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Mazdoor Kisan Shakti Sangathan
“The Right to Information, The Right to Live”

“पुराने को छोड़ नये के तरफ”
Jawaharlal Nehru
“Step Out From the Old to the New”

Indian Standard

RETAINING WALL FOR HILL AREA — GUIDELINES

PART 1 SELECTION OF TYPE OF WALL

ICS 93.020

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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

Fig. 1 DIFFERENT TYPES OF RETAINING WALLS — (Continued)
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/subsurface 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)*

<table>
<thead>
<tr>
<th>Type</th>
<th>Retaining Walls</th>
<th>Gabion</th>
<th>Reinforced Earth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Timber Crib</td>
<td>Dry Stone</td>
<td>Banded Dry Stone/ Masonry</td>
</tr>
<tr>
<td>Top width</td>
<td>2 m</td>
<td>0.6-1.0 m</td>
<td>0.6-1.0 m</td>
</tr>
<tr>
<td>Base width</td>
<td>--</td>
<td>0.5-0.7 H</td>
<td>0.6-0.65 H</td>
</tr>
<tr>
<td>Front batter</td>
<td>4:1</td>
<td>vertical</td>
<td>varies</td>
</tr>
<tr>
<td>Back batter</td>
<td>4:1</td>
<td>varies</td>
<td>vertical</td>
</tr>
<tr>
<td>Inward dip of foundation</td>
<td>1:4</td>
<td>1:3</td>
<td>1:3</td>
</tr>
<tr>
<td>Foundation depth below</td>
<td>0.5-1 m</td>
<td>0.5 m</td>
<td>0.5-1 m</td>
</tr>
<tr>
<td>drain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range of height</td>
<td>3-9 m</td>
<td>1-6 m</td>
<td>6-8 m</td>
</tr>
<tr>
<td>Hill slope angle</td>
<td>&lt;30°</td>
<td>&lt;35°</td>
<td>20°</td>
</tr>
<tr>
<td>Toe protection in case of soft rock/soil</td>
<td>Boulder pitching</td>
<td>Boulder Pitching</td>
<td>No</td>
</tr>
<tr>
<td>N O T E S</td>
<td>General</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Timbers 15 cm with stone rubble well packed behind timbers. 10% of all headers to extend into fill. Ecologically unacceptable.</td>
<td>Set stones along foundation bed. Use long bond stones. Hand packed stones in back fill.</td>
<td>Cement masonry bands of 50 cm thickness at 3 m c/c. Other specifications as for dry stone wall.</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Application</th>
<th>Least durable</th>
<th>Most durable</th>
<th>Can take differential settlement and slope movement</th>
<th>Huge potential used more as stable reinforced fill platform for road rather than preventive method of slope support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non ductile structure most susceptible to earthquake damage</td>
<td></td>
<td></td>
<td>Very flexible structures</td>
<td></td>
</tr>
</tbody>
</table>
### Table 2 Selection of Breast Walls

*(Clause 3.1)*

<table>
<thead>
<tr>
<th>Type</th>
<th>Breast Walls/Revetment Walls</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry Stone</td>
<td><strong>Remarks</strong></td>
</tr>
<tr>
<td>(1)</td>
<td>Banded Dry Stone Masonry</td>
<td>1. Wall construction requires special skills and practical labour. Curing of masonry walls generally not feasible in hills due to paucity of water.</td>
</tr>
<tr>
<td></td>
<td>Cement Masonry</td>
<td>2. The typical dimensions shown rely both on well-drained backfill and good foundation conditions.</td>
</tr>
<tr>
<td></td>
<td>Gabion</td>
<td>3. Detailed design is necessary in case of soil slopes and walls higher than 6 m and poor foundation conditions.</td>
</tr>
<tr>
<td></td>
<td>Horizontal Drum Walls</td>
<td>4. Gabion walls should be used in case of poor foundation/seepage conditions. They can take considerable differential settlement and some slope movement.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagrammatic cross-section</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top width</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Base width</td>
<td>0.29H</td>
<td></td>
</tr>
<tr>
<td>Front batter</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>Back batter</td>
<td>3:1</td>
<td></td>
</tr>
<tr>
<td>Inward dip of foundation</td>
<td>1:3</td>
<td></td>
</tr>
<tr>
<td>Foundation depth below drain</td>
<td>0.5 m</td>
<td></td>
</tr>
<tr>
<td>Range of height</td>
<td>6 m</td>
<td></td>
</tr>
<tr>
<td>Hill slope angle</td>
<td>35-60</td>
<td></td>
</tr>
<tr>
<td>Toe protection in case of soft rock/soil</td>
<td>No pitching</td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>Pack stone along foundation bed. Use bond stones. Specify minimum stone size.</td>
<td>Revetment walls have uniform section of 0.5 m with 0.75 m thickness for batter of 2:1 or more. Section shaped to suit variation and overbreak in rock cut slope.</td>
</tr>
<tr>
<td></td>
<td>Cement masonry (1:6) bands of 0.5 m thickness at 3 m c/c.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weep holes 15 x 15 cm at 1.5-2 m c/c and grade 1:10. Cement sand (1:6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Step in front face 20-50 cm wide. Otherwise as for retaining walls.</td>
<td>Use vertical single drum for 0.7 m height. Anchor drum walls on sides. Fill debris material.</td>
</tr>
<tr>
<td>Application</td>
<td>Least durable/economical</td>
<td>Non ductile structures most susceptible to earthquake damage. Revetments are used to prevent only major erosion, rock fall, slope degradation particularly where vulnerable structures are of risk.</td>
</tr>
<tr>
<td></td>
<td>Little used</td>
<td>Very flexible</td>
</tr>
<tr>
<td></td>
<td>Most durable/costly</td>
<td>Flexible</td>
</tr>
<tr>
<td></td>
<td>Quite durable/costlier or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Promising/most economical or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Revetments are used to prevent only major erosion, rock fall, slope degradation particularly where vulnerable structures are of risk.</td>
<td></td>
</tr>
</tbody>
</table>
ANNEX A

(Foreword)

COMMITTEE COMPOSITION

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