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STUDY ON DESIGNING OF BUILDINGS IN HILLY REGIONS-UTTRAKHAND

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Abstract—*The designing of buildings is a challenge whether it is in a plain or elevated land. But in the hills the major influencing factor among many others is climate, which determines the building configurations, form and gives advantages of passive designing. In addition, the designing of buildings becomes more challenging mainly due to its topography. The vulnerability aspects raise more critical conditions for designing of buildings in hills, as in the case of Uttrakhand, since it lies in the active seismic belt of Himalayas. And also as a new state, it is developing fast and expected to carry on lot of building construction activities.*
In hills, the buildings have to be constructed on sloped topography and the plain areas are left for playgrounds and social gatherings. Building on slopes need different architectural forms and configurations, which are guided by many factors in hills, such as contours, orientation of buildings and sites, slopes and earthquake resistant considerations etc. Unfortunately, these factors are not given due importance as non-engineered construction is in practice. This is increasing, risk of failures and damages of building and hill slopes causing loss of human life and property. Thus, there is urgent need for engineered construction with respect to height of buildings in hills that mainly evolves out from topography, architecture, climate and disaster, and preparing guidelines for planning and designing of buildings.

Keywords*: Site Planning, site development, Building Orientation, earthquake resistant consideration, Building Materials.*

INTRODUCTION

Uttarakhand lies in the Northern part of India amidst the magnificent Himalayas and dense forests. The population of the state is around 7 million and is increasing at the rate of 1.92% per year. The region is mostly hilly (approx 88 percent) and the remaining 12 percent falls in the plains. The state is very rich in natural resources and especially water and forests as it has many glaciers, rivers, forests, mountain peaks.

With the increase of population, hilly regions of the country are also developing very fast. Development of area requires construction of buildings and infrastructure facilities such as roads, water services and electric power etc. The availability of level land in hilly regions is very scanty. Therefore, the buildings are to be constructed on the hill slopes keeping flat land for playgrounds and social functions etc. Buildings on slopes need different architectural forms & configurations, which are guided by many factors such as contours, orientation, slopes access etc.

Most of the hilly regions of Uttrakhand lie in the seismic active belts of Himalayas, so risks, hazards and humanitarian emergencies are common in hills due to recurrent natural disasters, rock falls, landslides and storms etc. That is why to print buildings from disaster as well to safeguard people's life and maintain ecological balance of its development; careful interventions of humans are needed.

There is also need of to protect the occupants from the extreme climate of hills and provide them with thermal comfort. There is a need to design the buildings nature friendly.

ARCHITECTURAL CHARACTERISTICS FOR DESIGNING A BUILDING IN HILLY AREAS.

The architectural character of hill buildings is mainly determined by the climate, topography and altitude of the hills. so, while designing the buildings we have to take care of following:

- Site planning
- Building Layout
- Building Orientation
- Building configuration
- Building components

The study here aims to identify all the parameters, which are needed to be considered during the entire process of building design.

1. SITE PLANNING

Site selection and planning for buildings in hills is a difficult task as compared to similar projects in plains because of hilly terrain and unplanned cutting activity for terrace development.

Since in hills, the gradient varies, so the accessibility to building becomes difficult and as gradient increase the problem of accessibility also increases. The buildings placement at sites needs to follow the natural contour to maintain the stability of hill, having high degree of slopes. Thus, site planning is an aspect of development, depending upon various factors.

The following are important consideration that should be kept in mind while site selection & development:

Location of Site

The location of site on the hilly regions is a very important aspect as these regions are associated with severe cold climate. So, the sights must be located on those sites of the hilly region, which receives maximum sunlight in the daytime.

Site should not be susceptible to high winds, storms, floods such as in basins, peak of hillocks and tops of cliffs. The sites at hillocks should be avoided as these areas have high wind velocities which cause air infiltration in the building causing discomfort to the building user.

Site should be away from river banks and streams so that there may not be slope failure due to undermining by rain discharge, flood, etc. Building should be away from line extending from river or streambed.

Site near river banks where twisting of the river occurs should be avoided as it may cause under cutting of the hills and may lead to landslides so such site should be avoided for development.

Site should not be susceptible to flood such as in basins. If site is selected are such areas than plinth of the building should be above flood protection level.

Site should be nearest to motor road, necessary amenities such as hospitals, schools, transportation centers, marketing center, water supplies, electric lines, natural water source, etc., necessary for users of the building.

Preferably, the site must be selected on the leeward side of the hill to protect the building from the cold winds.

2. SITE DEVELOPMENT

Building Layout

The building should be located at a sufficient distance front the edge of the site, so that in case slope failure occurs during earthquake the building and its occupants remain safe.

Plantation and Vegetation

Plantation and vegetation all around the developed site are the best way to prevent all types of damages. Trees with deep roots should be planted above and below the terraces for improvement of stability. Shrubs could also be grown on the hill surface to improve stability and check soil erosion. Tilting of trees will be natural reminder of safety action to be taken.

Site Drainage

The slope around the building is no 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 towards natural stream. Buildings on sloping site require special considerations for proper drainage. The natural flow of water should be diverted from the foundations. A minimum of one-meter wide apron should be provided all around. Suitable unlined or lines drain as per necessity should be provided. These should be so located and discharged that rainwater flow spread over a large area. This is just as concentrated high discharge may cause erosion on lower side surface of hill, which may lead to serious problems. Proper drainage holes for sub surface/discharge should be provided if necessary.

Slope modification

Hillside slopes liable to slide during an earthquake should be avoided and only stable slopes should be chosen to locate the building. Also, it will be preferable to have several blocks on terraces than to have one large block with deep foundation. A site subjected to the danger by rock falls has to be avoided. Table-I, shows the maximum slope of site for construction and height of cutting.

Table I: Extent of cutting in hills.

S. No.	Type of Soil	Maximum slope of site for construction	Preferable height of cutting
1.	Ordinary soil with vegetation or disturbed vegetation	25o	4m
2.	Ordinary soil with dense forestation vegetation, soft medium rock shale	25o	4m
3.	Soil mixed boulder	30o	6m
4.	Hard rocks	40o	8m

Source: Selection, Development and Stabilization af Sites for Buildings in Hills. (Research paper by) Dr. Gopal Ranjan

3. BUILDING ORIENTATION

The building orientation determines the amount of radiation it receives. The orientation, with respect to air patterns, affects the amount of natural ventilation

On hilly regions to achieve best thermal comfort longer façade of building should face south, which receives maximum solar radiation in winter. In case of non-availability or best orientation, the longer wall of building should be exposed to southeast direction to gain thermal comfort.

In cold climate building should preferably be compact. Its external surface area should be as small as possible. To minimize the heat losses from the building. Further care should be taken in working out appropriate architectural design configuration detail of openings to stop infiltration of cool air.

4. EARTHQUAKE RESISTANT CONSIDERATION

Symmetry: The building as a whole or its various blocks should be kept symmetrical about both the axes. Symmetry leads to torsion during earthquakes and is dangerous. Symmetry is also desirable in the placing and sizing of door and window openings, as far as possible.

Regularity: Simple rectangular shapes behave better in an earthquake than shapes with many projections. Torsional effects of ground motion are pronounced in long narrow rectangular blocks. Therefore, it is desirable to restrict the length of a block to three times the width. If longer lengths are required then two separate blocks with sufficient separation in between should be provided.

Simplicity: Ornamentation involving large cornices, vertical or horizontal cantilever projections, fascia stones are dangerous and undesirable from a seismic viewpoint. Simplicity is the best approach. Where ornamentation is insisted upon, it must be reinforced with steel, which should be properly embedded or tied into the main structure of the building.

5. BUILDING COMPONENTS

Foundation: In the firm soil any type of footing (individual or strip type) can be used. Foundation should have a firm base of lime or cement concrete with requisite width over which the construction of the footings by means of RC beams just below plinth level is done.

Landslides are also caused by the earthquakes, so it is also necessary to have knowledge about it and precautions should be taken at initial stage only while planning and designing.

Walls: Walls can act as a load bearing or a non-load bearing member providing security, safety and also, they are to resist the climatic effects.

Opening in Walls: Window, ventilator and door opening reduce the shear and bending strength of walls, and their size as well as location are both significant in this respect. For better seismic behavior opening should be as small and centrally located.

Problem of torsion: Building on sloping site tends to pose torsional Problems due to the varying column stiffness.

Enclosed space: Within a building, the smaller rooms with properly bonded long and short walls forming a box like enclosure are seismically stronger than rooms with long uninterrupted walls.

Height: Restriction in height of load bearing wall building is necessary for better seismic safety.

Table II, shows the height restrictions in Moderate and Sever Seismic Zones.

Table II: Height Restrictions on Building in Moderate and Sever Seismic Zones

S. No.	Building Type	Suggested height
1.	Adobe house	One storey or one storey & Attic
2.	Field stone (Random Rubble masonry) in cay mud mortar	One storey or one storey & Attic
3.	Dressed stone masonry in cement mortar	Two storey, or Two storey & Attic
4.	Brick Masonry in mud with critical sections in cement mortar	Two storey, or Two storey & Attic
5.	Brick or cement block masonry in good cement mortar	Two storey, or Two storey & Attic
6.	Reinforced masonry	As per design depending upon the site condition
7.	Wood frame	Two storey, or Two storey & Attic
Source: Earthquake Resistant Construction and Architecture (BMTPC Publication) By A S Arya		

Roofs

Type of roof plays an important role in the seismic behavior of the house. Lighter roofs are preferable to heavy roofs. Sheeted roofs are better than tiled roofs. All elements of a roof should be so integrated that it may have the capability of acting as one stiff unit in plan for holding the walls together.

Floors

Similar to the roofs, those floors which are rigid in the horizontal direction such as reinforced concrete slabs are much superior in their diaphragm action to wood –joist floor and jack arch or flat arch floors. For holding the walls together, the floor elements should have full bearing on the walls. This will help in restraining the floors against falling down during severe shaking of walls.

Also, the flexible wood –joist floors should be formed into grillages and prefabricated flooring elements should be well connected together to achieve horizontal bending rigidity of the floors.

Gables

External gables can be avoided by using hipped roofs, and internal gables can be left open if false ceiling is used in the building.

Seismic bands

The most important concept in strengthening of masonry Buildings the provision of horizontal seismic bands.

CONCLUSIONS

With time, all the regions of Uttarakhand are developing, thus the construction of buildings could not be avoided. All the hilly regions of Uttarakhand lie in seismic zone of IV and V, so all the buildings must have earthquake resistant construction. Mostly landslide occurrences are prominent with earthquake in hilly regions so building should be located in the zone where it is not prone to landslides. Our construction practice may increase the chances of landslides whether earthquake occurs or not, so as a precautionary measures all buildings should be located at a safer distance from angle of repose. The edge of the footing must be laid at suitable distance from the sloping surface.

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