भारतीय मानक

पहाड़ी क्षेत्र में भवन निर्माण के स्थल के चुनाव और विकास के मार्गदर्शी सिद्धान्त

भाग 2 चयन और विकास

Indian Standard

SELECTION AND DEVELOPMENT OF SITE FOR BUILDING IN HILL AREAS — GUIDELINES

PART 2 SELECTION AND DEVELOPMENT

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BUREAU OF INDIAN STANDARDS
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FOREWORD

This Indian Standard (Part 2) was adopted by the Bureau of Indian Standards, after the draft finalized by the Rock Mechanics Sectional Committee had been approved by the Civil Engineering Division Council.

Buildings in hilly regions are constructed on varying types of foundation soil and rock formations occurring on hill slopes, undulating ground, hill tops and level terraces. The behaviour and geological characteristics of such sites are in general significantly different from those encountered in plains.

Cost of site development in hilly areas is much more than that in plains. The stability of the sites especially after cutting hill slopes to obtain level ground to locate the building greatly affects the cost of site developement. Such costs are about 20 to 40 percent of the total cost of building complex or even more on unsuitable sites.

Improper selection and development of building sites often causes landslides. This causes damages to buildings and loss of life and injury to the occupants, and the affected area remain in danger from probable landslides, uprooting of trees and related surfacial movements.

Damage to buildings located on cut slopes, often occur due to failure of the cutting, which may have been excavated without any considerations of its stability. Methodology for stability analysis and excavation of cut slopes and construction of protection works vary from hill to hill and from area to area depending on the character of geological formations, vegetation, weathering and various other climatological, geohydrological and metreological conditions in region.

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 values should be the same as that of the specified value in this standard.

Indian Standard

SELECTION AND DEVELOPMENT OF SITE FOR BUILDING IN HILL AREAS — GUIDELINES

PART 2 SELECTION AND DEVELOPMENT

1 SCOPE

1.1 This standard (Part 2) gives guidelines for the selection of building sites in mountainous terrains on various types of soils and rock with least slope stabilization and/or protection works. An individual building site, depending upon the specific requirement, importance and special foundation soil and terrain characteristics may require separate detailed study and investigations.

1.2 In high altitude cold regions freezing and thawing of the ground pose special problems which require separate careful study for selection of building sites and evaluate the depth of building foundations. Also snowfall and avalanches along steep slopes which result in damage to building require detailed investigations for each site.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
1893 : 1984	Criteria of earthquake resistant design of structure (*fourth revision*)
12070 : 1987	Code of practice for design and construction of shallow foundation on rock
13063 : 1991	Code of practice for structural safety of buildings on shallow foundations on rock

3 STABILITY OF SLOPES

3.1 Hill slopes and cuttings which are stable under normal climate and weather conditions undergo movements and failures due to weathering along joints and other discontinuities in rocks, changes in drainage conditions, erosion and surface excavations, earthquakes and other causes. Surfacial soil and rocks over lying *in-situ* rock often undergo creep movements, and under extreme hydrometerological conditions result in debris slides and avalanches. Field survey and stability analysis of hill slopes and cuttings should be carried out and buildings located on stable hill slopes.

3.2 Cuttings and excavations on stable hill slopes are made to locate buildings. Such cuttings often require protection works which adds to the site development costs. It is essential to ensure stability of such cuttings to have adequate safety of the buildings. Cut slopes as shown in Table 1 with height less than 5 m or two to three storey heights of residential buildings are in general stable. For higher cut slopes special investigations should be carried out and details of protection works should be worked out and implemented.

Table 1 Stable Cut Slopes
(*Clauses* 3.2, 6.1 *and* 109)

Sl No.	Type of Soil/Rock	Stable Cut Slope Without any Protection Work (Vertical to Horizontal)	Stable Cut Slope with Breast-Wall or Minor Protection Works
(1)	(2)	(3)	(4)
i)	Soil or soil-mixed boulder with:		
	a) Disturbed vegetation	1 : 1	6 : 1
	b) Disturbed vegetation over-laid on firm rock	Vertical for rock portion and 1 : 1 for soil portion	Vertical for rock portion and 6 : 1 for soil portion
ii)	Same as above but with dense vegetation forests medium rock and shales	1 : 0.5	6 : 1
iii)	Hard rock, shale or harder rocks with inward dip	1 : 0.25 to 0.1 and vertical or over-hanged	Not needed
iv)	Same as above but with outward dip or badly fractured rock shale	At dip angle or 1:0.5	6 : 1

4 SELECTION OF BUILDING SITES IN HILLY AREAS

4.1 Building sites in hilly areas are generally located on slopes and hill tops with roads girdling in between levels to provide access to the residences. Large flat grounds and valley bases are left as open spaces for recreational and agricultural use. For selection of an individual building site, nature and behaviour of soil or rock (and dip and strike of discontinuity surfaces) should be assessed at the cuttings or test pits (450 mm × 450 mm) at bottom and 1 to 2 m in depth or by augur boring (in soils). Many rocks behave like clay or silt on wetting or on submergence, rock pieces should therefore be kept in water for 24 hours for assessing the effect of wetting.

4.2 Hill sides with less than 30° slope in general are noted to be stable as the gradient correspond to safe angle of repose of slope forming material. Stable slopes steeper than 30° with *in-situ* rock exposure are encountered in hilly terrain, if the discontinuity surfaces dip into the hill to prevent outward and downward movement of rock wedges. Building sites should in general be located on hill side with not more than 30° slope. None residential temporary buildings may be constructed on steeper slopes up to 45°. The heights of cutting in hill slopes should not exceed as detailed in Table 2.

Table 2 Maximum Height of Cutting
(*Clauses* 4.2 *and* 10.9)

Sl No.	Nature of Soil/ Soil Strata	Maximum Heights of Cutting
(1)	(2)	(3)
i)	Loose soil or boulders with soil matrix	4 m
ii)	Compact soil or boulders with soil matrix which remains vertical in 4 m high cutting when dry	6 m
iii)	Soil or boulder with soil matrix overlain on loose, soft or fractured rock strata	5 m
iv)	Soil or boulders with soil matrix overlying firm hard rock	6 m
v)	Hard stable rock with or without compact soil or boulder with soil matrix up to 2 m thick	8 m

4.3 Building foundations resting on *in-situ* rock with discontinuity surfaces, if any, dipping inside the hill are in general stable and buildings may be constructed without any clearance in between the building and the rock face. Stepped storeyed buildings may be planned on such hard stable rock zones.

4.4 If the bedding and other discontinuity surfaces dip away from the hill side or the near surface strata consist of soil formed by weathering of *in-situ* rocks, flood plain deposits, rock scree and other overburden material over *in-situ* rock, adequate clearance in between the outer face of the wall of building facing the hill side and the toe of the buttress or retaining walls constructed for protection of cut slope is required to be provided. The width of the clearance depends upon the stability of the cutting with its protection works and the probable extent of movement of soil debris of cut slope forming slope angle of about 40° or equal to the angle of repose of talus or the soil rock aggregate.

4.5 The foundation of an individual building should be located away from the edge of the terraces formed as natural flood plain deposits or constructed by cutting and filling along the hill side or at the river bank. Such foundations should lie away from the line extending from the toe of the terrace or the river bank at an angle of 30°. The location of buildings with respect to other drainage courses or streams should also be at safe distances depending on the angle of repose of material existing in the area.

4.6 Individual buildings should be so oriented that it is properly sunlit and it shall not be located on the bottom of the valleys or permanent shadow zones of ridges and peaks, and high wind zones. The buildings shall be so oriented that no part of the building can be blown off during high winds or hit by falling boulders and avalanches from steep slopes and cliffs.

4.7 In hilly areas the building interact with wind, modifying flow pattern in its own neighbourhood and generating a new flow regime mainly depending upon locations of building sites on the hill slopes with respect to whole valley. A new flow regime shall produce small scale turbulance in the flow, the magnitude and direction of the turbulant flow depending upon the orientations of the individual buildings. Such turbulant flow over the surface of the building determines the wind loads on the building, specially on the roofs. In areas where important building complex are proposed in hilly terrains it is advisable that model studies are undertaken and wind pressures determined. It is desirable that the direction of prominent winds are observed and orientation of buildings is choosen accordingly. Sheet roofings in buildings in hilly terrains should be provided with ties, properly hooked in the roof and embedded in the ground.

4.8 Hill sides susceptible to landslides and erosion at toe due to probable meandering of the rivers and gullies should be avoided to locate the buildings. Hill sides with moderate soil cover supporting thick vegetation with tall trees often are uprooted and

fall down during extreme hydrometerological conditions resulting in cyclones and heavy rainfall. Such areas as far as possible should be avoided in location of building complexes.

The building site should be at a reasonably higher level above river and gullies such that the site is unaffected by landslide dam reservoirs. In Himalayan region, landslide dams are often formed in narrow gorges of weak rocks in cloud burst prone areas.

The site should also be much away from quarries as repeated blasting may cause landslide or cracks in the building due to slope movement.

4.9 If the hill side consist of *in-situ* rock strata exposed on the surface with dips greater than 20° outwards from the hill side safety against creep or sliding of the rock strata should be checked and factor of safety against sliding of the hill side should not be less than 1.2 m.

4.10 Hill sides having extensively folded, faulted, fractured and fissured rock strata should be avoided for location of buildings. In case of non-availability of other sites detailed geotechnical investigations should be undertaken to check the stability of hill side before a decision is taken to locate a building. The location of building complex in such cases shall preferably be finalised by a technical committee consisting of a geotechnical engineer, a civil engineer, a geologist, a town planner and an architect or a technical commitee of a Municipal Corporation in case of private construction.

4.11 In hill sides with varying near surface soil and rock strata which could undergo unequal settlements, buildings should be so planned, oriented and designed that higher loads comes on the more compact foundation strata. Such situations are very frequently observed on hill sides. Width and depth of foundations have to be suitably designed depending upon the distribution of the soil and hard rock strata in different parts of the foundations, and the dimensions worked out conservatively for softer rock or soilbase part of the foundation in comparison to hardrock part of the foundation.

4.12 For heterogeneous rock and soil mass existing on hill sides RCC strip foundations should be provided. There should be enough reinforcement along the wall to take care of loose and soft pockets below strip footing. In case of framed structures with isolated footing structural beams interconnecting isolated footing shall be provided.

4.13 Detailed geotechnical investigations of site shall be done in following cases for assessing suitability of site and development works:

a) When area of a building is more than 500 m^2.
b) Dip of rock beds strata near the foundations are more than 20°.
c) Wide fissures, regular cracks, faults, voids, etc, exist at building site.
d) Heterogeneous rock formation with shear zones and layer or seams of soft rock or clay exist.
e) If the proposed foundation area of the building complex is infested with long green roots.
f) If there is appreciable seepage of water and erosions in the foundation area of the building complex site.

4.13.1 Detailed geotechnical investigations should be done by competent geotechnical engineers and engineering geologists who will certify that the site after development is stable along with slopes in the above situations.

5 GEOTECHNICAL INVESTIGATIONS

5.1 Site development in hilly regions consumes about 30 to 40 percent of total cost of building complex, therefore the following investigations shall be done to obtain the following geotechnical parameters:

a) Type of Soil Rock : Weathered or intact, dip of bedding planes, drainage conditions, shear planes, material between the joints, tension cracks, type of plantation, verticality of trunks of the trees, etc.
b) Thickness of overburden, nature of soil-strata, details of soil matrix, etc.
c) Estimation of shear-parameters of the *in-situ* soil mass which will govern the failure.
d) Drainage pattern of the area and permeability tests in the area to see the drainage conditions.
e) Specific slip zones in the area, if any.

5.2 After above parameters have been obtained it shall be decided as to what type of buildings are to be constructed that is whether of rigid type or flexible type. Both have their own merits and demerits. The type of buildings shall depend upon the specific requirement of buildings and whether they are temporary or permanent.

a) The safe bearing capacity of building foundations shall be calculated. Where seismic forces are also considered, the safe bearing capacity shall be increased as specified in IS 1893 : 1984.
b) Building foundations shall be fully safeguarded against the causes of settlement (*see* IS 13063 : 1991 and IS 12070 : 1987).

6 TERRACE DEVELOPMENT

6.1 Following points shall be kept in mind during development of terrace for a building site:

a) *Height of Cutting* — shall be as minimum as possible. It shall not be more than given in **3.2**. Slope of cutting shall be kept as given in Table 1 or as slope of stable-cuts observed at the nearby buildings and roads.

b) *Clearance Around Buildings* — Failed cut slopes will tend to make a slide debris with a slope angle of about 40° or equal to angle of repose. For a typical site for construction of a building on hill-slope suitable clearance shall be left between edge of cut-face and outer face of the wall of building even if breast wall is constructed for protection of cut slope. A minimum clearance of 1.5 m between toe of wall and building wall should be provided. A suitable breast wall may be made, when soil or soil mixed boulder deposit rests over rock which are mostly met in practice. On valley side, the clearance should be such that base of foundation rests on firm soil or rock and not on filled up ground. It should be more than 1.5 m. Top of soil crust should be made impervious by any suitable method such as stone pitching, vegetation, etc. In case of hill sides with hard stable rock mass stepped storeyed buildings without any clearance in between hill face may be constructed.

c) *Blasting* — The effect of blasting on slope conditions is a most significant factor and as far as possible it should not be resorted to for rock-cutting. If necessary, it may be restored to when rock is very hard and of stable nature and when there are no structures in the vicinity. It shall only be carried out under thorough and competent supervision and with the written permission of appropriate authorities, taking all precautions connected with blasting operations.

d) *Proper Drainage* — On the uphill side of a building on a sloping site, drainage requires special consideration. The natural flow of water shall be diverted away from the foundations. Suitable lined or unlined drains shall be provided all around the building in order to get proper drainage. The rain water should flow as scattered as possible towards water course or stream or main drains.

6.2 The problem of failure of retaining walls and foundations of buildings is generally due to percolation of sewerage or soak pit water and house waste water from kitchen, bathrooms, etc, behind these structures and so for the safety of foundation, the ingress of surface or sub-surface water behind a structure may be prevented by constructing proper surface drains and keeping soak pit far away.

6.3 The slope of ground all around building should be not less than 1 : 50 built in such a way that rain water does not find way to ingress in ground excessively and moves away quickly to surface drains or away on adjoining hill surface towards natural streams. A minimum of 0.75 m wide apron should be provided all around the building to prevent entry of water into foundation.

6.4 Proper Orientation of Building

Buildings in hilly areas should be so planned, oriented and designed but higher load comes on harder part of foundation soil. Since inner side of cut slope may have higher bearing capacity, building should be so oriented and planned that higher load may come on inner side.

6.5 Width of developed land in hilly areas is often quite small and restricted because of cuttings. Therefore, longer buildings should be planned in view of above facts depending on the slope of ground and width of land available after cutting. If it is an office complex or school which cannot be planned in one long building or the length of the complex is more than 50 m, then it should be built in a number of smaller and stepped storeyed buildings.

6.6 Protective works like drains, breast wall, stone-pitching, cut slope trimming, plantation or other protective and drainage works shall be completed as early as possible. Delay in execution of protection and drainage works result in manifold increase of problems during rains. These works shall not be delayed. Preferably these be done simultaneously as cutting progresses. No site development work like cutting in loose soil, rock strata or protection work should preferably be done before rains and during monsoon season.

6.7 The material excavated for site development shall be disposed of properly in such a manner that it causes no problem of maintenance and is not a source of trouble to neighbouring lower sites. It has been seen at many places that land-slides of loose material dumped along the slope occured at lower sites and resulted in heavy damages to buildings, transmission lines, trees, etc. Depositing excavated soil by the side of site, therefore shall not be permitted. All excavated material shall be dumped at far away places where there is no likelihood of any future problem and where no future development works are planned.

6.8 Normally, height of breast wall for protection of cut-slope and hill side retaining wall shall not be more than 4 m. It shall be further raised by 1 m incase of danger of jumping boulder. Vertical front face and sloping back face retaining walls shall be economical since its height shall be much lesser than front-sloped retaining wall. Suitable weep holes shall be provided in breast wall and retaining wall for proper drainage.

6.9 Retaining walls and breast walls should be made of dry stone masonry or dry stone masonry with masonry bands in 1 : 6 cement sand mortar of 400 mm to 600 mm thick at top and bottom with 3 m to 5 m vertical spacing in bands. In case of fine soils like silt, clay or shales which behave like soils in presence of water, retaining walls and breast walls shall be designed after detailed study of soils, rocks, etc, in laboratory and at site.

7 STEPPED TERRACE DEVELOPMENT

7.1 Stepped terrace development and stepped storeyed building construction may be adopted for offices, schools and other building complexes because of following advantages:

a) It results in least hill cutting, disturbance to hill stability and also in least deforestation.
b) Cost of site development works, slope protection and other protection works is reduced considerably.
c) Least load comes on valley side, so danger of foundation failures is avoided.

7.2 Stepped terrace development should not be done on soil mixed boulders, loose weathered soft rocks, badly fractured rocks, rocky zone having dip more than 20° dipping outward on downward site.

7.3 Following precautions shall be taken for construction of buildings on stepped terraces excavated on hill sides:

a) Any face of hill (except hard stable rock out crops) shall not be used as building wall.
b) Minimum clearance of 1.0 m, preferably 1.5 m should be given between retaining wall face and building wall for proper ventilation, lighting and minimum dampness.
c) Height of hill cutting for stepped storey buildings in stable rock hill sides for any step shall not be more than 4 m.
d) Kitchen, lavatory, water-closets, etc, shall be located and oriented away, as far as possible, from hill cut face and at outer spaces of building so as to avoid dampness due to seepage of water and to avoid foul smell, if any.
e) Upper storeys should be as light as possible.
f) Building should have both external and internal stairs.
g) Building complex should have approaches from sides via terrace sides connected from rooms and verandahs.
h) In order to provide for safety against fire protection, escape routes shall be provided. For this each storey of the building complex shall be connected by adjoining hill slope.
j) A 300 mm thick impervious layer of compacted silty soil should be laid on all terrace behind retaining walls up to aprons. This will prevent flow of rain water inside backfill of retaining walls.

8 STABILITY OF SLOPES AND STEPPED TERRACES

8.1 The purpose of slope stability analysis in this context is to contribute to the safe and economic design of excavations required for the development of terraces. The factor of safety shall be calculated for individual slopes as well as for the whole stepped terrace.

8.2 The following minimum factors of safety of both natural and cut slopes be ensured for the safety of the foundations on these slopes:

Type of Slope	*Static Factor of Safety*	*Dynamic Factor of Safety*
Soil slope/Talus/ Debris slopes	1.5	1.2
Rock slopes	1.2	1.0

9 STILT FOUNDATIONS FOR ECOFRIENDLY CONSTRUCTION

In hilly regions, cutting of slopes for building horizontal terraces creates complicated problems, like unstable slopes, new drainage problems and other related problems. In order to economise in time and money STILT foundations have been developed. The superstructure may consist of wooden or steel framed structures with fibre-glass or aluminium or corrugated GI sheet roofings. Walls may be claded with PVC sheets. However, for large tall buildings. RCC stilt frames with RCC columns foundations at different levels may be made.

10 SURFACE PROTECTION OF HIGH STEEP CUT SLOPES

10.0 Selection and development of site should be such that high steep cuts are avoided. Steep cuts involve very costly and difficult protection works. It has been observed that most of the slips and landslides occur during monsoon when water percolates in the joints, fissures, seems providing

lubrication to weak-planes. The main aim of surface protection works is therefore to provide proper drainage measures in the area. The following measures may be adopted.

10.1 Minor trimming or cutting may be done to make the slope stable with minor protection works both for soil and rock.

10.2 Suitable or unlined drain as per necessity shall be provided. These shall be so located and discharged that rain water flow is spread over in a large area because concentrated high discharge may cause erosion on lower side surface of hill which may lead to serious problems. Proper drainage holes for subsurface discharge and rain water should be provided. Filters may also be provided where necessary. The ultimate aim of providing drainage works is that water coming from the uphills is diverted to natural streams without causing any harm to the structures. Water shall not be allowed to flow along the bottom of cut. It shall reduce and check undermining, erosion and failure of slope. Suitable breast walls may be made. Proper slopes shall be maintained all around for quick drainage of the whole area.

10.3 All the barren surface above the cut should be planted with light but deep rooted bushes, shrubs, etc. This will check soil erosion and also improve stability of slope and also improve the microsystem for abosrbing the toxic gases from the environment and enrich the lining environment.

10.4 Grouting or guniting may be resorted to with caution in all those cases where plantation cannot be developed. It will check entry of water into the rock joints and avoid slope failures in most of the cases. In order to improve the top surface of ground, guniting may be done around the building, top surface of cut slope, filled or built-up ground surface.

10.5 On all sloping surfaces, stone pitching may be done in 150 mm to 200 mm thickness, filling all joints with 1 : 6 cement-sand mortar. If economy does not allow stone pitching, all joints may be filled in by fine soils, and grass or small plants may be planted on it. Roots of grass shall spread in the voids and grip the soil pebbles, rock pieces, etc, thereby preventing the entry of water into the ground.

10.6 Reinforcing bars and rock bolting may prove very useful in cases where the rock is highly fractured, fissured or weathered. The basic underlying idea of using rock-anchors for slope stabilization is that rock-anchors create compressive forces which are uniformly distributed over the potential failure plane. Rock slide is thus prevented along the anticipated failure plane.

10.7 In hilly regions storm water drainage is the main problem. The object of the storm water drainage is to collect and carry, for suitable disposal, the rain-water collected within the premises of the building complex. Drainage shall avoid all possibilities of slope failure due to ingress of water. The best way to get best drainage pattern is to have a group-discussion at site between habitants of the area and the field engineers.

10.8 Fundamental requirement of efficient drainage is that rain water should move away from the site as early as possible without stagnation. Further, water should flow as scattered as possible on surface so as to avoid any surface erosion. Surfaces which are soft and susceptible to erosion should be made impervious by any of the suitable means like grass, vegetation, stone-pitching, surface grouting, guniting, etc. It is also necessary that the natural drainage pattern is restored at the earliest after site development.

10.9 The following works normally done on just thumb rules lead to serious accidents, slope failures and other catastrophies. These points need significant attention on the part of field-engineer responsible for execution:

a) *Non-restoration of Existing Drainage Pattern* — Normally drainage pattern existing before site development is not restored properly. Water should be disposed off to natural streams or water-courses by means of lined or unlined drain as per necessity of site.

b) *Improper Ground Slope Around Building* — Many times proper slope is not given in developed ground after hill cutting or filling. It causes ingress of large quantity of water which causes water pressure and provides lubrication to soil grains, rock-joints ultimately causing slope failures. Field engineer, should check that proper slope has been provided during hill-cutting and after construction of building.

c) *Improper Location of Soak Pits* — Many times soak pits are constructed in front or the rear of buildings which causes dampness in adjoining soil-rock masses, leading to slope failures. If hill slopes are greater than 30°, then soak-pits should neither be made at front or at the back of building but they should be made by the side of buildings. This will avoid any slope failure and building shall not be damaged.

There shall be a minimum clearance of 2 m between the foundation on rock mass and the soak pit so that pressure bulb is unaffected by the seepage through joints from the soak pit.

d) *High Cutting and High Retaining Walls* — Many times high cutting is done vertically and high retaining walls are constructed. The stability of such construction always remains in question and many times they fail causing fatal accidents including damage to buildings. Retaining walls become unable to bear heavy back pressures causes by slopy hill face in the back of retaining wall along with induced water pressures due to ingress of water behind retaining wall. It is therefore, recommended that criteria as given in Tables 1 and 2 should be adhered to, where high cuts are involved. Height of retaining walls shall normally be not more than 4 m. The foundation of the retaining wall shall be given a slope of 3:1 towards hill side.

e) *Improper Selection of Site* — Many times improper and steep hills of more than 35° are selected which requires high cutting posing significant economic problems and accidents too. As such, steep grounds shall always be avoided.

f) *Successive Retaining Walls* — Successive retaining walls should not be made since these walls have more chances of collapse under heavy surcharge pressures, caused due to toe pressure of upper retaining walls. Heavy higher retaining walls of height more than 5 m are more susceptable for collapse due to heavy back-pressure or failure of foundation rock soil below toe of retaining walls. These walls fail most often. They remain intact only when they are subjected to remarkable pressures that is when there are stable rock behind retaining walls or when rock below toe of every retaining wall is stable and strong.

g) *Vertical Tension Cracks* — Presence of a vertical crack around a building complex on hilly terrain should be taken as an indication of potential instability and that, in case of an important slope, this should signal the need for detailed investigations into the stability of that particular slope. Not only the building but also the vertical crack, if any, seen in the area should be investigated thoroughly because it is a sure indication that shear failure has initiated within the slope.

10.10 In hilly regions, failure of a building on uphill side may result in damage to many other buildings on downhill side resulting in loss of human lives apart from involvement in legal court cases. Strict inspection and quality control measures shall be taken during construction of such areas. From safety point of view during construction of such complexes, regular inspections should be done by the municipal engineer of the locality.

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