents.

4.2.2 The alignment and layout are best decided based on model studies.

4.2.3 In case of a head regulator of a canal, constructed adjacent to the main structure, the alignment of the guide bank should further endeavour to induce favourable flow conditions for the entry of water with minimum silt into the canal.

4.2.4 In other cases, guide banks should be so aligned that the flow is uniformly distributed across the waterway as far as possible.

4.3 Classification of Guide Banks

Guide banks can be classified according to:

a) their form in plan, and

b) their geometrical shape.

4.3.1 According to Form in Plan

Guide banks can be divergent ***upstream,*** parallel and convergent upstream (see Fig. 1).

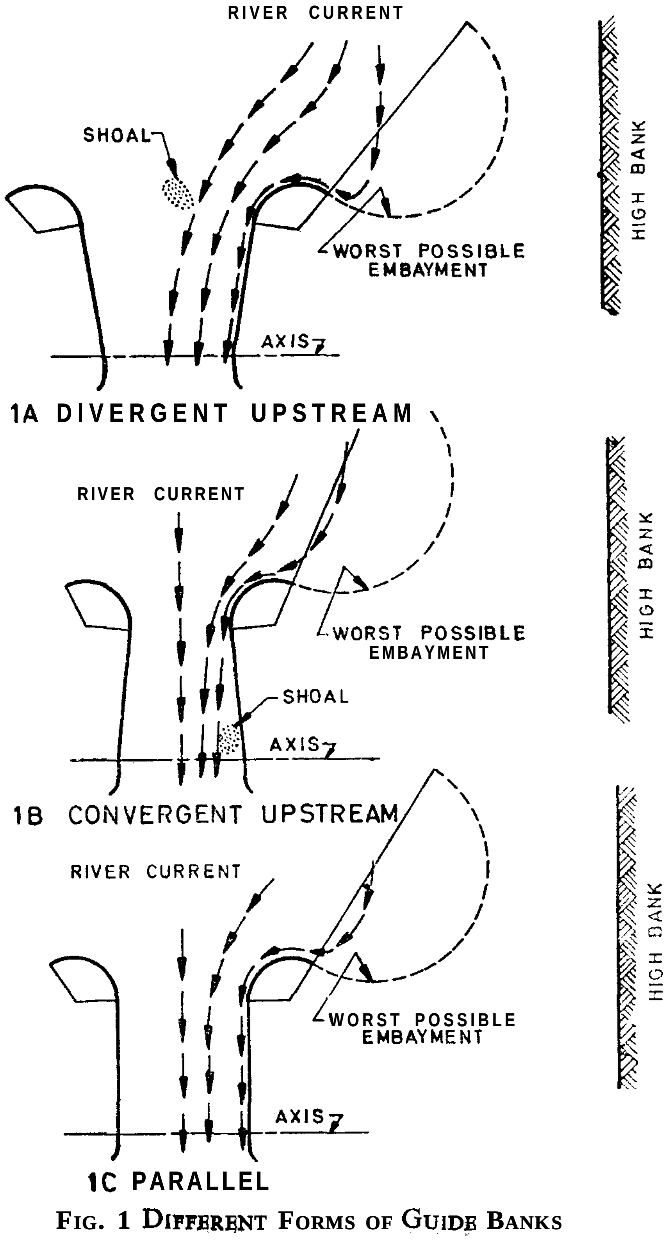


FIG. 1 DIFFERENT FORMS OF GUIDE BANKS

4.3.1.1 *Guide banks divergent upstream*

They exercise an attracting influence on flow and they may be used where the river has already formed a loop and the approaching flow has become oblique to keep flow active in bays adjacent to them. However, the approach embankment gets relatively lesser protection in worst possible embayments compared to equal bank length of parallel guide banks (see Fig. 2).

Divergent guide banks require a longer length in comparison to parallel guide banks for the same degree of protection to approach embankments. However, hydraulically they give better distribution of flow across the waterway.

4.3.1.2 ***Parallel guide banks***

Parallel guide banks with suitably curved heads have been found to give uniform flow from the head of the guide banks to the axis of the structure.

4.3.1.3 ***Guide banks convergent upstream***

Convergent guide banks have disadvantage of excessive attack and heavy scour at the head and shoaling all along the bank rendering the end bays inactive.

4.3.2 ***According to Geometrical Shape***

The guide banks can be straight or elliptical with a circular or multi-radii curved head (see Fig. 3). Elliptical guide banks have been found more suitable in case of wide flood plain rivers for better hydraulic performance. In case of elliptical guide banks, the ratio of major axis to the minor axis is generally in the range of 2 to 3·5.

Due to gradual change in curvature in elliptical guide banks the flow hugs the guide banks all along its length as against separation of flow occurring in case of straight guide banks after the curved head which leads to obliquity and non-uniformity of flow.

4.4 **Other Type of Guide Banks**

Other type of guide banks differing in form mentioned in 4.3.1 or shape mentioned in 4.3.2 may be provided if warranted by site conditions and supported by model studies.

4.5 **Length of Guide Banks**

4.5.1 ***Upstream Length***

4.5.1.1 The general practice is to keep the upstream length of guide banks as 1·0 ***L*** to 1·5 ***L***, where ***L*** is the length of structure between the abutments. For elliptical guide banks the upstream length (that is semi major axis ***a***) is generally kept as 1·0 ***L*** to 1·25 ***L***. This practice is generally applicable where the waterway is within the close range of ***L*** that is, Lacey's waterway.

4.5.1.2 For wide alluvial belt the length of guide banks should be decided from two important considerations, namely (a) the maximum obliquity of current (it is desirable that obliquity of flow to the river axis should not be more than 30"), and (b) the limit to which the main channel of the river can be allowed to flow near the approach embankment in the event of the river developing excessive embayment behind the guide bank. The radius of worst possible loop should be ascertained from the data of acute loops formed by the river during past. In case of river where adequate past surveys are not available, the radius of worst loop can be determined by dividing the average radius of loop worked out from the available surveys of the river by 2·5 for river having a

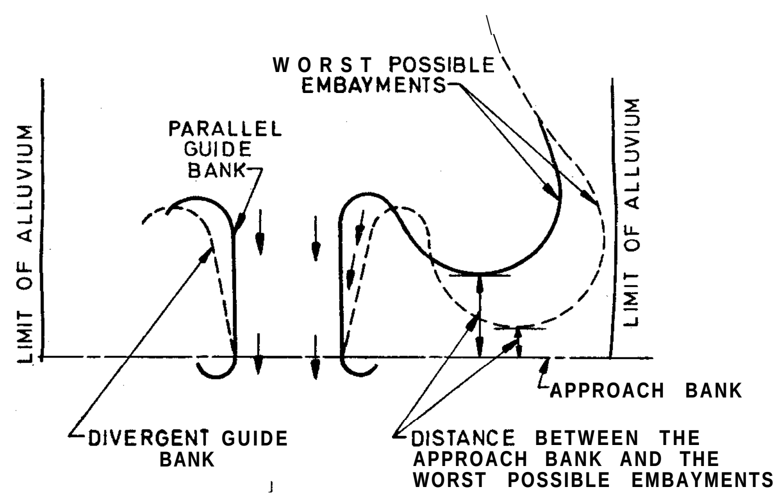


FIG. 2 EXTENT OF PROTECTION PROVIDED BY PARALLEL AND DIVERGENT GUIDE BANKS

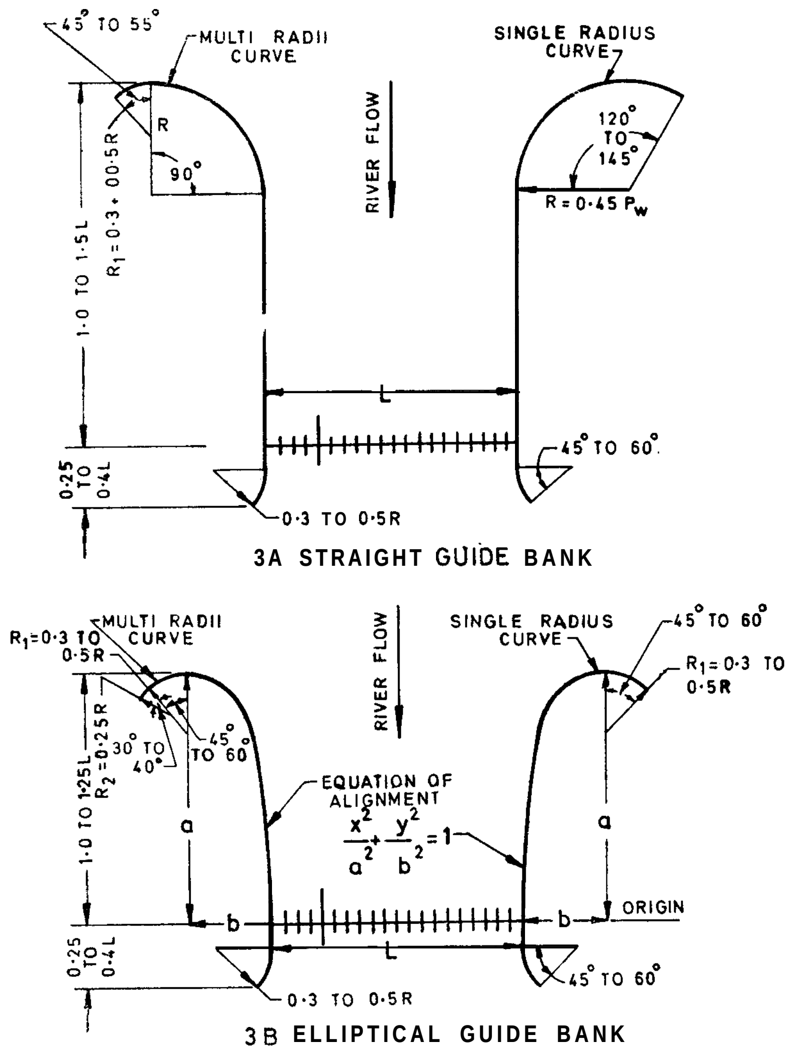


FIG. 3 GEOMETRICAL SHAPE OF GUIDE BANKS

maximum discharge up to 5 000 m^3/s and by 2·0 for discharging above 5 000 m^3/s. The above considerations are illustrated in Fig. 4. The limit to which the main channel of the river can be allowed to flow near approach embankment has to be decided based on importance of structure and local conditions.

4.5.1.3 In cases where the detailed examination in accordance with 4.5.1.2 is difficult for want of data, as a general guide the upstream length of the guide bank may be kept 1·0 *L* to 1·5 *L*.

4.5.2 *Downstream Length*

On the downstream side the river tries to fan out to regain its natural width. The function of guide bank is to ensure that the river action does not adversely affect the approach embankment. The downstream length will therefore, has to be determined so that swirls and turbulence likely to be caused by fanning out of the flow downstream the guide bank do not endanger the structure and its approach. The length of 0·2 *L* to 0·4 *L* is recommended.

4.5.3 In allimportant cases the lengths, both upstream and downstream, should be decided based on results of model studies incorporating the past history of river in the reach where the structure is proposed.

4.6 **Radius of Curved Head and Tail**

4.6.1 Function of curved head is to guide river flow smoothly and axially to the structure, keeping end spans active. A too small radius gives a kick to river current making it oblique and therefore larger radius to attract and guide the flow is needed, but it is uneconomical. Radius should be kept as small as possible

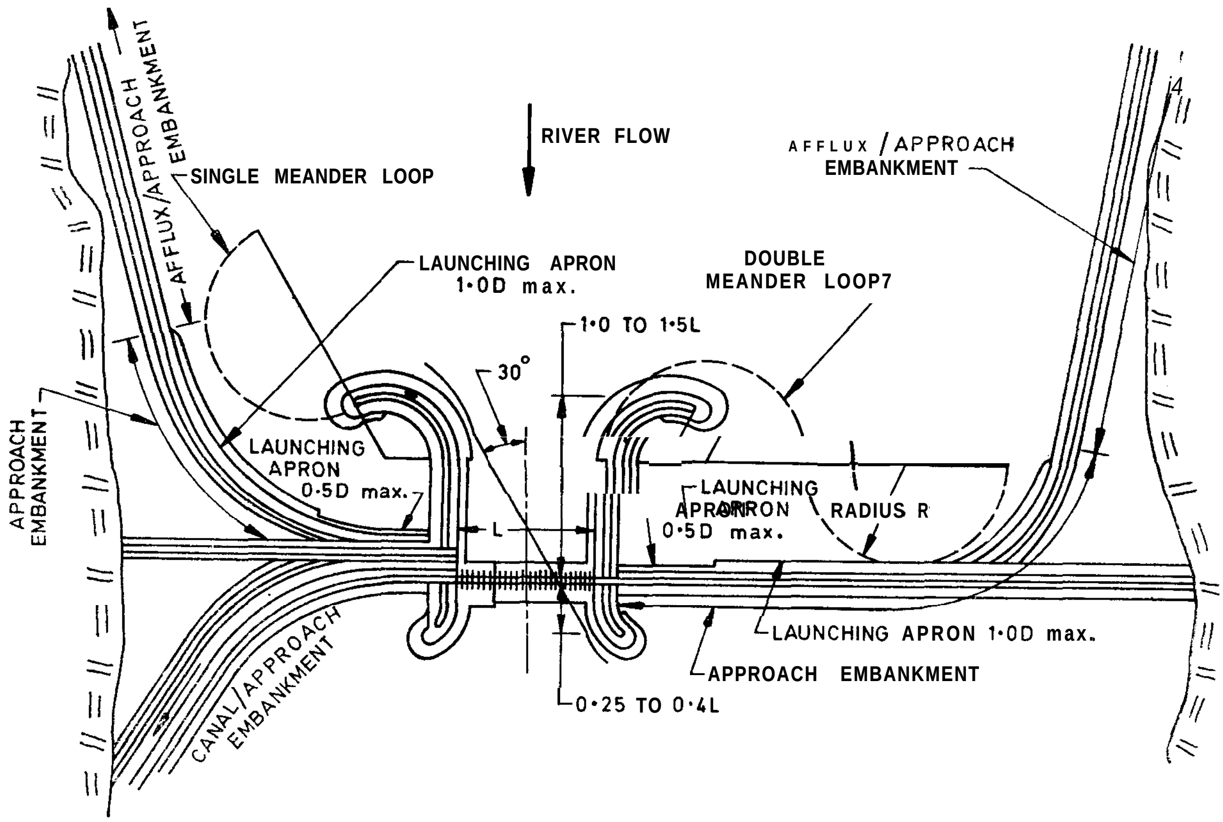


FIG. 4 TYPICAL LAYOUT OF GUIDE BANK

consistent with proper functioning of bank. Radius of curve head equal to 0·45 *L* has been found to be satisfactory.

4.6.2 Radius of curved tail may be 0·3 to 0·5 times the radius of curved head.

4.6.3 Considerable economy consistent with smoother conditions at the head may be achieved by adopting a composite curve of two or three different radius instead of a single large radius. This can be best decided by model studies.

4.7 **Sweep Angle**

The sweep angle is related to the loop formation. For curved head the angle of sweep may range from 120” to 145” according to river curvature. For curved tail it varies from 45” to 60”.

5 DESIGN OF GUIDE BANKS

5.1 Material

Guide banks may be made of locally available materials from river bed, preferably silt, sand or sand-cum-gravel.

5.2 Top Width

The top width should be 6 to 9 m to permit transport of material. At the nose of guide banks, the width may be increased suitably to enable vehicles to take turn and for stacking stones.

5.3 Free Board

A free board of 1·0 m to 2·0 m may be provided above the design flood level. Where heavy wave action is apprehended and/or aggravation is anticipated, a higher free board may be provided.

5.4 Side Slope

It depends on the angle of repose of the material of guide banks and the height. Side slopes of 2 : 1 to 3 : 1 are generally recommended.

5.5 Protection of Structures

5.5.1 Curved head is prone to damage due to concentration of discharge caused by collection of over bank flow and direct attack of current obliquely. The shank is subjected to attack by parallel/oblique flow. The curved tail is subject to attack by fanning out of current.

5.5.2 The effect of these attacks is the formation of deep scour holes at toe and erosion of river side slopes. Hence toe and slope both have to be protected.

5.6 **Toe Protection**

Launching apron should be provided for protection of toe and it should form a continuous flexible cover over the slope of the scour hole in continuation of pitching up to the point of deepest scour. Launching apron should be laid at normal low water level, or at as low a level as techno-economically viable. The stone in the apron should be designed to launch along the slope of the scour hole so as to provide a strong layer that may prevent further scooping out of the river bed material. The size and shape of apron depends on the size of stone, thickness of launched apron, the depth of scour and slope of launched apron.

5.6.1 *Size of Stone*

The required size of stones, concrete blocks, crates, etc, can be determined as follows:

The weight of the stones required on sloping surface to withstand erosive action of flow may be determined using following relationship or by using Fig. 5:

$$W = \frac{0.0232\ 3\ S_s}{K\,(S_s - 1)^3} V^6$$

$$K = \left[1 - \frac{\sin^2 \theta}{\sin^2 \phi} \right]^{\frac{1}{2}}$$

where

W = weight of stone in kg,

S_s = specific gravity of stones,

ϕ = angle of repose of protection material,

θ = angle of sloping bank, and

V = velocity in m/s.

In case of crates filled with stones the bulk specific gravity of the protection is required to be worked out to account for the porosity. The empirical relation for the porosity '*e*' is given below.

$$e = 0{\cdot}245 + \frac{0{\cdot}086\ 4}{(D_{50})^{0{\cdot}21}}$$

where

D_{50} = mean diameter of stones used in crate in millimeters.

The crate openings should not be larger than the smallest size of stone used.

The mass specific gravity of the protection can be worked out using following relationship:

$$S_m = (1 - e)\, S_s$$

For working out volume of crates, S_m should be used instead of S_s. Shape of crates or blocks should be as far as possible cubical. Crates may be made of G.I. wire or nylon ropes of adequate strength and should be with double knots and close knits.

5.6.2 *Thickness of Launched Apron*

The thickness of launched apron would depend upon the thickness of the pitching on slope. Thickness of pitching on slope should be equal to two layers of stones determined for velocity as indicated in 5.6.1 in the case of free dumping stones. Thickness of protection layer should be checked for negative head created due to velocity from following formula:

$$T = \frac{V^2}{2\,g\,(S_s - 1)}$$

where

V = velocity in m/s,

T = thickness in m, and

S_s = specific gravity of stones.

In the case of crates, the thickness of crates be decided on the basis of the above formula subject to the condition that the mass of each crate shall not be less than that determined on the basis of velocity consideration in 5.6.1.

The thickness of the launched apron should be 25 to 50 percent more than the thickness of the pitching on the slopes.

5.6.3 *Depth of Scour*

The extent of scour depends on angle of attack, discharge intensity, duration of flood and silt concentration, etc.

The regime depth D may be determined as given below:

$D = 0.473\,(Q/f)^{1/3}$ for waterway equal to or more than lacey's waterway.

In case where the waterway is less than lacey's waterway and also the flow is non-uniform, D may be calculated as:

$$D = 1.33 \left(\frac{q^2}{f} \right)^{1/3}$$

where

D = scour depth in m,

f = silt factor

= 1.76 $\sqrt{d}$ where *d* is the mean diameter of river bed material in mm,

Q = discharge in cum/s,

q = intensity of discharge in cum/s/m.

The depth of design scour for different portions of the guide banks may be adopted as below:

Location	*Design Scour Depth to be Adopted (D x Scour Factor)*
Upstream curved head of guide bank	2·0 *D* to 2·5 *D*
Straight reach of guide bank to nose of downstream guide bank	1·5 *D*
Downstream curved tail of guide bank	1·5 *D* to 1·75 *D*

5.6.4 ***Slope of Apron After Launching***

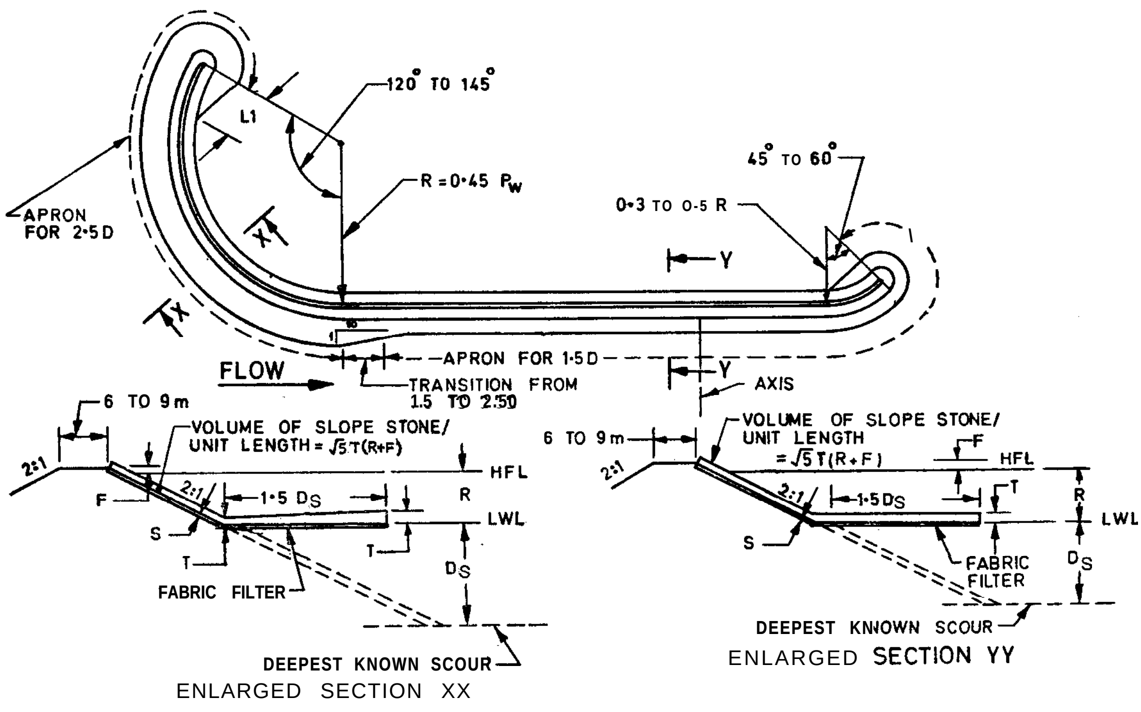
The slope of launched apron may be taken as 2 H : 1V for loose bouiders or stones and 1·5H : 1V for concrete blocks or stones in wire crates. Adequate quantity of stone for the apron has to be provided to ensure complete protection of the whole of the scoured face according to levels and slopes as determined in ***5.6.3.***

5.6.5 Size and Shape of Launching Apron

5.6.5.1 After determining the thickness of launched apron as described in 5.6.2 and the level of design scour to be adopted for different portions of the guide banks as described in 5.6.3, the quantity of stone required for launched position of apron from laid level to design scour level can be calculated. The quantity of stone so calculated may be provided in a wedge shape having a width of 1·5 D_s (Fig. 6) and average thickness, ***T.*** Thickness of laid apron may be kept 0·8 ***T*** near the toe of the guide bank and 1·2 ***T*** at the river end.

5.6.5.2 Minimum loss of stones occurs when the apron is placed at the lowest possible level since the launching is minimum. Apron should be laid at as low a level as economically viable.

5.6.5.3 At curved head, the apron has to cover large area in launched position, so thickness may be increased taking increased length in consideration.



LEGEND

F Free board

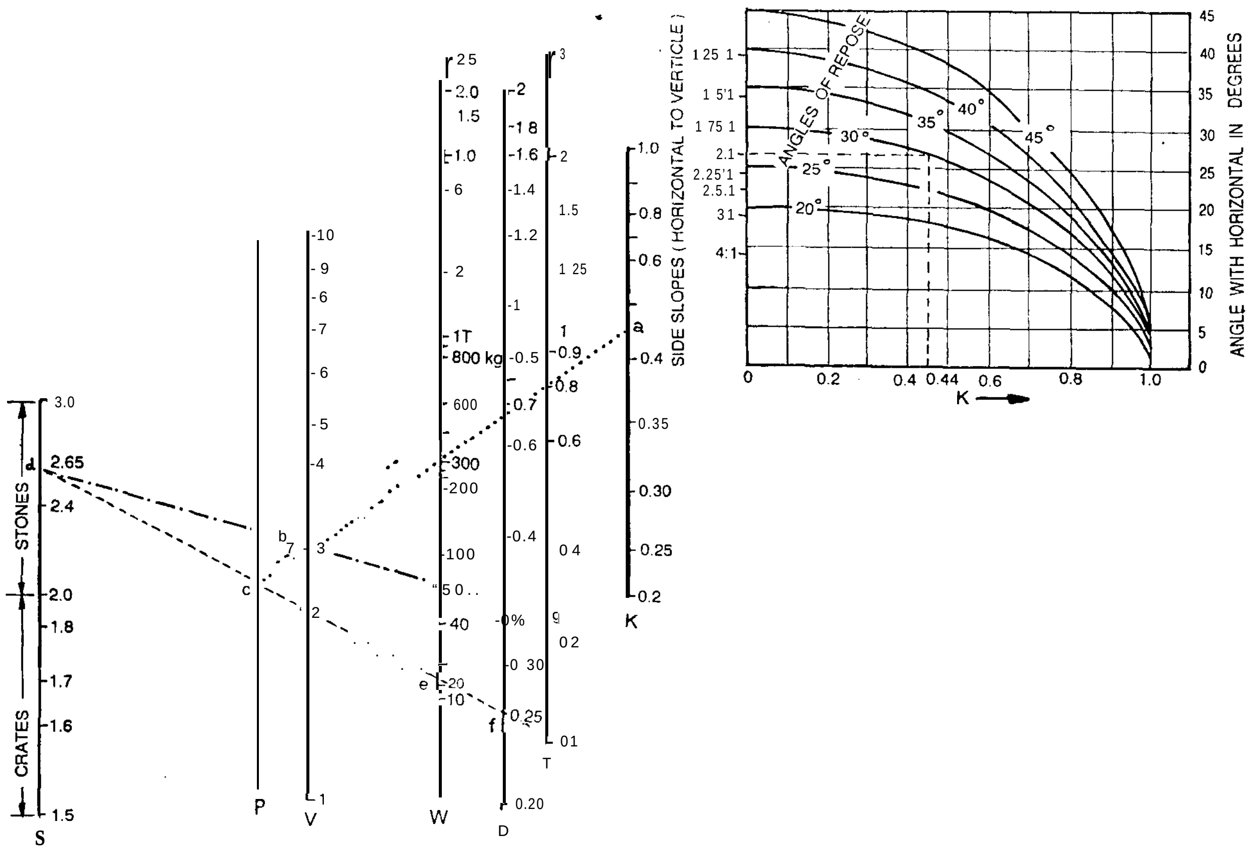
R Rise of flood above low water level

D_s Depth of scour for calculation of apron stone

T Thickness of slope stone/apron

S Thickness of soling (Filter)

FIG. 6 TYPICAL DETAILS OF GUIDE BANK (FOR 2 : 1 SLOPE OF LAUNCHED APRON AND SCOUR FACTOR 2·5 FOR UPSTREAM CURVED HEAD AND 1·5 FOR SHANKS)



ILLUSTRATION

Velocity 3 m/s

Bank slope 2 : I

Angle of repose 30 degrees

Specific gravity 2·65

$$K = \sqrt{1 - \frac{\sin^2 \theta}{\sin^2 \phi}}$$

$$W = \frac{0.023\ 23}{K} \cdot \frac{S_s}{(S_s - 1)^3} V^6$$

$$T = \frac{V^2}{2g(S_s - 1)}$$

$$D = 0.124 \sqrt[3]{\frac{W}{S_s}}$$

} Expressions

STEPS

1. From bank slope and angle of repose find from upper diagram, $K = 0.44$
2. Locate *a* on *K* line
3. Locate *b* on *V* line corresponding to 3 m/s
4. Join *a b* and extend to meet *P* line at *c*
5. Locate *d* on *S* line
6. Join *d c* and extend to meet *W* line at *e*. Read the weight $W = 20$ kg
7. Extend *d c e* to meet *D* line at *f*
   Read the stone diameter as $D = 0.25$ m
8. Join *d b* and extend to meet *T* line at *g*
   Read the thickness of pitching as $T = 0.25$ m

For safety purpose provide two layers of stones weighing 20 kg ($D = 0.25$ m) so that the total thickness of pitching is 0·50 m

FIG. 5 NOMOGRAPH FOR RIVER BANK PROTECTION BY STONES

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5.6.5.4 At the junction of head and shank normally high velocities exist. Design **scour** depth varies from 2·5 *D* to 1·5 *D*. This transition should be effected in a length of one-fourth of radius of head from the head towards the shank. (Details have been shown in Fig. 6.)

5.7 **Slope Protection**

The river side earthen slope of guide banks are protected against river action by covering them with dumped or hand placed stones and concrete blocks. This pitching is intended to remain in its laid position (see Fig. 6).

5.7.1 The rear slopes of guide banks are not subjected to direct attack of river and may be protected against wave splashing by 0·3-0·6 m thick cover of spawls or by turfing. In case, however, a parallel or back flow leading to erosive action is likely as evident from model studies at the rear face, suitable pitching may be necessary.

5.7.2 For the design of pitching on the river side, factors that affect are size or mass of the individual stone, its shape and gradation, thickness and slope of pitching and type of filter underneath. The predominant flow characteristic which affects the stability of pitching is velocity along the bund. Other factors like obliquity of flow, eddy action, waves etc, are indeterminate which could be studied on models and may be accounted for by providing adequate margin of safety by increasing the design mean velocity for determining the size and mass of stone.

5.7.2.1 Sizes for hand placed pitching can be less due to interlocking effect which offers greater resistance to movement of stones.

5.7.3 The thickness of the pitching should be equal to the size of stone determined from the velocity consideration as indicated in 5.6.1 and 5.6.2. For dumped stone pitching the thickness may be two times the size of stone. In general the following guidelines are followed:

a) Brick on edge can be adopted up to an average velocity of 2 m/s,

b) Quarryed stones of size 350 mm and/or weighing 40-70 kg should be used up to an average velocity of 3·5 m/s, and

c) For higher velocity cement concrete blocks/crated stone could be used.

NOTE — Round and smooth boulders should be avoided particularly for hand placing.

5.8 **Drainage Arrangement**

A system of open paved drains (Chutes) along the sloping surface terminating in lognitudinal collecting drains at the junction of berm and slope should be constructed at 30 m centre to drain the rain water. The drains are to be formed of stone pitching or with precast concrete section. The crest of guide bank should be sloped 1: 50 from upstream to downstream riverside to countryside and longitudinal paved drams according to approved drawing are to be constructed at downstream/countryside edge of the crest. These longitudinal drains should drain the rainwater in chute drain.

6 DESIGN OF FILTER

A graded filter generally specifying the standard criteria conforming to IS 8237: 1985 should be provided below the protection. The filter is required below pitching on the slope as well as below the apron also. The use of synthetic filter is preferable from the point of quality control and convenience of laying. The criteria for synthetic filter is given in Annex A. A 15 cm thick sand layer should be provided on the filter to prevent the mechanical rupture of the fabric by armoured layer.

ANNEX A

(*Clause* 6)

CRITERIA FOR SELECTION OF FILTER FABRIC

Geotextile filters may be recommended because of ease in installation and their proven effectiveness as an integral part of protection of bed materials, may be used to select the correct filter fabric:

a) For granular material containing 50 percent or less fines by weight, the following ratio should be satisfied:

$$\frac{85\% \text{ passing size of bed material (mm)}}{\text{Equivalent opening size of fabric (mm)}} \geqslant 1{\cdot}0$$

In order to reduce the chances of clogging, no fabric should be specified with an equivalent opening size smaller than 0.149 mm. Thus the equivalent opening size of fabric should not be smaller than 0·149 mm and should be equal to or less than 85 percent passing size of bed material.

b) For bed material containing at least 50 percent but not more than 85 percent fines by weight, the equivalent opening size of filter should not be smaller than O-149 mm and should not be larger than O-211 mm.

c) For bed material containing 85 percent or more of particles finer than 0·074 mm, it is suggested that use of non-woven geofabric filter having opening size compatible to the equivalent values given in (a) above may be used.

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Review of Indian Standards

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