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IS 14458-2 (1997): Guidelines for retaining wall for hill area, Part 2: Design of retaining/breast walls [CED 56: Hill Area Development Engineering]



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पहाड़ी क्षेत्र की रिटेनिंग दिवारें — रीति संहिता

भाग 2 रिटेनिंग/ब्रेस्ट दिवारों के डिजाइन

Indian Standard

**RETAINING WALL FOR HILL AREA —
GUIDELINES**

PART 2 DESIGN OF RETAINING/BREAST WALLS

ICS 93.020

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

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Hill Area Development Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

Retaining wall is a structure used to retain backfill and maintain difference in the elevation of the two ground surfaces. Retaining wall may be effectively utilized to tackle the problem of landslide in hill area by stabilizing the fill slopes and cut slopes.

From the initial construction cost considerations, one metre of extra width in filling, requiring retaining walls, costs much more than constructing the same width by cutting inside the hill. Similarly the cost of a breast wall is several times more than a non-walled cut slope. However, considering maintenance cost, progressive slope instability and environmental degradation from unprotected heavy excavations, the use of retaining walls on hill roads and terraces becomes essential. This standard (Part 2) is, therefore, being formulated to provide necessary guidance in design of retaining/breast walls for stability of hill slopes, the other parts of the code being as follows which are under preparation:

- Part 1 Selection of type of wall,
- Part 3 Construction of dry stone walls,
- Part 4 Construction of banded dry stone walls,
- Part 5 Construction of cement stone walls,
- Part 6 Construction of gabion walls,
- Part 7 Construction of RCC crib walls,
- Part 8 Construction of timber crib walls,
- Part 9 Design of RCC cantilever wall/buttressed walls/L-type walls, and
- Part 10 Design and construction of reinforced earth retaining walls.

In the formulation of this standard, assistance has been derived from Mountain Risk Engineering Handbook.

The composition of technical committee responsible for the formulation of this standard is given at Annex B.

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 : 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

RETAINING WALL FOR HILL AREA — GUIDELINES

PART 2 DESIGN OF RETAINING/BREAST WALLS

1 SCOPE

This standard (Part 2) deals with design of gravity type structures used to support earth or other materials behind them which would otherwise not stay in that position. Other types of retaining structures are covered in Part 9 and Part 10 of this standard (*under preparation*)

2 REFERENCES

The Indian Standards listed in Annex A contain provisions which through reference in this text, constitute provision 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 GENERAL

3.1 Gravity type retaining structures in hills are generally of two types:

- a) Breast wall, and
- b) Retaining wall.

3.1.1 Breast walls are normally stone masonry walls provided to protect the slopes of cutting in natural ground from the action of weather and cut slope failure but not from impact of snow avalanches. A toe wall cannot be used to stabilize an unstable slope.

3.1.2 Retaining walls are built to resist the earth pressure of filling and the traffic loads of the road. These are commonly used in hill roads when the road goes in embankment or partly cutting and partly filling (*see Fig. 1*). The retaining walls are also used extensively to develop sites for building complexes.

4 BEARING CAPACITY

4.1 The allowable bearing capacity shall be calculated in accordance with IS 6403 on the basis of soil test data. In case of non-erodible rocks, the bearing capacity shall not exceed one-half the unconfined compression strength of the rock if the joints are

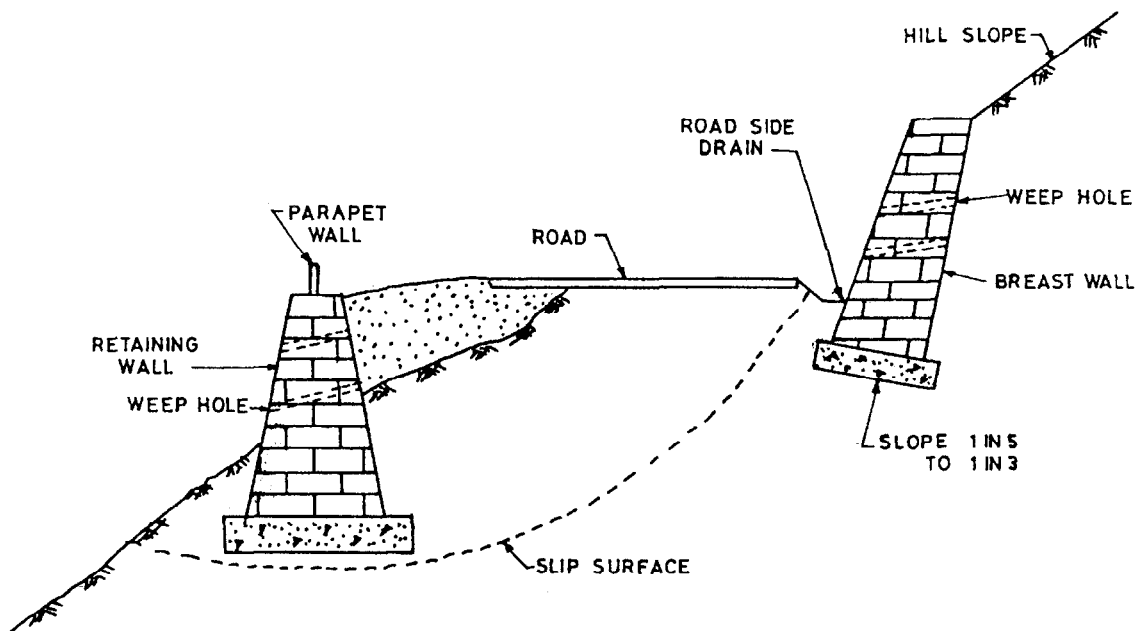


FIG. 1 TYPICAL ARRANGEMENT OF RETAINING WALL AND BREAST WALL IN A ROAD CROSS-SECTION

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. In the

absence of soil test data, for preliminary design, the values given in Table 1 may be adopted. Bearing capacity of rocks may be determined in accordance with IS 12070. In case of erodible and weak foundations (clay, loose soil, etc) gabion walls shall be preferred as they can withstand high differential settlements.

Table 1 Safe Bearing Capacities for Different Types of Soil
(Clause 4.1)

Type of Bearing Material	Symbol	Consistency of Place	Recommended Value of Safe Bearing Capacity (t/m ²)
(1)	(2)	(3)	(4)
Well graded mixture of fine and coarse-grained soil, glacial till, hard pan, boulder clay	GW-GC, GC, SC	Very compact	100
Gravel, gravel-sand mixtures, boulder-gravel mixtures	GW, GP, SW, SP	Very compact	80
		Medium to compact	60
		Loose	40
Coarse to medium sand, sand with little gravel	SW, SP	Very compact	40
		Medium to compact	30
		Loose	30
Fine to medium sand, silty or clayey medium to coarse sand	SW, SM, SC	Very compact	30
		Medium to compact	25
		Loose	15
Fine sand, silty or clayey medium to fine sand	SP, SM, SC	Very compact	30
		Medium to compact	20
		Loose	15
Homogeneous inorganic clay, sandy or silty clay	CL, CH	Very stiff to hard	40
		Medium to stiff	20
		Soft	5
Inorganic silt, sandy or clayey silt, varied silt-clay-fine sand	ML, MH	Very stiff to hard	30
		Medium to stiff	15
		Soft	5

4.2 When earthquake forces are included, the permissible increase in allowable bearing capacity shall be in accordance with 3.3 of IS 1893.

4.3 The value of cohesion 'c' and angle of internal friction ' Φ ' vary for different backfill and foundation materials. These values shall be determined by experiment. However for preliminary design the values given in Table 2 may be used.

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 structure to withstand these loads and pressures.

5.1.1 Following forces shall be accounted for in the design:

- Self weight of the retaining structure;
- Live load and imposed loads, if any;
- Earth pressure acting on the wall;

Table 2 Typical Strength Characteristics of Soil
(Clause 4.3)

Group Symbol	c (Cohesion of Soil) (t/m ²)		Φ' (Effective Stress Envelope) (degrees)	$\tan \Phi'$
(1)	(2)	(3)	(4)	(5)
GW	0	0	> 38	> 0.79
GP	0	0	> 37	> 0.74
GM	—	—	> 34	> 0.87
GC	—	—	> 31	> 0.60
SW	0	0	38	0.79
SP	0	0	37	0.74
SM	0.5	0.2	34	0.67
SM-SC	0.5	0.15	33	0.66
SC	0.75	0.1	31	0.60
ML	0.7	0.1	32	0.62
ML-CL	0.65	0.2	32	0.67
CL	0.9	0.15	28	0.54
MH	0.75	0.21	25	0.47
CH	1.0	0.1	19	0.35

- d) Water pressure due to water table/subsurface seepage;
- e) Water pressure due to water table on toe side, if any;
- f) Seismic forces; and
- g) Special loads, if any.

The self weight of the structure, and live and imposed loads shall be estimated in accordance with IS 875 (Parts 1 to 5). 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 other seismic forces on the retaining structure shall be estimated in accordance with IS 1893. For low volume roads, the walls may not be designed for earthquake forces. In case of retaining walls for roads earth pressure due to surcharge shall be in accordance with IRC Codes.

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 and breast walls shall be designed as rigid walls, using following criteria:

- | | | | |
|--|--|---|-----------------------------|
| <ol style="list-style-type: none"> a) Factor of safety against overturning b) Factor of safety against sliding | > 2.0 (static loads)
> 1.5 (with earthquake forces) | } | (see also IS 1904) |
| <ol style="list-style-type: none"> d) Minimum base pressure e) Factor of safety against floatation | > 0 (zero)
> 1.25 | } | [see also IS 4247 (Part 3)] |

NOTE — The live loads and 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).

- c) Maximum base pressure $\leq q_a$ (allowable bearing capacity)
 $\leq 1.33 q_a$ (during earth-quake)
- f) In case of steep hills, the factors of safety for slip surface below foundation shall be greater than 1.5 and 1.0 in static and seismic conditions respectively.

The design of wall foundations shall meet the requirements of IS 1080 and IS 1904.

5.3 Sometimes, to achieve the minimum factor of safety given in 5.2(b) and thereby resist sliding it may be necessary to increase the base area or to add

concrete keys monolithic with foundation slab or to provide piles.

5.4 It is generally not possible to design each and every wall along the entire length of a road. Standard designs as given in Table 3 may be adopted for walls less than 8 m in height and 120 m^2 area in a low hazard zone provided the allowable bearing capacity is more than the maximum pressure indicated in the table.

6 OTHER DETAILS

6.1 Depth of Walls

The depth of retaining wall and breast wall below ground level or terrace level shall be at least 500 mm below side drain within soil or highly jointed rock and foundation shall be on natural firm ground. All multiple breast walls shall be taken to the firm rock surface.

6.2 Stepping of Base of Wall on Rock Slope

If the retaining wall is made on rock slope, the foundation shall be stepped as shown in Fig. 2. In case of steep slopes ($>35^\circ$), retaining walls with front face nearly vertical and back-face inclined shall be used as it will reduce the height of wall considerably.

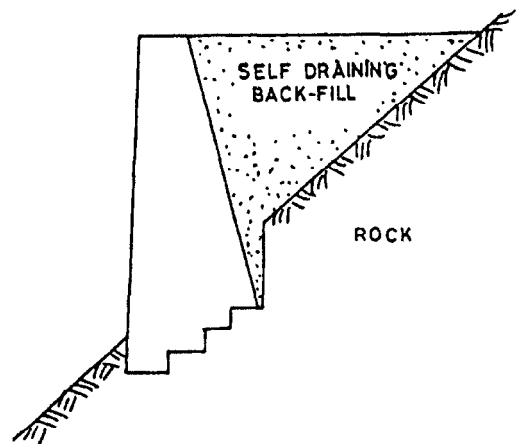


FIG. 2 STEPPING OF FOUNDATION OF WALL ON ROCK SLOPE

6.3 Dip of the Base of Wall Towards Hillside

A dip of the base of wall towards hillside to the extent of 3 : 1 (horizontal : vertical) proves very economical in seismic conditions (see Fig. 3). It increases factor of safety against sliding significantly.

6.4 Negative Batter of Backside of Breast Wall

Breast wall with negative batter (see Fig. 3) on cut-slope side reduces earth pressure significantly. So even nominal section of breast wall stabilizes cut slopes in soil, provided breast wall is founded on rock or firm natural ground. Negative batter of upto 1 : 3 (horizontal : vertical) is recommended.

Table 3 Standard Design of Cement Masonry and Dry Stone Masonry Retaining Walls
(Clause 5.4)

Back Fill Type	Particulars	Cement Masonry												Dry Stone Masonry											
		Ht 3M			Ht 6M			Ht 8M			Ht 10M			Ht 3M			Ht 6M			Ht 8M			Ht 10M		
Good Back-fill	Top width in m	0.65	0.70	—	0.75	1.00	1.00	0.80	1.00	1.00	0.90	1.00	—	0.70	—	—	0.75	0.95	1.00	0.85	1.00	1.00	0.90	1.00	—
	Base width in m	1.91	2.01	—	3.92	4.78	8.41	5.23	8.10	10.96	6.64	13.57	—	2.01	—	—	3.92	4.32	8.50	5.33	6.89	11.81	6.64	14.58	—
Full Drainage	Foundation pressure in t/m ²	14.00	13.00	—	25.0	20.00	13.00	33.00	20.00	17.00	40.00	21.00	—	11.00	—	—	22.00	20.00	17.00	29.00	20.00	13.00	36.00	16.00	—
Fair Back-fill	Top width in m	0.60	0.75	—	0.90	1.00	1.00	0.95	1.00	1.00	1.00	1.00	1.00	0.75	—	—	0.85	1.00	—	1.00	1.00	1.00	1.00	1.00	1.00
	Base width in m	1.81	2.11	—	4.12	4.47	4.88	5.53	6.59	8.14	6.94	9.90	14.03	2.11	—	—	4.12	4.42	—	5.63	6.49	6.94	6.94	8.50	10.26
Low pore Water pressure	Foundation pressure in t/m ²	15.00	13.00	—	25.00	22.00	20.00	32.00	25.00	20.00	39.00	25.00	11.00	11.00	—	—	22.00	20.00	—	28.00	22.00	20.00	34.00	25.00	20.00
Poor Back-fill	Top width in m	—	—	—	—	—	—	1.00	1.00	1.00	1.00	1.00	—	—	—	—	—	—	—	1.00	1.00	1.00	1.00	1.00	1.00
	Base width in m	—	—	—	—	—	—	6.49	7.89	8.50	7.79	11.01	—	—	—	—	—	—	—	6.54	8.65	8.70	7.84	10.11	11.97
High pore Water pressure	Foundation pressure in t/m ²	—	—	—	—	—	—	22.00	20.00	19.00	29.00	23.00	—	—	—	—	—	—	—	22.00	20.00	16.00	25.00	20.00	18.00
GC, SC ML	Foundation pressure in t/m ²	—	—	—	—	—	—	22.00	20.00	19.00	29.00	23.00	—	—	—	—	—	—	—	22.00	20.00	16.00	25.00	20.00	18.00

NOTES

1 Wall Geometry : Front face vertical back, face inclined, base inclined with hill.

2 Back Fill Top : Horizontal with surcharge 1.5 t/m².

3 Select wall dimensions such that allowable bearing capacity is greater than the foundation pressure.

4 The base width for dry stone masonry wall is slightly less for cement masonry wall because wall friction angle is likely to be equal to angle of internal friction of back fill in the case of dry stone masonry.

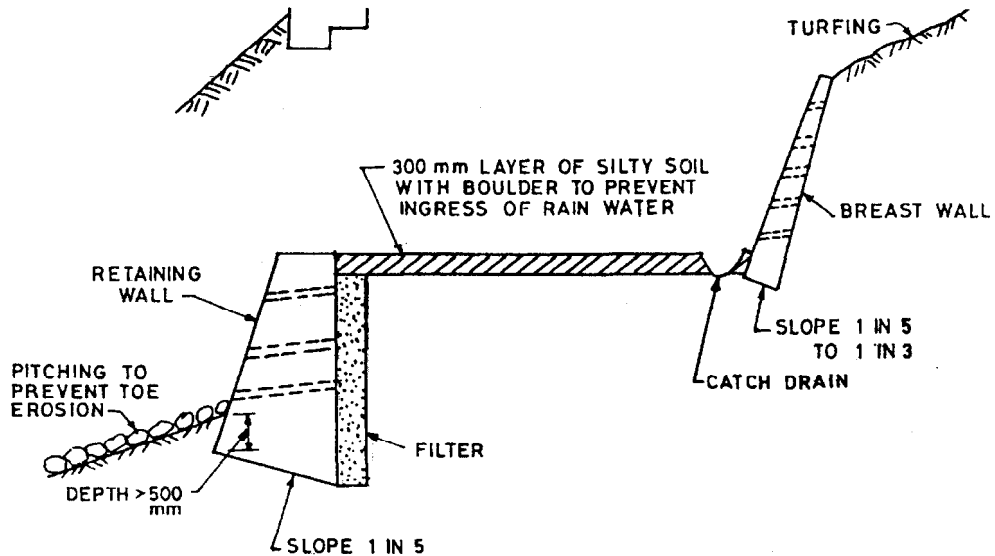


FIG. 3 TERRACE DEVELOPMENT FOR BUILDING COMPLEXES WITH RETAINING WALL AND BREAST WALL

6.5 Drainage Plan

6.5.1 Inverted filter shall be provided behind retaining walls to drain off ground water table or rain water seepage.

6.5.2 Weep holes shall be provided in cement stone masonry walls at spacing of about 1.5 m centre-to-centre in either direction. The size of weep holes shall be 100 mm to 150 mm PVC (flexible) pipes and shall be embedded at 10° down from the horizontal towards valley side to effectively drain the water from ground.

6.5.3 Impervious silty soil layer or back-fill of about 300 mm thickness shall be provided on the top to prevent seepage of rain water in the back-fill or into the foundation of buildings on terraces (see Fig. 3). However, the back-fill shall be of self-draining material (coarse sand, gravel and boulder), free of fines.

6.5.4 Natural gullies shall be diverted away from the building site so that flow of rain water does not

cause erosion of breast walls on topmost terrace. Grass turfing shall be laid on the ground slope to prevent erosion.

6.5.5 Catch water drains shall be avoided near the top of the breast 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 breast walls for 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.

6.6 Erosion Control of Toe of Retaining Walls

The rain water flows at a high speed from high retaining walls (>3 m). This may lead to toe erosion of soft rocks (shale/sand rock/conglomerate, etc) at the foundation. So dry stone pitching may be done as shown in Fig. 3. Stones of 150 mm size may be laid on slope for a distance of 1 m below the toe of retaining walls.

ANNEX A

(Clause 2)

LIST OF REFERRED INDIAN STANDARDS

<i>IS No.</i>	<i>Title</i>	<i>IS No.</i>	<i>Title</i>
875	Code of practice for design loads (other than earthquake) for buildings and structures: .	1893 : 1984	Criteria for earthquake resistant design of structures (<i>fourth revision</i>)
(Part 1) : 1987	Dead loads — Unit weights of building material and stored materials (<i>second revision</i>)	1904 : 1986	Code of practice for design and construction of foundations in soils: General requirements (<i>third revision</i>)
(Part 2) : 1987	Imposed loads (<i>second revision</i>)		
(Part 3) : 1987	Wind loads (<i>second revision</i>)	4247	Code of practice for structural design of surface hydel power stations: Part 3 Substructure (<i>first revision</i>)
(Part 4) : 1987	Snow loads (<i>second revision</i>)	(Part 3) : 1978	
(Part 5) : 1987	Special loads and load combinations (<i>second revision</i>)	6403 : 1981	Code of practice for determination of bearing capacity of shallow foundations (<i>first revision</i>)
1080 : 1986	Code of practice for design and construction of shallow foundations on soils (other than raft, ring and shell) (<i>second revision</i>)	12070 : 1987	Code of practice for design and construction of shallow foundation on rock

ANNEX B
(Foreword)
COMMITTEE COMPOSITION

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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards Monthly Additions'.

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Amendments Issued Since Publication

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