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

व्यापक परिचालन मसौदा

हमारा संदर्भ: सीईडी 56/टी-19 **20 मई 2024**

तकनीकी समिति: पहाडी क्षेत्र इंजीनियरी विकास विषय समिति, सीईडी 56

प्राप्तकर्ता :

क) सिविल इंजीनियरी विभाग परिषद्, सीईडीसी के सभी सदस्य
ख) सीईडी 56 के सभी सदस्य
ग) रूचि रखने वाले अन्य निकाय

प्रिय महोदय/महोदया,

निम्नलिखित भारतीय मानक का मसौदा संलग्न है:

प्रलेख संख्या	शीर्षक
सीईडी 56 (25715)WC	**पहाड़ी क्षेत्रों के लिए रिटेनिंग दीवार – दिशानिर्देश** **भाग 8 प्रबलित सीमेंट कंक्रीट (आरसीसी) रिटेनिंग दीवारों का डिजाइन का भारतीय मानक मसौदा** [(IS 14458 (भाग 8)] ICS 93.020

कृपया इस मानक के मसौदे का अवलोकन करें और अपनी सम्मतियॉ यह बताते हुए भेजे कि यदि यह मानक के रूप में प्रकाशित हो तो इस पर अमल करने में आपके व्यवसाय अथवा कारोबार में क्या कठिनाइयाँ आ सकती हैं ।

सम्मतियाँ भेजने की अंतिम तिथि : **23 जून 2024**

सम्मति यदि कोई हो तो कृपया अधोहस्ताक्षरी को उपरिलिखित पते पर संलग्न फोर्मेट में भेजें या **manoj@bis.gov.in** पर ईमेल कर दें ।

यदि कोई सम्मति प्राप्त नही होती है अथवा सम्मति में केवल भाषा सम्बन्धी त्रुटि हुई तो उपरोक्त प्रलेख को यथावत अंतिम रूप दिया जाएगा। यदि सम्मित तकनीकी प्रकृति की हुई विषय समिति के अध्यक्ष के परामर्श से अथवा उनकी इच्छा पर आगे की कार्यवाही के लिए विषय समिति को भेजे जाने के बाद प्रलेख को अंतिम रूप दे दिया जाएगा ।

यह प्रलेख भारतीय मानक ब्यूरो की वैबसाइट **www.bis.gov.in** पर भी उपलब्ध हैं।

धन्यवाद ।

भवदीय,

(द्वैपायन भद्र)
प्रमुख (सिविल इंजीनियरी)

संगलन : उपरिलिखित

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS

MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG, NEW DELHI 110002

DRAFT IN WIDE CIRCULATION

Our Ref: CED 56/T-19 **20 May 2024**

TECHNICAL COMMITTEE: Hill Area Development Engineering Sectional Committee, CED 56

ADDRESSED TO:

a) All Members of Civil Engineering Division Council, CEDC
b) All Members of CED 56
c) All others interests.

Dear Sir/Madam,

Please find enclosed the following document:

Doc No.	Title
CED 56 (25715)WC	**Draft Indian Standard** **Retaining Wall for Hill Areas – Guidelines** **Part 8 Design of Reinforced Cement Concrete (RCC) Cantilever Retaining Walls** [(IS 14458 (Part 8)] ICS 93.020

Kindly examine the draft standard and forward your views stating any difficulties which you are likely to experience in your business or profession, if this is finally adopted as National Standard.

Last Date for comments**: 23 June 2024**

Comments if any, may please be made in the attached format and mailed to the undersigned at the above address or preferably through e-mail to **manoj@bis.gov.in**.

In case no comments are received or comments received are of editorial nature, you may kindly permit us to presume your approval for the above document as finalized. However, in case of comments of technical in nature are received then it may be finalized either in consultation with the Chairman, Sectional Committee or referred to the Sectional Committee for further necessary action if so desired by the Chairman, Sectional Committee.

The document is also hosted on BIS website **www.bis.gov.in.**

Thanking you,

Yours faithfully,

(**Dwaipayan Bhadra**)
Head (Civil Engineering)

Encl: As above

FORMAT FOR SENDING COMMENTS ON BIS DOCUMENTS

(Please use A-4 size sheet of paper only and type within fields indicated. Comments on each clause/sub-clause/table/fig etc. be started on a fresh box. Information in column 3 should include reasons for the comments and suggestions for modified working of the clauses when the existing text is found not acceptable. Adherence to this format facilitates Secretariat's work) {Please e-mail your comments to manoj@bis.gov.in}

Doc. No.: CED 56 (25715)WC

Title: Retaining Wall for Hill Areas – Guidelines
Part 8 Design of Reinforced Cement Concrete (RCC) Cantilever Retaining Walls
[(IS 14458 (Part 8)] ICS 93.020

LAST DATE OF COMMENT: **23 June 2024**

NAME OF THE COMMENTATOR/ORGANIZATION: ______________________

Sl. No.	Clause/Para/Table/ Figure No. Commented	Comments/Modified Wordings	Justification of the Proposed Change

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

Draft Indian Standard

RETAINING WALL FOR HILL AREAS – GUIDELINES PART 8 DESIGN OF REINFORCED CEMENT CONCRETE (RCC) CANTILEVER RETAINING WALLS

[(IS 14458 (Part 8)]
ICS 93.020

Hill Area Development Engineering Sectional Committee, CED 56	Last date of Comments **23 June 2024**

FOREWORD

(*Formal clauses will be added later*)

Retaining walls are structures, which support the backfill and maintain the difference in elevation of the two ground surfaces. They are generally located at the toe of cut slopes on valley side of a hill road section or excavated platform. Retaining walls are effectively utilized to tackle the problems of landslide in hill areas by providing support to the hill slopes or cut slopes.

In general, 1 m of extra width in filling and requiring retaining wall at the end may cost more than excavating the same width by cutting inside the hill. However, considering maintenance cost, progressive slope instability and environmental degradation resulting from unprotected excavation, the use of retaining walls becomes essential. This standard (Part 8) is therefore, formulated to provide necessary guidelines for design of RCC Cantilever retaining wall for stability of hill slopes. This standard is being published in different parts. The following parts have already been published:

(Part 1) : 1998 Selection of type of wall
(Part 2) : 1997 Design of retaining/breast walls
(Part 3) : 1998 Construction of dry-stone walls
(Part 4) : 2018 Construction of banded dry stone masonry walls
(Part 5) : 2018 Construction of cement stone masonry walls
(Part 6) : 2018 Construction of Gabion Walls
(Part 7) : 2018 Construction of Peripheral Reinforced Gabion Walls

Other parts being formulated are:

a) Construction of RCC crib walls, and
b) Design and construction of reinforced earth retaining walls.

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 shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Draft Indian Standard

RETAINING WALL FOR HILL AREAS – GUIDELINES
PART 8 DESIGN OF REINFORCED CEMENT CONCRETE (RCC) CANTILEVER RETAINING WALLS

1 SCOPE

This standard (Part 8) deals with the design of RCC cantilever retaining wall which include L-Type, Reversed L-Type, T-Type, Inverted T-Type, Buttressed and Counterfort retaining walls. This standard is mainly focuses on the design criteria of RCC retaining walls which is used to support earth or other materials behind them which would otherwise not stay in that position.

2 REFERENCES

The standards listed in Annex A contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were 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 standards indicated in Annex A.

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply (refer Fig. 1).

3.1 Backfill – Backfill is the material used to bring the ground surfaces up to design elevations.

3.2 Cap – The cap is an optional component which is often included if a guard rail or barrier fence is attached to the top of the stem.

3.3 Footing – The footing is the structural component that must transmit vertical forces to the undisturbed soil. Consequently, the footing is designed using the same criteria as those used for shallow foundations.

3.4 Front Face and Back Face – The front face is the side of the stem which is exposed for much of the wall height and the back face is the side of the stem which is adjacent to the backfill for most of the wall height.

3.5 Heel and Toe – The heel is the face of the footing on the back side of the wall, and the toe is the footing face on the front side of the wall. Those portions of the footing on the front and back sides of the wall are termed the toe projection and heel projection respectively.

3.6 Key – A key is an optional component that may be included to resist lateral thrust and movement. Keys may be located at different positions along the base of the footing.

3.7 Stem – The stem acts structurally as a cantilever beam which must resist the lateral thrust caused by the soil mass against the wall.

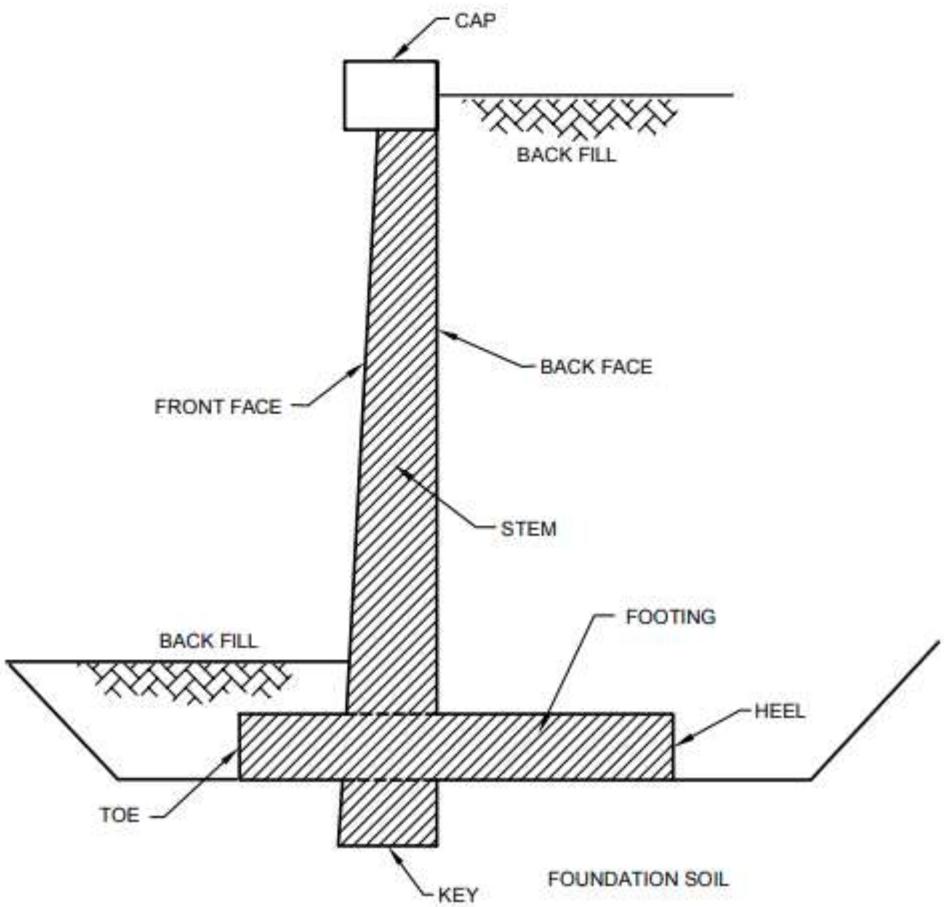


FIG. 1 CANTILEVER RETAINING WALL TERMINOLOGY

4 GENERAL

Retaining walls are built to resist the earth pressure of filling and the traffic loads of the road. The different type of RCC cantilever retaining wall is given in Fig. 2. These are commonly used in hill roads when the road goes in embankment or partly cutting and partly filling (*see* Fig. 3). Retaining walls are erected to bring stability to slopes or to support existing landslides. The classification of retaining walls is covered in IS 14458 (Part 1). A RCC cantilever retaining wall resists bending due to earth pressures from the backfill, which provides part of the stabilizing weight by resting on the base slab and thereby acts together with the wall as a semi-gravity structure. A shear key is sometimes provided below the base slab of the retaining wall to improve sliding resistance. A RCC cantilever retaining wall is generally economical for retained heights of up to about 8 m. For greater heights, the thickness of the stem of the cantilever wall becomes excessive, and a counterfort retaining wall is more appropriate.

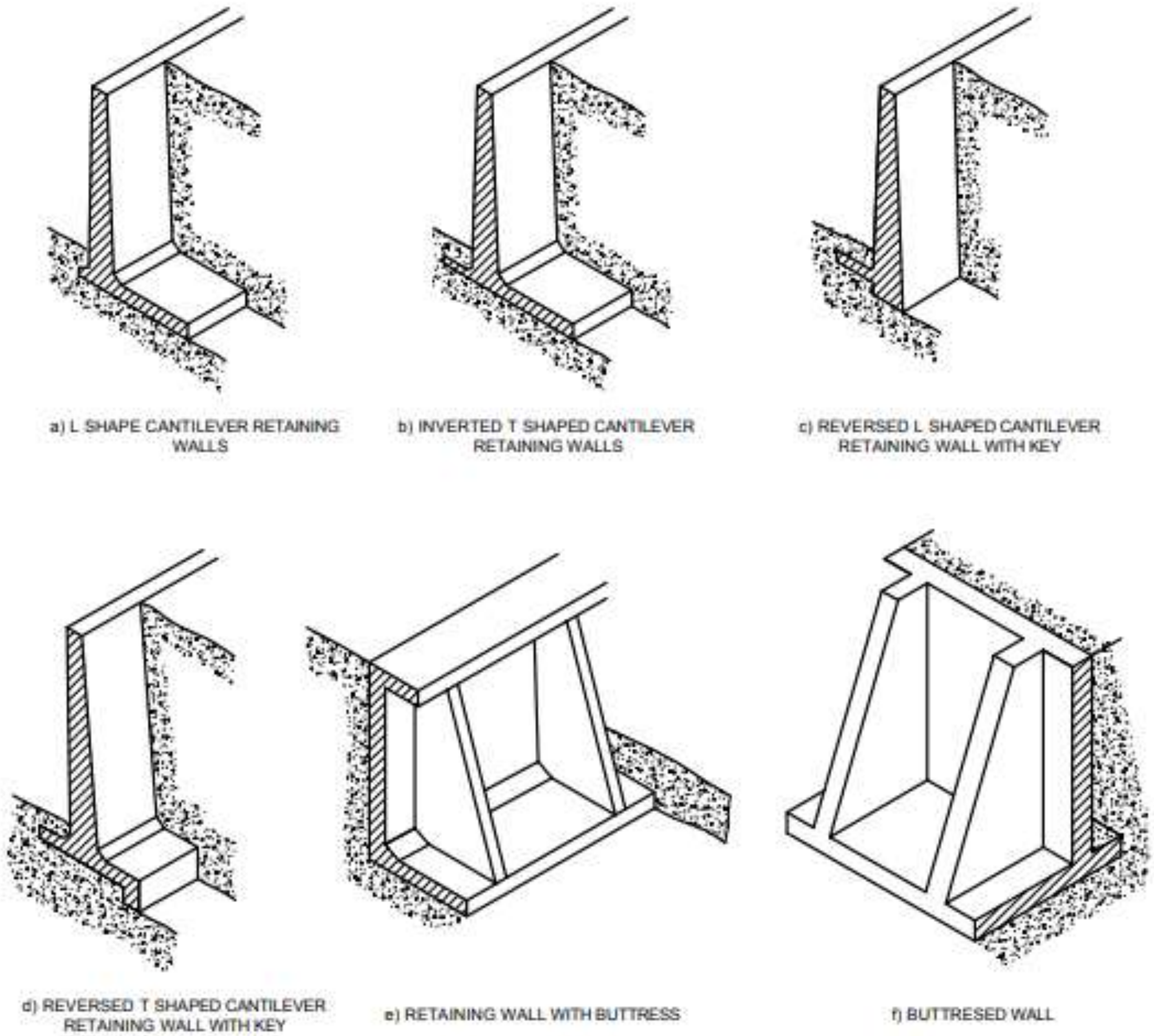


FIG. 2 TYPES OF RCC CANTILEVER RETAINING WALL

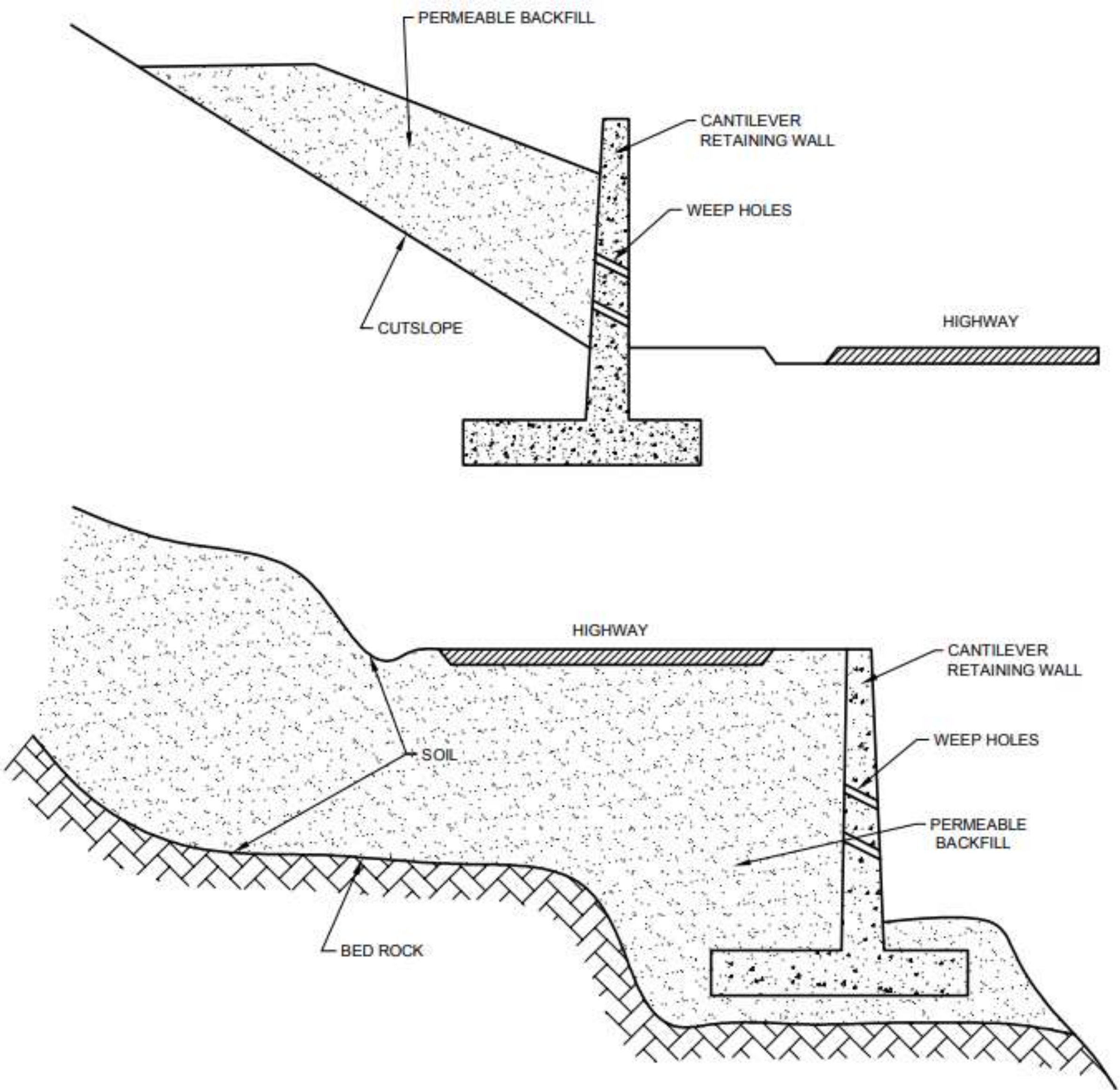


FIG. 3 SCHEMATIC DIAGRAM OF RCC CANTILEVER RETAINING WALL

5 DESIGN CRITERIA

5.1 The design of a retaining structure shall consist of two principal parts, the evaluation of loads and pressures that may act on the structure and the design of the structures to withstand these loads and pressures.

5.1.1 Following forces shall be accounted for in the design:

a) Self-weight of a retaining structure;
b) Imposed loads, if any;
c) Earth pressure acting on the wall;
d) Water pressure due to water table/subsurface seepage;

e) Water pressure due to water table on the side, if any;
f) Seismic forces; and
g) Special loads, if any.

The self-weight of the structure and imposed loads shall be estimated in accordance with IS 875 (Parts 1 to 2). In the usual cases, live load may be taken between 250 kg/m^2 to 500 kg/m^2 on the top width of the wall. The earth pressures and seismic forces on the retaining structure shall be estimated in accordance with IS 1893 (Part 1) with respect to the depth of retaining wall. For low-volume roads, the walls may not be designed for earthquake forces. In the case of the retaining walls for hill roads, earth pressure due to surcharge shall be considered in the design & analysis. The consideration of full water pressure behind the wall may lead to quite heavy section. Adequate arrangement for release of this water pressure shall be made. At least 30 percent water pressure shall always be considered even in case of provision of good efficient pressure release system.

5.2 Retaining walls shall be designed as rigid walls, using flowing criteria.

(a)	Factor of safety against overturning	2 (static loads) 1.5 (with earthquake forces)
(b)	Factor of safety against sliding	1.75 (static loads) 1.33 (with earthquake forces)
(c)	Factor of safety against bearing capacity failure	3 (static loads) The allowable bearing pressure may be increased by 25 to 50 percent under earthquake conditions [IS 1893 (Part 1)]

(d) In the case of steep hills, the factors of safety for slip surface below the foundation shall be greater than 1.5 and 1.0 in static and seismic conditions respectively.

NOTE – The imposed loads adding to stability of the structure shall not be considered in working out the factors of safety given in 5.2(a) and 5.2(b).

The design of wall foundations shall meet the requirements of IS 1080 and IS 1904. For a free-standing retaining wall, the wall together with the backfill up to a vertical plane above its heel can be treated as a monolithic block for the purpose of checking against sliding, overturning, and bearing capacity failures. Active earth pressures may be assumed in the calculations. The wall stem and base slab of a reinforced concrete retaining wall should be designed to resist the bending moments and shear forces due to pressures acting on the wall. In the structural design, at-rest and compaction-induced earth pressures should be assumed, unless deformation calculations show that there will be sufficient movement to reduce these pressures. In order to prevent large lateral pressures from being exerted on the wall stem, it is worthwhile to limit the compaction loading behind the wall. For L-shaped and inverted T-shaped retaining walls, the wall stem should be designed as a cantilever. A tapered wall stem is sometimes provided to reduce the volume of concrete required.

6 BEARING CAPACITY

6.1 The allowable bearing capacity shall be calculated in accordance with IS 6403 on the basis of soil test data. In the case of non-erodible rocks, the bearing capacity shall not exceed one-half the unconfined compression strength of the rock if the joints are tight. Where the joints are open, the bearing capacity shall not exceed one-tenth the unconfined compression strength of the rock. Bearing capacity for weak and closely jointed rock shall be assessed after visual inspections supplemented as necessary by field or laboratory tests to determine their strength and compressibility. Bearing capacity of rocks may be determined in accordance with IS 12070.

6.2 When earthquake forces are included, the permissible increase in allowable bearing capacity as per IS 1893 (Part 1).

7 DESIGN STEPS

7.1 External Stability

External stability analysis is used to evaluate the ability of the wall to resist lateral pressures applied by surcharges and the backfill and retained soil. The possible modes of external stability that are generally considered are illustrated in Fig. 4. Although the figure shows a cantilever wall, these modes of external stability are typically considered for all types of walls. The figure shows the external forces that act on a typical wall system. A wall must be proportioned to ensure an adequate factor of safety against failure as given below.

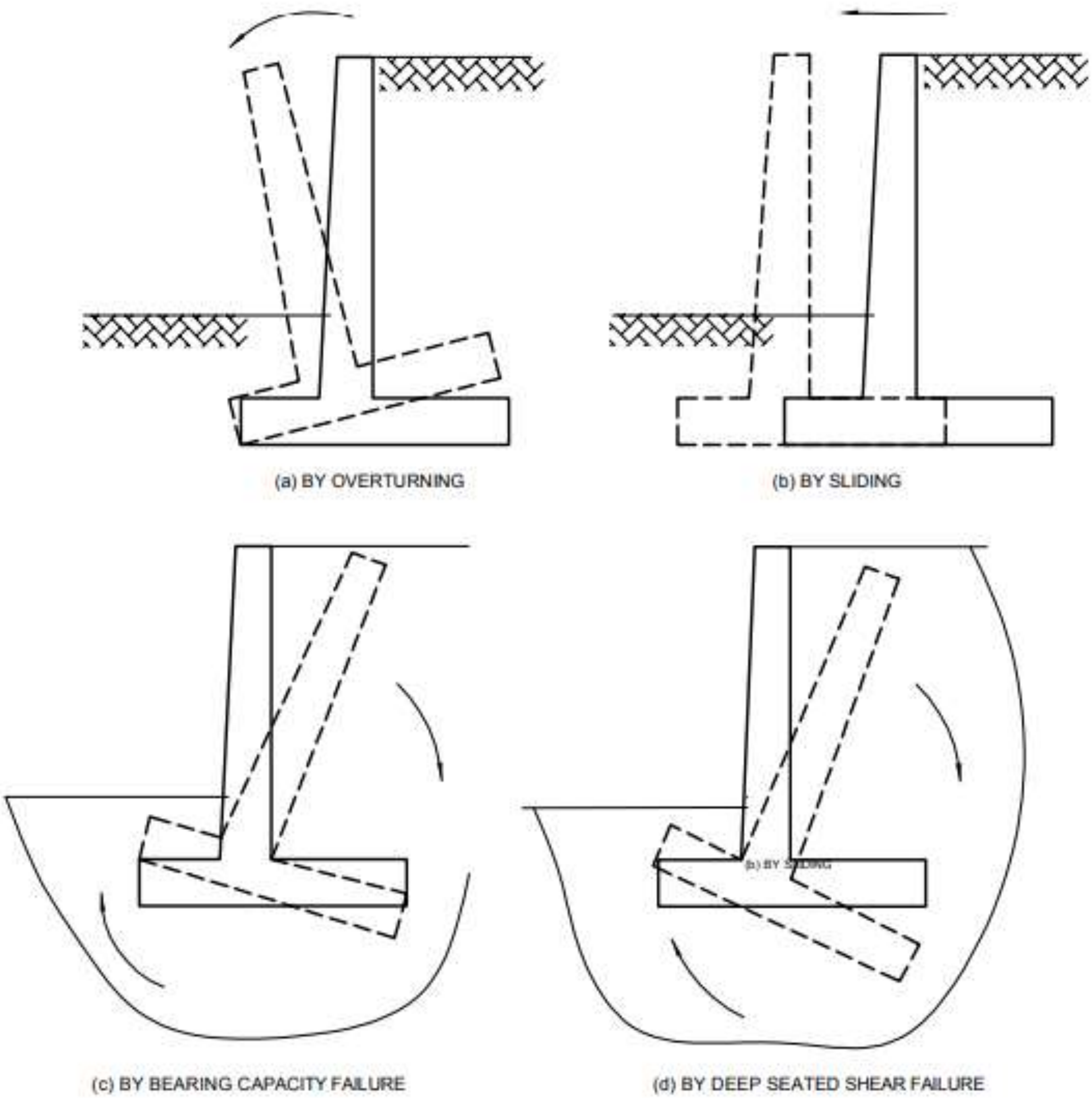


FIG. 4 FAILURE OF RETAINING WALL:

7.1.1 *Sliding*

Sliding may occur when the lateral pressure on the wall exceeds the available lateral resistance along the base of the wall. The lateral resistance may have several components including frictional resistance and adhesion that can be mobilized between the base of the wall and the underlying wall foundation soil or rock and passive resistance from the soil in front of the wall or adjacent to any foundation keyway. Passive resistance from soil in front of the wall is typically neglected for sliding stability calculations. For the case shown in Fig. 5, the factor of safety (FS), against sliding would be given as:

$$FS = \frac{F_\mathrm{r}}{P_\mathrm{h}} = \frac{N \ \ tan\, \delta_\mathrm{B} + C_\mathrm{B}\, B}{P_\mathrm{h}}$$

where

N = resultant vertical load,
δ_B = interface friction angle between the wall base and the foundation,
C_B = adhesion between the wall base and the foundation,
B = wall base width, and
P_h = horizontal earth pressure resultant.

If an adequate factor of safety against sliding cannot be achieved, design modifications should be considered. Modifications may include:

a) increase the width of the wall base;
b) using an inclined wall base or battering the wall to decrease the horizontal load;
c) constructing a shear key; and
d) embedding the wall foundation or slope base to a depth for which adequate lateral resistance can be mobilized.

7.1.2 *Overturning*

Overturning may occur when the driving moments (generated by the lateral pressure against the wall) are in excess of the resisting moments (generated by the self-weight of the wall and moments about the toe of the wall (point O, Fig. 5).

$$FS = \frac{\sum \text{Resistant Moments}}{\sum \text{Driving Moments}}$$

Overturning conditions can be improved by increasing the width of the wall or, for concrete cantilever walls, relocating the wall stem towards the heel of the wall base.

In addition, for walls founded on soil, the line of action of the resultant vertical load, N, must be within the middle third of the wall base. This condition can be expressed as:

$$e \leq \frac{B}{6}$$

Where the eccentricity, e, is the distance from the centerline of the wall to the line of action of the resultant vertical force and B is the width of the base of the wall (Fig. 5). The load eccentricity is caused by the moment applied to the wall foundation resulting from the horizontal component of earth pressure. This moment includes a non-uniform pressure on the bottom of the wall foundation and, if the eccentricity is greater than $B/6$, can lead to loss of contact pressure between the bottom of the wall and the ground. For walls founded on rock, the allowable eccentricity must be less than $B/4$.

7.1.3 *Bearing Capacity*

Bearing capacity failure may occur when the maximum bearing pressure along the wall base (q_{max}) exceeds the allowable bearing pressure of the wall foundation soil or rock (q_{u}). The factor of safety against a bearing a bearing capacity failure can be expressed as:

$$FS = \frac{q_{\mathrm{u}}}{q_{\mathrm{max}}}$$

The value of q_{max} can be evaluated based on the magnitude and line of action of the resultant vertical load, N. The value of q_{u} can be estimated using bearing capacity theory. The minimum factor of safety for bearing capacity failure is typically taken 3.0.

Bearing capacity can be improved by one or more of the following methods:

a) ground improvement;
b) increasing wall or slope embedment;
c) excavation of weak soils and replacing with compacted fill;
d) employing staged construction techniques; and
e) increasing wall width.

7.1.4 *Global Stability*

Global stability may occur if the shear stresses along a deep seated surface under the wall exceed the soil shear strength along the same surface. This failure is similar to a slope stability analysis using trial circles. These computations can be done by using a computer program for slope stability analysis.

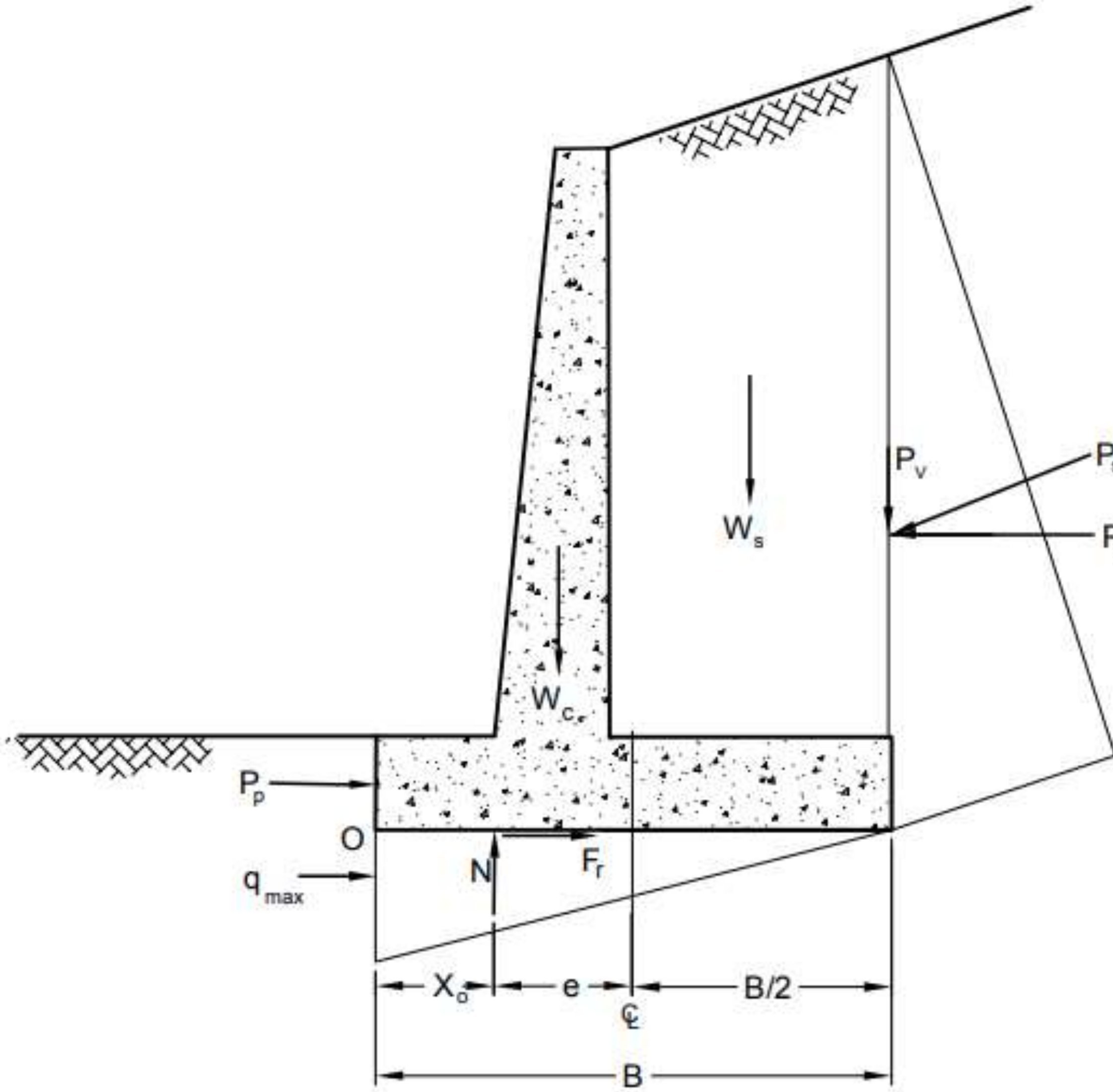


FIG. 5 FORCES ON CANTILEVER RETAINING WALL

7.1.5 *Design of Stem*

Stem of the retaining wall structurally behaves as a cantilever slab. Shear and moment at the base of the stem resulting from lateral earth pressures are computed and used to determine the stem thickness and necessary reinforcement. A load factor of 1.5 is used while designing to resist the factored moment and shear force. Vertical main reinforcements should be provided on the soil side of the stem and additional temperature and shrinkage reinforcement of 0.12 percent of the gross cross section should be provided transverse to the main reinforcement.

7.1.6 *Design of Heel Slab*

Heel slab is also designed as a cantilever subjected to downward loads consisting of its own weight, the weight of soil above it and any loading due to the surcharge and upward soil reactions. For heel slab reinforcement is required at the top of the slab.

7.1.7 *Design of Toe Slab*

Toe slab is assumed to be a beam cantilevered from the front face of the stem. The loads supported by the toe slab are weight of the cantilever slab and the upward soil pressure beneath. Usually, any earth fill on top of the toe is neglected. The maximum moment for design is taken at the face of the stem, whereas the maximum shear for design is assumed to occur at a distance *d* from the face of the stem because the reaction in the shear does introduce compression into the toe of the footing. Generally, the thickness of the toe is kept same as that of heel, although such a practice is not essential. In toe slab the reinforcement is required at the bottom of the slab.

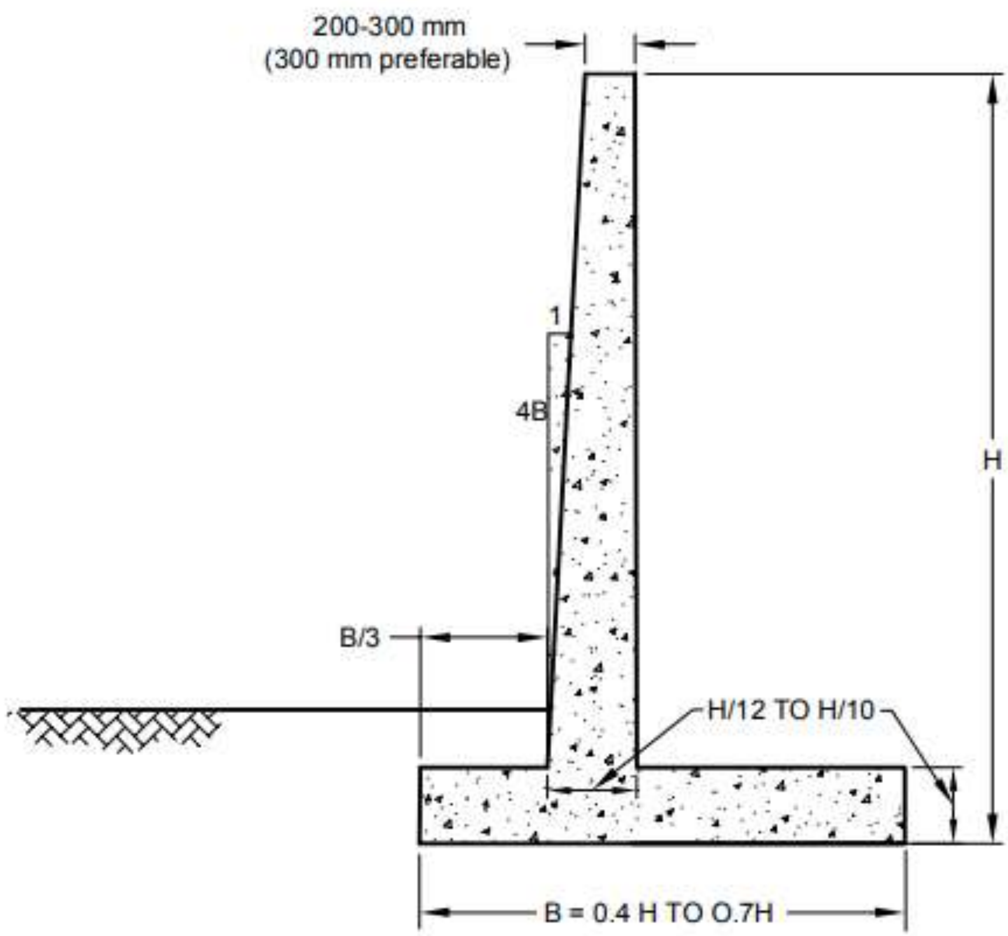


FIG. 6 GEOMETRY OF RCC CANTILEVER RETAINING WALL

7.1.8 *Seismic Design*

The active earth pressure acting on retaining walls are enhanced due to earthquake motions. The extent of this increase is called dynamic increment and can be computed by Mononobe-Okabe formula as follows:

The total active earth pressure including the earthquake effect is given by:

$$P_a = \frac{1}{2}\gamma h^2 C_a$$

$$C_a = \frac{(1 \pm \alpha_v)\cos^2(\emptyset - \lambda - \alpha)}{\cos\lambda\cos^2\alpha\cos\ (\delta + \alpha + \lambda)} \times \left[\frac{1}{1 + \left\{\frac{\sin(\emptyset + \delta)\sin(\emptyset - i - \lambda)}{\cos(\alpha - i)\cos(\delta + \alpha + \lambda)}\right\}^{\frac{1}{2}}}\right]^2$$

where

P_a = total earth pressure acting on the portion of wall upto depth h below ground;
γ = density of retained soil;
h = depth of portion of wall below ground;
C_a = co-efficient of active earth pressure;
α_v = vertical seismic co-efficient which may be taken equal to $\alpha_h/2$;
α_h = horizontal seismic co-efficient, values to be taken as per seismic zone from IS 1893 (Part 1);
$\emptyset$ = angle of internal friction of soil;
α = angle which the earth face of the wall makes with vertical;
i = slope of earth fill above the horizontal; and
δ = angle of friction between wall and earth or stone fill.

In the above expression, the positive sign of α_v means a direction of vertical acceleration which increases the weight of soil wedge below and negative value will indicate decrease in its weight.

The point of application of the earth pressure on the retaining wall is calculated by splitting the total pressure P_a in two parts P_{as} and P_{ad} where P_{as} is the static component without earthquake and P_{ad} is the dynamic increment due to earthquake. To determine P_{as}, P_a may be used but by putting $\alpha_h = \alpha_v = \lambda = 0$. That is,

$$P_{as} = \frac{1}{2}\gamma h^2 \frac{\cos^2(\phi + \alpha)}{\cos^2\alpha\cos(\delta - \alpha)} \times \left[\frac{1}{1 + \left\{\frac{\sin(\phi + \delta)\sin(\phi - i)}{\cos(\alpha + i)\cos(\delta - \alpha)}\right\}^{\frac{1}{2}}}\right]^2$$

Then, $P_{ad} = P_a - P_{as}$

The points of application of P_{as} and P_{ad} are to be taken at $h/3$ and $h/2$ respectively above the foot of the Coulomb wedge considered.

It may be clarified that both P_a and P_{as} act at an angle of δ with the horizontal and their horizontal and vertical components acting on the earth face of the wall shall be obtained by multiplying with $\cos\delta$ and $\sin\delta$ respectively.

8 STEPS TO BE FOLLOWED IN THE DESIGN & ANALYSIS OF A CANTILEVER RETAINING WALL

a) Calculate the depth of foundations and fix total height of the wall,
b) Select tentative proportions for the different components of the wall and fix the thickness for the stem from consideration of max B.M. at its junction with base slab,
c) Calculate all vertical and horizontal forces and check the stability of the wall against overturning,
d) Check the stability of the wall against sliding. Provide key under base slab if necessary,
e) Check the max. soil pressure at toe does not exceed the safe bearing capacity of soil, and
f) Calculate the max. B.M. for different wall components and design the toe and heel slab. Since the thickness of the toe/heel slab influences the height of stem, the design of the stem should be taken up subsequently. Check the section for shear and development length.

9 BACKFILL

The backfill layer immediately behind the wall should consist of hand packed stone or some granular material. These soils drain rapidly, are not susceptible to frost action or creep movements, and are easily placed and compacted in confined areas. In contrast, clayey soils drain slowly, are subject to seasonal volume changes, are susceptible to creep movements, and develop cracks due to shrinkage.

Remainder of the backfill should be rammed in 150 mm thick layers sloping towards the back of the wall, The top surface should better be sealed with bituminous macadam to prevent unnecessary direct seepage of water in the retaining wall increasing thereby the back pressure.

10 DRAINAGE PLAN

Inverted filter shall be provided behind retaining walls to drain off groundwater table or rainwater seepage.

Weep holes shall be provided at spacing of about 1.5 m centre-to-centre in either direction. The size of weep holes shall be 75 mm to 100 mm. At intervals, weep holes are run through the wall to carry away the accumulated water from the horizontal collector pipe unless it can discharge naturally from one end of the wall. PVC (flexible) pipes shall be embedded at 10° down from the horizontal towards the valley side to effectively drain the water from the ground. The inlets of all weep holes should be surrounded by loose stones. In wet situations, a continuous loose stone drain should connect the weep holes.

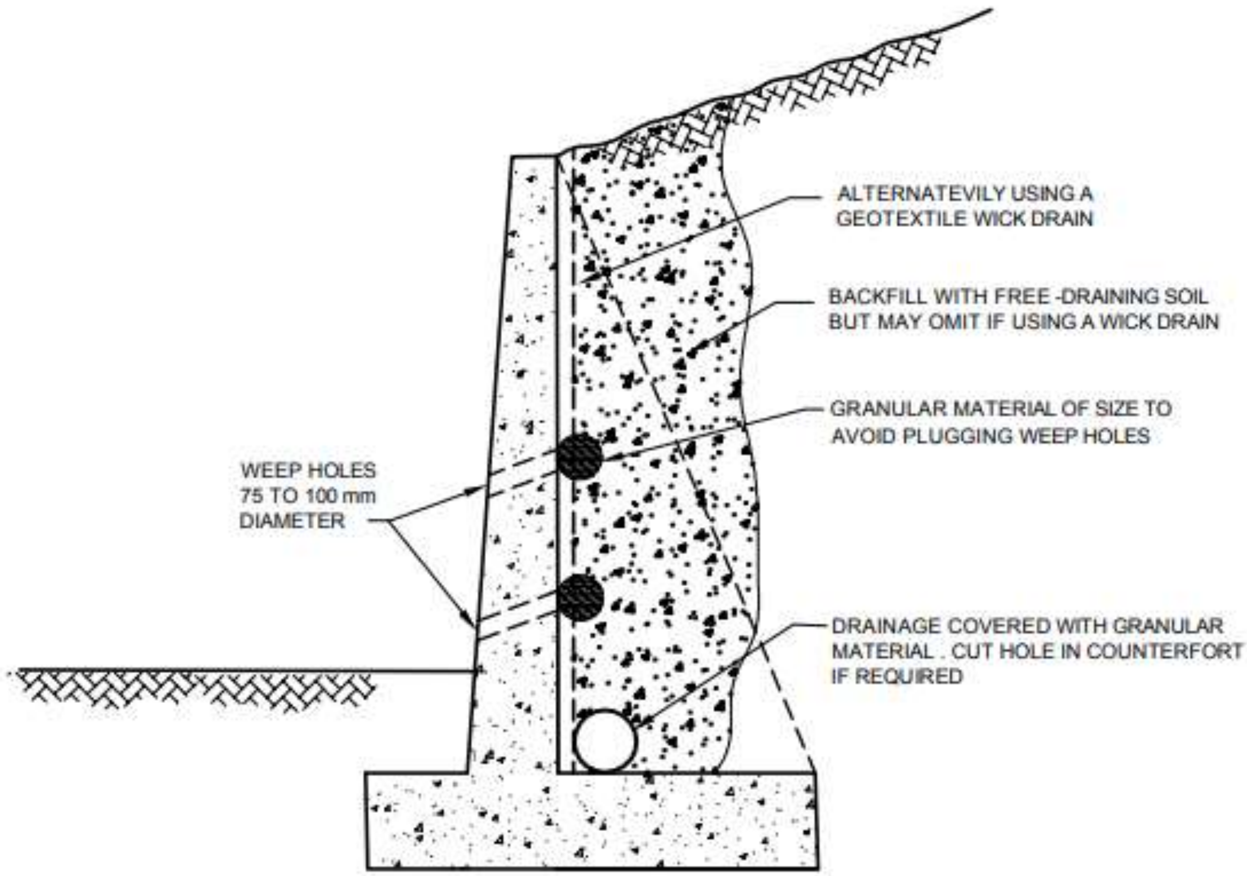
Filter material shall be provided around the entrance on the backfill side so the loss of fines does not occur. One may use a geotextile filter material along the vertical face of the wall and over the weep holes (with or without a granular backfilled zone). This allows water to penetrate the geotextile and travel vertically (and horizontally) to the weep holes while preventing the large loss of backfill fines shown in Fig. 7.

If a geotextile is not used, one should use very coarse gravel in the vicinity of the weep holes (and around any horizontal collector drain) that gradually grades to the backfill sieve size. If only a medium coarse sand is used, it will nearly always wash through the weep holes after several heavy rains. For sand backfill and a water source, a common 'compaction' procedure is to saturate the sand until there is visible surface water. This can be done only if the saturation water does not damage the surrounding soil.

Impervious silty soil layer or backfill of about 300 mm thickness shall be provided on the top to prevent seepage of rainwater in the backfill or into the foundation of buildings on terraces. However, the back-fill shall be of self-draining material (coarse sand, gravel, and boulder), free of fines.

Natural gullies shall be diverted away from the building site so that flow of rainwater does not cause erosion of retaining walls on topmost terrace. Grass turfing shall be laid on the ground slope to prevent erosion.

Catch water drains shall be avoided near the top of the retaining walls as they allow seepage of water in unmaintained conditions into the cut slope and destabilize it. If necessary, catch water drains may be provided far away from retaining walls for the above reasons. A catch water drain shall be provided at the toe of the breast wall to collect water from weep holes and surface runoff of the slope.



If weep holes are used with a counterfort wall at least one weep hole should be located between counterforts.

(a) Retaining wall drainage alternatives of granular backfill or geotextile wick drain. Note weep hole (as upper line) may cause staining of wall face from oxides in backfill. Do not use a longitudinal wall drain unless is can empty.

FIG. 7 DRAINAGE PROVISIONS FOR THE BACKFILL OF A RETAINING WALL

11 COMMON CAUSES OF FAILURE OF HILL ROAD RETAINING WALLS

There are a number of defects in the construction of the retaining walls in hill road and in its back filling which may ultimately lead to their failure. These are discussed below in detail.

11.1 Improper Construction of Wall

The construction of hill retaining walls in far-away places is usually supervised by non-technical persons and many construction defects creep in including the provision of inadequate section of the wall itself in place of the designed cross-section. Thus, there may be insufficient base width; improper slope at the base, that is, base may be made sloping outwards rather than inwards; the slope of bedding planes may be kept outward and not towards the backfill, the section of the wall may be made less than designed along the height, etc. Such defects are noticed in most of the damaged walls.

11.2 Improper Backfill

Where there is inadequate quality control, the backfilling behind retaining walls is sometimes done using muck (which may not be free draining) instead of using stone and coarse grained material filling. Much larger pressures may be exerted against the wall by the improper backfill material due to water which may be retained by it during rains.

11.3 Improper Drainage

Most hilly retaining walls are damaged during the raining season due to the collection of water behind retaining walls in their backfills which exerts very large pressures on the walls for which they are not designed. This happens because sound principles of drainage behind retaining walls are not adopted at the site. Where weep holes of small size are provided in the walls, they get choked after one or two heavy rains and do not then function as desired.

11.4 Seismic Action

Like all other structures, retaining walls are also shaken to the core during severe earthquakes and the pressure due to backfill also increased to some extent. However, the effective seismic forces are not high in the case of retaining walls in contact with the earth due to very high damping. It is therefore, expected that retaining walls designed for the code based seismic coefficients will be able to sustain the probable earthquake motions in the various seismic zones.

12 PRECAUTIONS DURING CONSTRUCTION

Foundation of structure must be taken deep enough to reach hard strata or rock and must be safe from scour, frost and surface water. The base must be substantial and capable of distributing the pressure over the foundation. Normally, no stone should be used which is less than 0.14 cu.m. in size. Bed of each stone should not usually be less than 1.5 times its height. The backfill layer immediately against the wall should consist of stone or some granular material. The soil or granular material between the backfill layer and hill slope should be rammed and compacted in layers sloping away and downwards from the back of the wall.

ANNEX A
(*Clause* 2)

LIST OF REFERRED INDIAN STANDARD

IS No./Other Standards	*Title*
IS 875	Design loads (other than earthquake) for buildings and structures – Code of practice:
(Part 1) : 1987	Dead loads - Unit weights of building materials and stored materials (*second revision*)
(Part 2) : 1987	Imposed loads (*second revision*)
(Part 3) : 2015	Wind loads (*third revision*)
(Part 4) : 2021	Snow loads (*third revision*)
(Part 5) : 1987	Special loads and load combinations (*second revision*)
IS 1080 : 1985	Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell) (*second revision*)
IS 1893 (Part 1) : 2016	Criteria for earthquake Resistant design of structures: Part 1 General provisions and buildings (*sixth revision*)
IS 1904 : 2021	General requirements for design and construction of foundations in soils – Code of practice (*fourth revision*)
IS 6403 : 1981	Code of practice for determination of bearing capacity of shallow foundations
IS 8009 (Part 1) : 1976	Code of practice for calculation of settlements of foundations: Part 1 Shallow foundations subjected to symmetrical static vertical loads
IS 8009 (Part 2) : 1980	Code of practice for calculation of settlement of foundations: Part 2 Deep foundations subjected to symmetrical static vertical loading
IS 12070 : 1987	Code of practice for design and construction of shallow foundations on rocks
IS 14458 (Part 1) : 1998	Retaining wall for hill area - Guidelines: Part 1 Selection of type of wall
FHWA SA 96 – 038 : 1997	Geotechnical engineering circular number-2 – Earth retaining systems
BS 8002 : 1994	Code of practice for retaining structures