IS 14458 (Part 1) (1998): Retaining Wall for Hill Area--Guidelines, Part 1: Selection of Type of Wall. ICS 93.020

भारतीय मानक

पहाड़ी क्षेत्र के लिए प्रतिधारक भित्ति हेतु मार्गदर्शी सिद्धांत

भाग 1 भित्ति के प्रकार का चयन

Indian Standard

RETAINING WALL FOR HILL AREA — GUIDELINES

PART 1 SELECTION OF TYPE OF WALL

ICS 93.020

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

May 1998

Price Group 4

FOREWORD

This Indian Standard (Part 1) 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 1) is, therefore, being formulated to provide necessary guidance in selection of retaining walls for stability of hill slopes, the other parts of the standard being:

Part 2	Design of retaining/breast walls
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
Part 10	Design and construction of reinforced earth retaining walls

In the formulation of this standard, considerable assistance has been provided by International Centre for Integrated Mountain Development, Kathmandu. Assistance has also been derived from Mountain Risk Engineering Handbook.

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

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, 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 1 SELECTION OF TYPE OF WALL

1 SCOPE

This standard (Part 1) covers the guidelines for selection of various retaining walls to suit the site conditions, for the purpose of imparting stability to the slopes in hill areas.

NOTE — The retaining walls are normally not intended to stabilize slope failures. They are mainly meant to support the active or passive earth pressure from the assumed failure wedge above the base of the wall. The stabilization of existing or probable failure planes caused by landslides, flows and falls require separate treatment and specific design approaches. Only the fill slopes and cut slopes could be stabilized/retained by retaining walls.

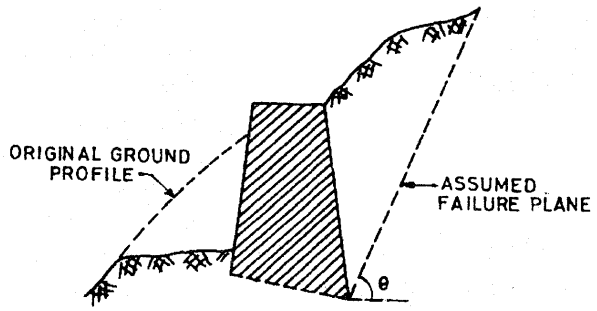
2 CLASSIFICATION

2.1 The retaining walls shall be classified on the basis of type of construction and mechanics of behaviour (*see* Fig. 1) as follows:

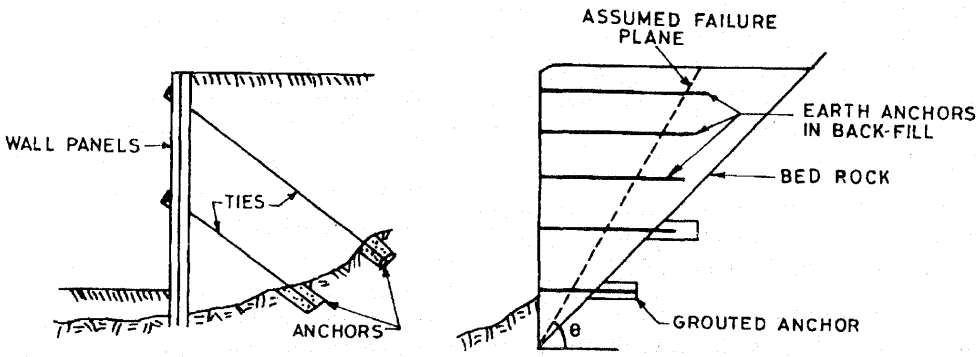
a) Gravity walls
b) Tie back walls
c) Driven cantilever walls
d) Reinforced earth walls
e) RCC walls

2.2 The classification of retaining walls with respect to their design and probable behaviour of construction medium may be as follows:

a) Bin walls
   i) Rectangular
   ii) Circular
   iii) Cross tied
b) Crib walls
   i) Concrete crib
   ii) Timber crib
c) Gabions walls and wire crated/sausage walls
d) Cement masonry walls
e) Dry stone masonry walls
f) Drum walls
g) Reinforced backfill walls

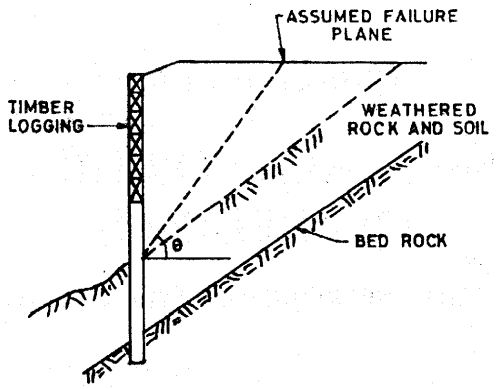


1(a) GRAVITY WALL

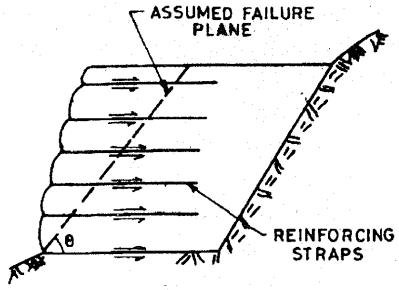


1(b) TIE BACK WALL

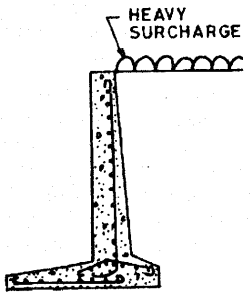
FIG. 1 DIFFERENT TYPES OF RETAINING WALLS — (*Continued*)



1(c) DRIVEN CANTILEVER WALL



1(d) REINFORCED EARTH WALL



1(e) RCC WALLS

FIG. 1 DIFFERENT TYPES OF RETAINING WALLS

i) Reinforced earth
ii) Fabric

h) Anchored walls
i) Horizontal sheet pile
ii) Vertical sheet pile
iii) H-pile, timber logged

j) RCC walls
i) Cantilever
ii) L-type
iii) Buttressed wall
iv) Frame retaining walls

3 SELECTION OF TYPE OF WALLS

3.1 In general, the choice of wall depends on local resources, local skill, hill slope angle, foundation conditions, slope of backfill, compatibility of materials and seismicity of the region (*see* Tables 1 and 2). However, the guidelines given in **3.1.1** to **3.1.14** shall be considered for selection of the type of retaining wall to be constructed for the purpose of imparting stability to the slopes in hill area.

3.1.1 For hilly roads, being of low volume, walls may not be designed for earthquake forces. It is economical to repair failed walls after earthquake.

3.1.2 Earthquake considerations lead to excessive wall dimensions. High walls may, therefore, be avoided by alternative geometric designs of roads and terraces unless justified by risk analysis. Walls with dip at the base towards hillside will reduce the base width in seismic areas.

3.1.3 Front battered retaining walls are many times more expensive than back battered walls in steep hilly areas.

3.1.4 A retaining wall on a thin talus slope may not be able to prevent the failure of entire talus slope during monsoon because of the quick rise of water table above the relatively impervious bed rock.

3.1.5 The construction of series of retaining walls one above another on an unstable or marginally stable slope shall be avoided as it adds more pressure on the lower walls destabilizing the slope contrary to the aim of stabilizing the slope. In such cases, unstable slope shall be stabilized by afforestation, surface/sub-surface drainage system, etc.

3.1.6 Improper backfill and poor drainage behind the wall involve complicated drainage conditions which are normally not considered in normal design. Proper drainage behind the walls shall, therefore, be provided.

3.1.7 The practice of undertaking wall construction after road/hill cutting poses the problem of disposal of excavated material and loss of top soil that could otherwise be used for vegetation. Hence during construction of retaining walls, the excavated material shall be disposed off at suitable identified sites.

3.1.8 Breast walls are more economical for cut slopes. Batter (negative) of the backfill side reduce base width of the wall significantly.

3.1.9 Dry stone retaining walls, breast walls and timber crib are economical but least durable, non-ductile structures. These are most susceptible to earthquake damages.

3.1.10 Gabion/wire crated walls shall be used in case of poor foundation or seepage conditions. These can take considerable differential settlement and some slope movement.

3.1.11 Banded dry stone masonry (height ≤ 6 m) and cement masonry walls are most durable but being non-ductile structures, are susceptible to earthquake damages.

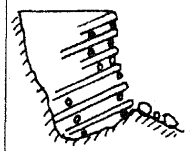
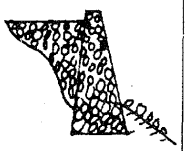
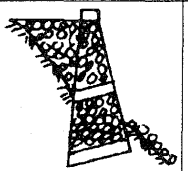
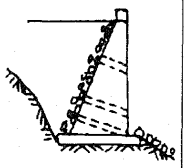
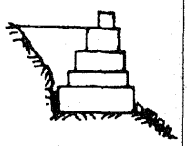
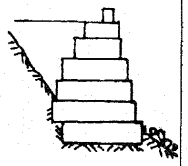
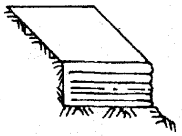
3.1.12 Reinforced earth is normally used as reinforced fill platform for road. Generally it is not used as preventive method of slope support.

3.1.13 Timber crib, dry stone masonry walls may be provided for hill slope angle less than 30° and, height less than 4 m in low volume roads. These are not suitable for terrace development because of short life.

3.1.14 Cement masonry, RCC walls, Gabion walls shall be considered for high volume roads, high cut slopes and terraces. These are also suitable for hill slope angles from 30° to 60°, where higher walls are needed.

Table 1 Selection of Retaining Walls

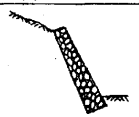
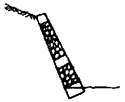
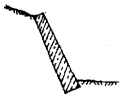
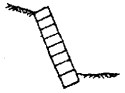
(*Clause* 3.1)

	Type	Retaining Walls						
		Timber Crib	Dry Stone	Banded Dry Stone/ Masonary	Cement Masonry	Gabion		Reinforced Earth
						Low	High	
	Diagrammatic Cross-section							
CONSTRUCTION NOTES	Top width	2 m	0.6-1.0 m	0.6-1.0 m	0.5-1.0 m	1 m	1-2 m	4 m or 0.7-0.8 m
	Base width	—	0.5-0.7 H	0.6-0.65 H	0.5-0.65 H	0.6-0.75 H	0.55-0.65H	4 m or 0.7-0.8 H
	Front batter	4:1	vertical	varies	10:1	6:1	6:1	3:1
	Back batter	4:1	varies	vertical	varies	varies	varies	3:1
	nward dip of foundation	1:4	1:3	1:3	horizontal or 1:6	1:6	1:6	horizontal
	Foundation depth below drain	0.5-1 m	0.5 m	0.5-1 m	0.5-1 m	0.5 m	1 m	0.5 m
	Range of height	3-9 m	1-6 m	6-8 m	1-10 m	1-6 m	6-10 m	3-25 m
	Hill slope angle	<30°	<35°	20°	35-60	35-60	35-60	<35
	Toe protection in case of soft rock/soil	Boulder pitching	Boulder Pitching					No
	General	Timbers 15 cm φ with stone rubble well packed behind timbers. 10% of all headers to extend into fill. Ecologically unacceptable.	Set stones along foundation bed. Use long bond stones. Hand packed stones in back fill.	Cement masonry bands of 50 cm thickness at 3 m c/c. Other specifications as for dry stone wall.	Weep holes 15 × 15 cm size at 1-2 m c/c. 50 cm rubble backing for drainage.	Stones to be hand packed. Stone shape important, blocky preferable to tabular. Specify maximum/minimum stone size. No weathered stone to be used. Compact granular back fill in layers (< 15 cm). Use H type gabion wall.		Granular back fill prefered. Use geogrid for H <4 m and tensur grid for H> 4 m. Provide drainage layer in case of seepage problems. Specify spacing of reinforcement grids.

<table>
<tr><td colspan="2"></td><td colspan="3">1. Foundations to be stepped up if rock encountered.
2. All walls require durable rock filling of small to medium size.
3. Drainage of wall bases not shown. Provide 15 cm thick gravel layer in case of clayey foundation.</td><td></td></tr>
<tr><td colspan="2" rowspan="3">Application</td><td>Least durable</td><td>Most durable</td><td>Can take differential settlement and slope movement</td><td rowspan="3">Huge potential used more as stable reinforced fill platform for road rather than preventive method of slope support.</td></tr>
<tr><td colspan="2">Non ductile structure most susceptible to earth-quake damage</td><td>Very flexible structures</td></tr>
<tr><td colspan="3">1. Design as conventional retaining walls. Assume surcharge on road of $2T/m^2$.
2. Used both as cut slope and fill slopes support. Breast wall is more economical for cut slope.
3. Choice of wall depends on local resources, local skill, hill slope angle, foundation conditions and also shape of back fill wedges as illustrated in diagrams and compatibility of materials.</td></tr>
</table>

Table 2 Selection of Breast Walls

(*Clause* 3.1)

Type	Breast Walls/Revetment Walls							Remarks
	Dry Stone			Banded Dry Stone Masonry	Cement Masonry	Gabion	Horizontal Drum Walls	
(1)	(2)			(3)	(4)	(5)	(6)	(7)
Diagrammatic cross-section								1. Wall construction requires special skills and practical labour. Curing of masonry walls generally not feasible in hills due to paucity of water.
Construction Notes: Top width	0.5			0.5	0.5	2	1	2. The typical dimensions shown rely both on well-drained backfill and good foundation conditions.
Base width	0.29H	0.3H	0.33H		0.23H	2	1	
Front batter								3. Detailed design is necessary in case of soil slopes and walls higher than 6 m and poor foundation conditions.
Back batter	3:1	4:1	5:1	3:1	3:1	3 to 5:1	3:1	
Inward dip of foundation	1:3	1:4	1:5	1:3	1:3	1:5	1:3	4. Gabion walls should be used in case of poor foundation/seepage conditions. They can take considerable differential settlement and some slope movement.
Foundation depth below drain	0.5 m	0.5 m	0.5 m	0.5 m	0.5 m	0.5-1 m	0.25 m	
Range of height	6 m	4 m	3 m	3-8 m	1-10 m	1-8 m	2.2 m	5. Other measures should also be taken, for example, check drains, turfing, benching of cut slopes in soft rocks, sealing of cracks, etc. All preventive measures should be implemented in one season. Total system of measures is far more effective than individual measures.
Hill slope angle	35-60			35-60	35-70	35-60	35	
Toe protection in case of soft rock/soil	No pitching			No	No	No	No	
General	Pack stone along foundation bed. Use bond stones. Specify minimum stone size.			Cement masonry (1:6) bands of 0.5 m thickness at 3 m c/c.	Weep holes 15 × 15 cm at 1.5-2 m c/c and grade 1:10. Cement sand (1:6)	Step in front face 20-50 cm wide. Otherwise as for retaining walls.	Use vertical single drum for 0.7 m height. Anchor drum walls on sides. Fill debris material.	
	Revetment walls have uniform section of 0.5 m/0.75 m thickness for batter of 2:1 or more. Section shaped to suit variation and overbreak in rock cut slope.							
Application	Least durable/ economical			Little used	Most durable/costly	Quite durable/costlier or	Promising/most economical or	
	Non ductile structures most susceptible to earthquake damage.					Very flexible	Flexible	
	Revetments are used to prevent only major erosion, rock fall, slope degradation particularly where vulnerable structures are of risk.							

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

Hill Area Development Engineering Sectional Committee, CED 56

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SHRI N. GOPALAKRISHNAN (*Alternate*)	

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Members	*Representing*
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SURVEYOR OF WORKS-I (NZ) (*Alternate*)	
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