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IS 14262 (1995): Planning and design of revetments - Guidelines [WRD 22: River Training and Diversion Works]

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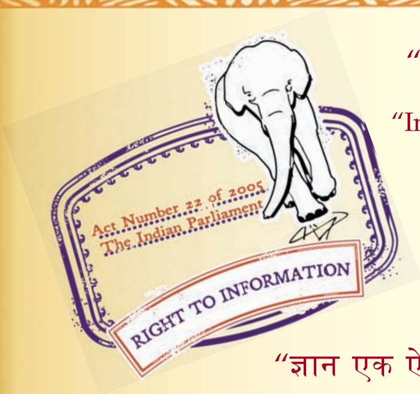

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“Knowledge is such a treasure which cannot be stolen”

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IS 14262 : 1995
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भारतीय मानक

रिवेटमेंट की आयोजना और डिजाइन — मार्गदर्शी सिद्धान्त

Indian Standard

PLANNING AND DESIGN OF REVETMENT — GUIDELINES

UDC 627·417 (026)

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

April 1995 Price Group 4

River Training and Control Works Sectional Committee, RVD 22

FOREWORD

This Indian Standard 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.

It is a common practice to use revetment for protecting the river bank, flood embankments, guide bunds, spurs, etc, from the fury of floods. The protection work of this type is known by different names such as stone pitching, rip-rap, revetment, etc. However, the most common technical term is revetment. The size and mass of stone to be used for revetment is required to withstand flow velocity, tractive force, etc, taking into consideration specific gravity of material in revetment, porosity, bank slope, angle of repose of bank and protecting material, etc. A filter is also required below the protection layer to prevent possible soil loss. This standard covers the planning and design of revetment for bank protection works. The construction and maintenance aspects of revetments are being covered in a separate Indian Standard.

Indian Standard

PLANNING AND DESIGN OF REVETMENT — GUIDELINES

1 SCOPE

This standard lays down the guidelines for planning and design of revetment used for embankments and bank protection works in case of alluvial rivers and canals.

2 REFERENCE

The Indian Standard 'IS 8237 : 1985 Code of practice for protection of slope for reservoir embankments (*first revision*)' is a necessary adjunct to this standard.

3 GENERAL DESIGN FEATURES

3.1 Dry Revetment

Stone used in revetment for river bank protection is subjected to hydrodynamic drag and lift forces. These destabilizing forces are expressed in terms of velocity, tractive force, etc. The stabilizing forces acting against these are component of submerged weight of stone and downward component of the force caused by contact of the stones.

Weight of the stone on horizontal bed may be expressed as:

$$W = 0{\cdot}023\,23 \frac{S_s}{(S_s - 1)^3} V^6$$

where

W = weight of stone in kg,

S_s = specific gravity of stone, and

V = mean velocity of water in m/s over the vertical under reference.

The weight of stone worked out is the minimum required. Use of higher weight stones will be based on the material available at site, ease of construction, factor of safety, etc.

3.2 Effect of Specific Gravity

In practice, density of stone could vary from 2 000 to 3 300 kg/m^3. The actual density of stone should be determined for calculating the weight of stone given in **3.1**.

3.3 Effect of Bank Slope and Angle of Repose

The weight of stone estimated for horizontal bed would not be sufficient for same velocity on the sloping bank because only component of self-weight normal to the slope acts as a stabilizing force. Therefore, for sloping banks, the weight has to be increased. The limiting value for the slope is the angle of repose of material of sub-base. Correction factor K for computing weight of stone on sloping face may be obtained from the following equation:

$$K = \sqrt{1 - (\sin^2\theta/\sin^2\phi)}$$

where

θ = angle of bank slope with horizontal, and

ϕ = angle of repose of material of protection works.

Thus the weight of stone would be

$$W = \frac{0{\cdot}023\,23}{K} \times \frac{S_s}{(S_s - 1)^3} V^6$$

Weight of stone may also be calculated using the nomograph given in Fig. 1 (*see page* 3).

For river training works, sub-base is to be graded to a stable slope depending upon the angle of repose and cohesion of bank material under saturated condition, and the height of the bank. For high bank a berm may be necessary. For important works stability of bank with designed slope and berm should be checked by slip circle method or by soil dynamic testing procedures. Mere large size stones/crates would not be adequate for protection if the same is not laid on a stable base. For normal bank protection a slope of 2 H : 1 V or flatter is recommended.

3.4 Size of Stone

Size of the stone D_s may be determined from the following relationship:

$$D_s = 0{\cdot}124 \sqrt[3]{\frac{W}{S_s}}$$

where

W = weight of stone in kg, and

S_s = specific gravity of stones.

Minimum dimension of the stones should not be less than D_s as obtained above. From the worked out weight and known specific gravity, the volume of stone should be calculated. Generally, the size of stone should be such that its length, width and thickness should be more or less the same, that is stone should be approximately cubical. Round stones or very flat stones having small thickness should be avoided.

3.5 Thickness of Protection Layer

Minimum thickness of protection layer is required to withstand the negative head created by velocity. This may be determined by the following relationship:

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

where

T = thickness of protection layer in m,

V = velocity in m/s,

g = acceleration due to gravity in m/s^2, and

S_s = specific gravity of stones.

For safety purposes, two layers of stones according to the size obtained in **3.4** above should be provided.

3.6 Stones in Crates

At high velocities, weight of stone determined from relationship given in **3.3** works out very high which makes handling and placing of stones difficult. Under such circumstances, small stones in crates are generally used. However, the specific gravity of the crate is different from that of the individual stone due to presence of voids. Porosity in crates may be worked out by the formula:

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

where

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

Mass specific gravity S_m of crates may then be determined from the equation:

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

Volume of the crate should be determined using S_m.

Crates should be laid with longer dimension along the slope of the bank. The size of the mesh of crate should be smaller than the smallest stone in the crate. The mesh should be double knotted. GI wire of minimum diameter 4 mm should be used for crates. Crate units may be tied to each other by 5 mm GI wire as additional precaution.

If crates are provided in layers, each layer should be tied to lower and upper layer at suitable intervals with 4 mm GI wire.

Launching apron should not be tied to crate on slope. A nomograph to determine the size and weight of stone or crates for revetment is given in Fig. 1.

Typical dry stone revetment is shown in Fig. 2 on page 5.

3.7 Filter

A graded filter of 150 to 300 mm thickness conforming to IS 8237 : 1985 should normally be provided below the revetment to prevent failure by sucking action of high velocity flow.

Synthetic/geotextile filter may be used from the point of view of quality control and convenience of laying. The criteria for synthetic filter is given in Annex A. A 150-mm thick sand layer should be provided over the filter fabric to prevent the mechanical rupture of the fabric by revetment stones.

4 REVETMENTS IN MORTAR

4.1 Sizes of the Stones

Stones, bricks or concrete blocks may be used for revetment in mortar. Size of stone, concrete block, etc, in this type of pitching, is not a critical aspect of design as every individual piece is bonded by mortar. Average size of the available stone may be used for the purpose. Thickness should, however, be decided using equation given in **3.5** to achieve stability against lifting. Typical revetment in mortar is shown in Fig. 3 (*see* page 5).

4.2 Panelling

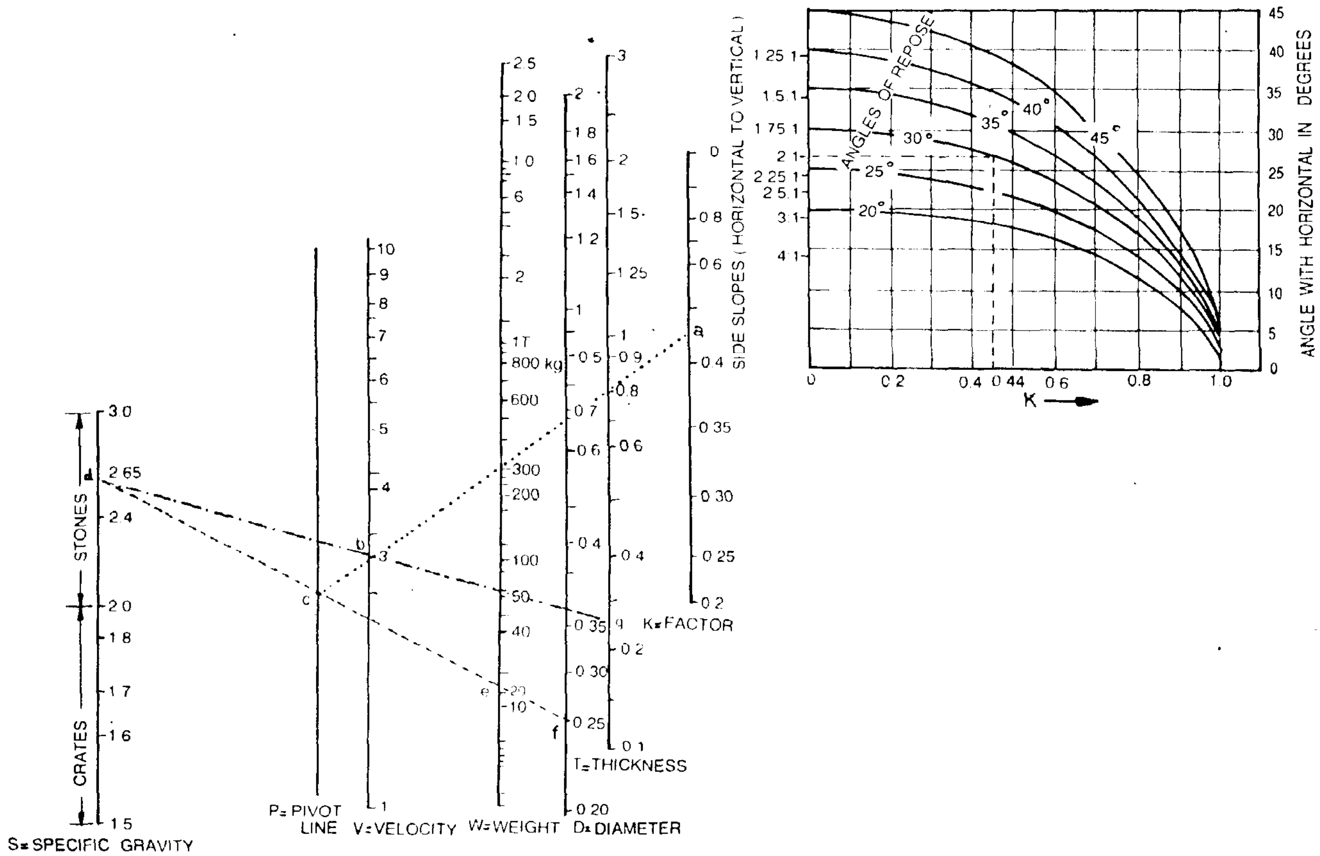
Mortar revetment should not be constructed in a continuous or monolithic form. To avoid cracks, joints at suitable interval are required to be provided. Generally, revetment is divided in panels of size 3 m × 3 m or 3 m × 5 m or so (*see* Fig. 4 on page 5). The size of the panel may be varied depending upon the river reach to be protected and the length of bank slope. Standard granular filter or synthetic fabric filter should be provided below the joint.

4.3 Drain Holes

Drain holes or weep holes are required to be provided in each panel for free drainage of pore water from the saturated bank soil beneath it. Depending upon the size of the panel, one or more drain holes need to be provided. The pipe provided in the drain hole should be up to the natural bank. Inverted filter or synthetic filter fabric should be provided at the end in contact with soil to prevent escape of soil particles. Other end of the drain pipe should be flush with the revetment face (*see* Fig. 3 on page 5).

5 TOE PROTECTION

To prevent the sliding and failure of the revetment on slope, toe is required to be protected. This may be in the form of simple key, a toe wall, a sheet pile or a launching apron. Different types of toe protections are also shown in Fig. 2 to 6 (*see* pages 5 and 6).



Illustration

Velocity : 3 m/s

Bank slope : 2 : 1

Angle of repose : 30 degrees

Specific gravity : 2·65

Expressions:

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

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

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

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

Steps

1. From bank slope and angle of repose find from upper diagram $T = 0.44$.
2. Locate a on K line.
3. Locate b on V line corresponding to 3 m/s.
4. Join ab and extend to meet P line at c.
5. Locate d on S line.
6. Join dc and extend to meet W line at e. Read the weight $W = 20$ kg.
7. Extend dce to meet D line at f. Read the stone diameter as $D = 0.25$ m.
8. Join db 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 ($D_s = 0.25$ m) so that the total thickness of pitching is 0·50 m. (Thickness of pitching should not be less than two times the diameter of stone calculated from W)

FIG. 1 NOMOGRAPH FOR RIVER BANK PROTECTION BY STONES

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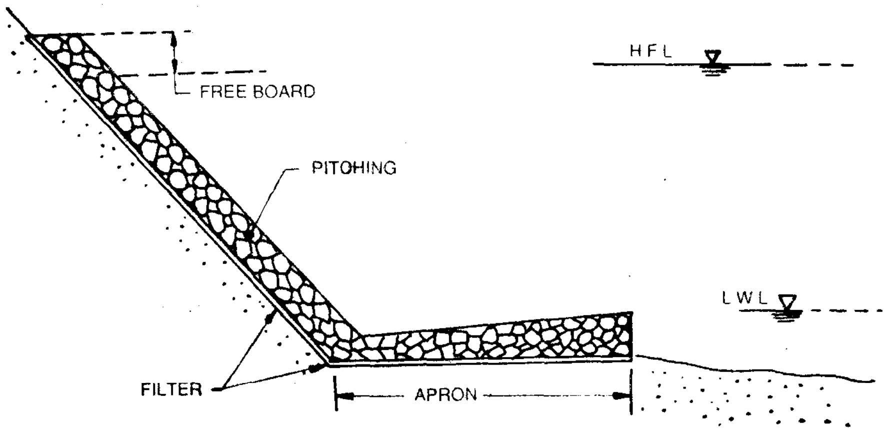

FIG. 2 DRY PITCHING WITH APRON

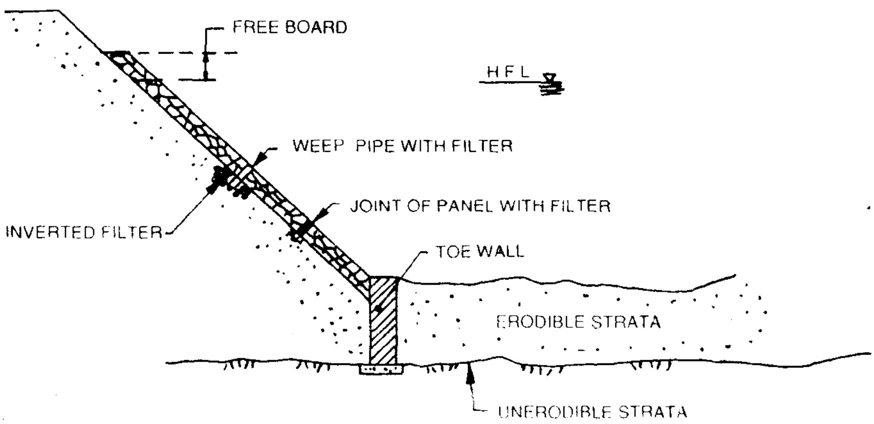

FIG. 3 PITCHING IN MORTAR WITH TOE WALL

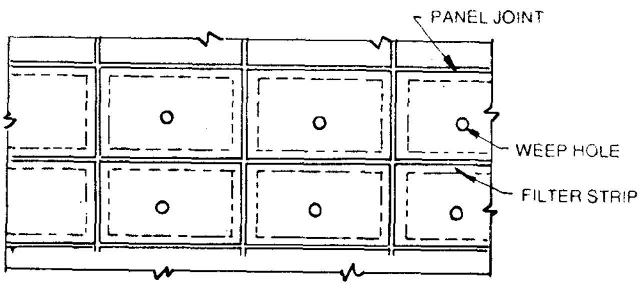

FIG. 4 FRONT VIEW OF PANEL

5.1 Simple key may be provided at the toe when rock or unerodible strata is available at the river bed and the overlying banks are under attack and subjected to erosion. The key is in the form of stones, bricks or concrete blocks filled in trench at the toe below the hard river bed for depth equal to the thickness of pitching for proper anchorage (*see* Fig. 5). Sole purpose of this key is to provide lateral support. The stones, bricks or blocks may be laid in mortar if pitching on slope is in mortar.

5.2 When hard strata is available below the river bed at a reasonable depth, toe wall is recommended. The thickness of toe wall depends upon the height of the wall and height of the overlying protection works. This wall may be constructed in masonry (*see* Fig. 3) and designed as a retaining wall with weep holes, etc.

5.3 When firm strata is not available at a reasonable depth below the river bed, toe protection in the form of sheet piles is recommended. The sheet pile may be made up of RCC or steel or bamboos depending upon the availability of material. Sheet piles should be driven below the anticipated maximum scour plus grip length (*see* Fig. 6).

Depth of scour may be worked out from the equation:

$$D_L = 0.473 \, (Q/f)^{1/3}$$

$$\text{or} \quad D_L = 1.33 \, (q^2/f)^{1/3}, \text{ and}$$

$$f = 1.76 \sqrt{d}$$

where

D_L = scour depth below HFL in m,

Q = discharge in m^2/s,

q = discharge per unit width in $m^3/s/m$,

f = silt factor, and

d = mean particle diameter of river bed material in mm.

Maximum anticipated scour for launching apron may be taken as = 1.5 D_L.

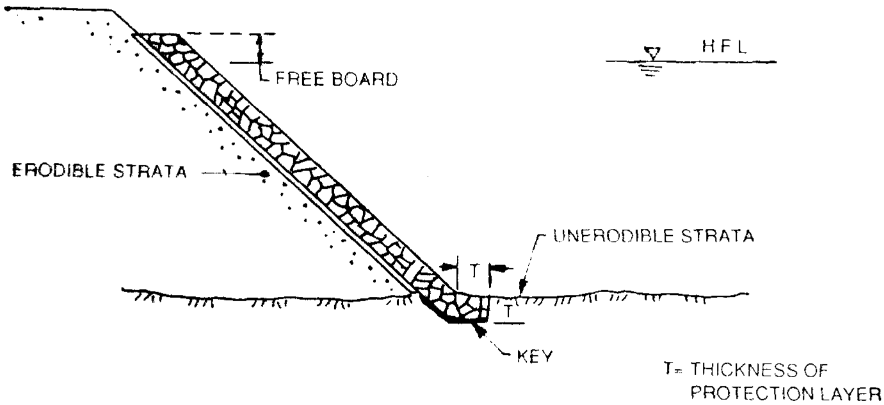

FIG. 5 TOE KEY

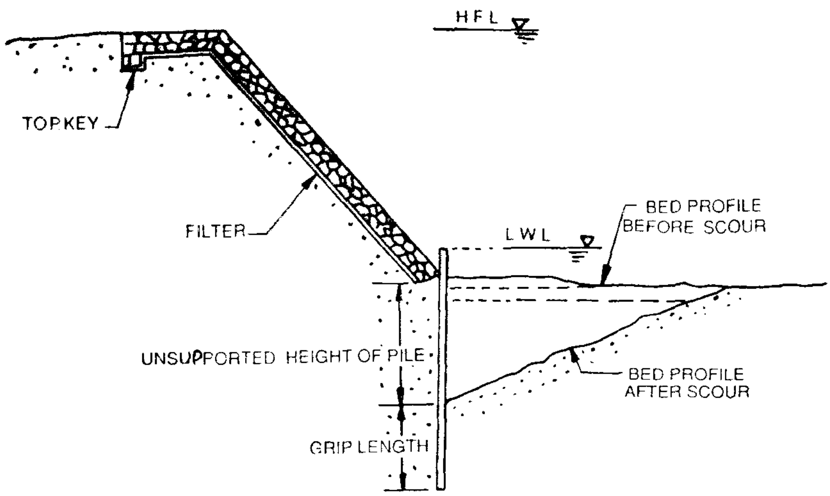

FIG. 6 TOE PROTECTION WITH PILE AND TOP KEY

5.4 Sheet piles are difficult to drive. Launching apron is, therefore, preferred and generally provided for dry rubble revetments (*see* Fig. 2).

5.5 Launching apron should be laid at normal water level or at as low a level as techno-economically viable. The stones in the apron should be designed to launch along the slope of the scour and provide a strong layer that may prevent further scooping out of the river bed material. The size and shape of the apron depends on the size of the stone, thickness of the launched apron, depth of scour and slope of launched apron. Weight and size of the stone for launching apron should be determined as in **3.3** and **3.4**. Thickness of launching apron should be determined as in **3.5**.

5.6 The slope of launching apron may be taken as 2 H : 1 V. Adequate quantity of stones for the apron has to be provided to ensure complete protection of the whole of the scoured face according to levels and slopes. The quantity of stones so calculated may be provided in a wedge shape having width of 1·5 D_L (*see* Fig. 2) and average thickness T. Thickness of the laid apron may be kept 0·8 T near the toe of the revetment and 1·2 T at the river end.

5.7 Filter as mentioned in **3.7** should be provided below launching apron.

6 ANCHORING

6.1 Proper anchor is required for keeping the revetment in place and serving the desired function.

Upstream edge from where the revetment starts, should be secured well to the adjoining bank. Similarly, downstream edge where the pitching ends also need to be secured well to the adjoining bank. For this purpose, the revetment should be properly anchored to the ground at its two ends by suitably extending it as may be required at site (*see* Fig. 7).

Anchorage is also required to be provided on the top for submerged bank (*see* Fig. 6). If the top of bank is above HFL, the revetment should be raised above HFL with adequate free board. Under such situation, anchorage at the top is not required (*see* Fig. 2).

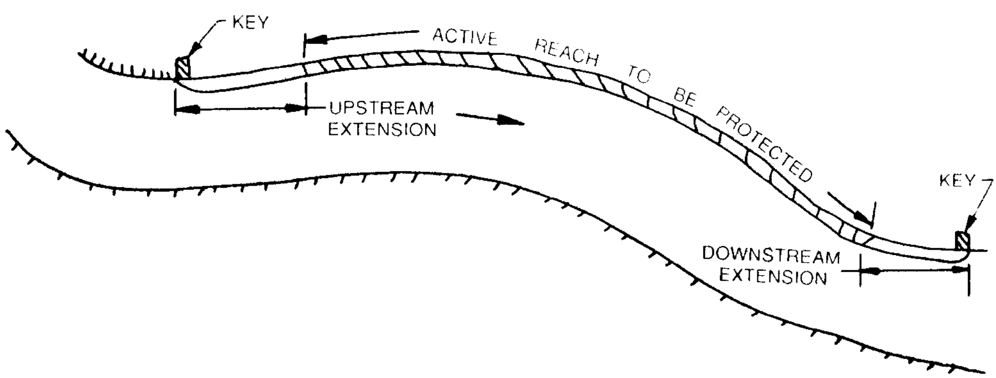

FIG. 7 UPSTREAM AND DOWNSTREAM KEY FOR REVETMENT

ANNEX A

(*Clause* 3.7)

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 works. The following criteria, depending on the gradation of bed material, 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:

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

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 the 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 0·149 mm and should not be larger than 0·211 mm.

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

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