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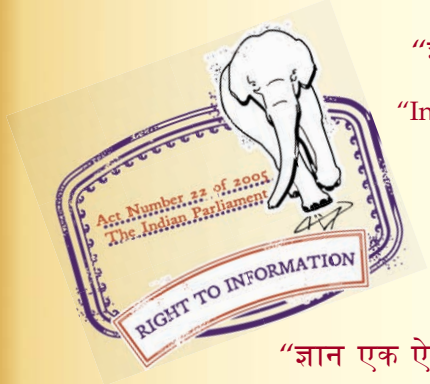

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Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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भारतीय मानक

पहाड़ी क्षेत्रों में आवासीय भवनों का स्थल निर्धारण, डिजाइन तथा सामग्री का चयन — मार्गदर्शी सिद्धान्त

Indian Standard

SITING, DESIGN AND SELECTION OF MATERIALS FOR RESIDENTIAL BUILDINGS IN HILLY AREAS — GUIDELINES

ICS 91.020;91.040.30;91.100

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

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Price Group 6

FOREWORD

This Indian Standard was adopted by 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.

Hilly areas in our country are prone to natural calamities like high speed winds, heavy rainfalls, cloud bursts, flash floods, frequent landslides, etc, and most regions fall under seismic zones IV and V. These natural disasters cause annual losses to life and property. The availability of data on types of housing and use of buildings materials in hilly region is limited. The building materials employed in construction of residential building are limited in their availibity. Therefore, conservation of materials assumes importance in design as well as construction activities. The use of new materials and technologies is imperative in addition to the need to lay down standards on strengthening measures for the existing structures, as well as design parameters for new structures.

This standard only provides guidelines in respect of disaster resistant constructions. For details corresponding codes of practices may be referred wherever applicable.

Emphasis should be laid while designing the layout of buildings, so as to meet the requirements for proper disposal of rain and sewage water with proper spouts and gutters in the roof so that the undue loading is not generated in the foundation or in the retaining wall due to accumulation of water.

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

There is no ISO standard on the subject. This standard has been prepared based on practices prevalent in the field in India.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the results of a test or analysis, shall be rounded of in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places to be retained in the rounded off value should be the same as that of specified value in this standard.

Indian Standard

SITING, DESIGN AND SELECTION OF MATERIALS FOR RESIDENTIAL BUILDINGS IN HILLY AREAS — GUIDELINES

1 SCOPE

1.1 This standard provides guidelines relating to planning and design, as well as selection of building materials for construction of residential buildings in hilly areas.

1.2 These guidelines are applicable to general residential, low rise buildings, built on individual plots of land, either non-engineered or marginally engineered structures. However, for industrial and special buildings specific requirements may have to be considered.

2 REFERENCES

The Indian Standards given 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 agreement based on this standard are encouraged to investigate the posibility of applying the latest editions of the standards indicated in Annex A.

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

3.1 Engineered Construction

Where normal planning and design practices of architecture and Civil Engineering are followed and supervised.

3.2 Marginally Engineered Construction

Where general design rules of thumb and specifications for main building elements are followed.

3.3 Non-Engineered Construction

Where people or householders themselves construct with the help of local artisans and with traditional methods and materials.

3.4 Disaster Resistant Building

Building which suffer only limited damage when struck by a disaster agent.

3.5 Earthquake Resistant Building

Building which permits occupants adequate time to evacuate safely in the event of an earthquake.

3.6 Wind Resistant Building

Building which provides a basic margin of safety against high wind.

3.7 Ekra

Straws/reeds/split bamboo or bamboo mat both faces plastered with mud and cowdung or lime and sand or cement and sand.

3.8 Tarja

Bamboo mat woven in diagonal or oblique twill pattern.

4 ZONES

4.1 Hilly areas in India, stretch from Kashmir and Himachal Pradesh in North-West to Arunachal Pradesh and Nagaland in extreme North-East covering the whole of the Himalayan range. The entire stretch of hilly region has wide variations in geology, geomorphology, climate, altitude and materials resources. The varying geological situations and ongoing development activities, climatic variation, hydrogeological conditions result in different types of hazards like landslides, avalanches, mud flows, flash floods occurring frequently in these areas. Among the various catastrophic calamities, these hilly regions also have high risk due to earthquakes. These areas are prone to seismic activity as most regions fall under seismic zones IV and V (*see* IS 1893).

4.1.1 Unprecedented exploitation of the Himalayas is another reason for occurrence of landslides. North, North-West Himalayan areas consisting of Jammu and Kashmir, Himachal Pradesh and Western Uttar Pradesh are more prone to avalanches, earthquakes, floods and high speed winds. Sikkim is highly prone to landslides and seismic activity. North-East Himalayan area consisting of Arunachal Pradesh, Mizoram, Nagaland, Meghalaya, Tripura, Manipur and Assam are mostly affected by floods and fall under seismic zone V.

4.1.2 These hilly areas are prone to two or more types of natural calamities, such as floods and landslides, earthquakes and avalanches, avalanches and landslides. There may be overlapping of occurances of disasters.

5 CLIMATE

5.1 Hilly regions of the Himalayan range from North-

West to extreme North-East fall under cold humid and temperate humid climate. The climatic conditions shall be categorised on basis of average of daily mean temperature and relative humidity for the month. Temperate 20°C - 30°C, cool 15°-20°C and cold < 15°C temperature, and dry 25-30, humid 50-75 and very humid 75-100 percent humidity.

5.2 These hilly regions are having following climatic conditions during the stated months.

Month	*North*	*North-East*
January	Cold humid	Cold humid
May	Cold dry	Temperate humid
August	Temperate very humid	Temperate very humid
November	Cold humid	Temperate humid

5.3 A residential building shall essentially be a form of protection against the external climate. The prevailing climatic condition shall, therefore, be a major factor for consideration in design of a house to ensure a reasonable degree of thermal comfort to the occupants.

5.3.1 In temperate humid area shade is required but it shall be obtained by segregation of houses and shady tree plantation not very close to house. Removal of moisture from the surface of the skin shall be a prime requirement for human comfort.

5.3.2 In cool upland regions, there is a short swing between seasonal temperatures and day and night temperatures. Design shall be influenced by that extreme which last the longest in the year. The design of roof and wall thickness, position of openings, etc, shall influence the human comfort conditions within the house.

5.3.3 Traditionally, house facing the East direction are preferred by the inhabitants in North and North-East regions of the Himalayas.

6 PLANNING AND DESIGN CONSIDERATIONS

6.1 Existing housing typology shall be kept in view for preparation of designs for residential buildings. Apart from climatic conditions, the life styles, living habits, socio-economic levels, occupation and cultural pattern of habitants shall govern the house-forms. Generally tribals are inhabitants of these areas and are adhering to their traditional customs and systems of house building. The planning and design of a house shall also depend upon criteria like safety of domestic invasion by predators etc.

6.1.1 As the terrain of hilly regions have vallies or slopes, the houses shall be either detached or semi-detached. Since large pockets of flat land may not be available, it will not be possible to attain the row housing concept. Moreover, living style and preference of habitants may not appreciate row housing concept. Cluster of four to six houses are common practice. Therefore, group housing to match the terrain characteristics shall be preferred.

6.1.2 The design and distribution of various functional spaces and service areas shall meet requirements of local building bye-laws. However, space dimensions and shape of building shall be controlled by breadth and depth ratio. The recommended ratio 2.5:1.0 shall be preferred where flat land, orientation and wind direction meets the requirements.

6.1.3 Flat land is normally not available in hilly regions. The houses are required to be constructed on partially sloping land made available by cutting and filling. It shall be necessary to protect the house by building retaining walls /breast walls [*see* IS 14458 (Part 2)] to avoid landslides occurring at time of earthquakes or heavy rains.

6.1.4 The house forms and patterns prevailing in the North, and North-East states of hilly regions have different typology. Space for storage of fuel wood and granary is quite common in hilly regions. The salient design features of existing typology is described in brief in Annex B.

6.1.5 The shape and size of the house shall be governed by the type of pitched roof and materials used for covering. The room dimensions shall be small.

6.1.6 There are many design features which can reduce the effect of the forces of high winds on a house. Most of the building features are contrary to ideal requirements for a wind-resistant house, so compromises in the design will have to be made. Following are some of features with rules of thumb:

a) Do not build any opening which cannot be reached and closed off during the calamity.

b) Provide openings in suitable locations where wind pressure can escape.

c) Design the roof to reduce suction and breaking lifting pattern.

d) Design corners to reduce the pressures by allowing wind to slip around the corners. (This can be done often by rounding or bevelling the corners of a house.)

e) Avoid creating areas where wind can be trapped and excessive pressure can build up.

f) Avoid creating courtyards or patios to reduce circular or turbulent winds.

h) Provide all doors and windows not less than 1 m from each other and also not less than 1 m from the end of a wall.

6.1.7 Following rules of thumb shall apply for earthquake resistant design:

a) Provide uniform opening area opposite each other in the parallel external walls.

b) Provide all doors and windows not less than 1 m from each other.

c) All doors in internal and external walls shall be centered, or not less than 1 m from the end of the wall.

d) In case of lean to roof, the highest wall of house shall not be more than half metre higher than the opposite wall.

e) All doors inside the house should open in the direction of the nearest door leading to the outside of the house.

f) The thickness of mortar joint should not be more than 15 mm.

6.2 Site Selection

6.2.1 There shall be three main objectives for the selection of sites:

a) Safety,

b) Developable topography, and

c) Close to place of work.

6.2.2 The following points shall be considered in making a preliminary survey of a site option:

Access to

a) water,

b) service, and

c) communication links and integration with nature and neighbourhood.

6.2.3 *Location*

a) In locating a house, take advantage of natural wind breaks such as stand of trees, small hills or hedges.

b) Avoid sites on or near tall hills. Tall hills can increase wind speed by as much as 50 percent.

c) Valleys tend to funnel winds creating abnormally high wind speeds. Therefore, efforts should be to avoid such sites.

d) Building places near one another shall develop intense suction on the gable end of pitched roofs. Building shall also be spaced with small gaps to stabilise the flow on the lee side.

6.2.4 *Siting*

a) No house shall preferably be located closer than 1 m to another house.

b) No house shall preferably be located closer than 10 m to a steep slope.

c) No house shall be built on a land fill or on the edge of a slope known to have been levelled.

6.2.5 Following points shall be kept in view with reference to particular risks.

6.2.5.1 *Earthquake*

a) Use available data on disposition of faulting and spread of poor bearing soils and unrestrained sands.

b) Avoid narrow ridges, steep slopes, narrow valleys and sites near cliffs or large gullies that is within 150 m.

c) Prefer sites with hard bedrock at or near the surface.

d) Prefer sites where landslides are unknown in surrounding area.

e) Prefer sites where there is no sign of active faulting and avoid offset rock lays, row of ponds or swamps and deep or long cracks in ground.

6.2.5.2 *Cyclones*

a) Prefer sites away from sea coast, flood plains and lakesides.

b) Following to be avoided:

1) Low elevation relative to lagoon, river or surrounding land;

2) Lack of natural outlet to discharge the volume of water or restriction at the outlet; and

3) Building at the foot of slopes receiving direct surface run-off.

6.2.5.3 *Landslides*

a) Use all available data on disposition of risk area.

b) Local geographical conditions shall indicate severity of risk.

6.2.5.4 *Flash floods*

a) Avoid low lying areas, wetlands and lagoon mouths;

b) Avoid edges of inland lakes;

c) Avoid flood plains and particularly the flood way;

d) Avoid housing in narrow defiles upriver;

e) Avoid downstream banks and flow ways below dams and particularly in earthquake areas; and

f) Provide protective measures such as channelisation, ponding areas, flood walls, etc.

6.2.5.5 *Snow avalanches*

a) Use all available data on disposition of risk area. Heavy snow fall may be associated with heavy rains.

b) Prefer sites away from avalanches sites.

c) Avoid formation of snow pockets on roof and on site.

d) Design roofs with slopes greater than 50° to disregard snow load.

e) Snow load shall be as per IS 875 (Part 4).

6.3 Shape of Building

6.3.1 A house plan of circular shape shall be ideal for high wind regions.

6.3.2 A house plan of rectangular shape shall be evolved, provided length to width ratio does not exceed 2.5 : 1.

6.3.3 The parallel walls of the buildings shall be of equal length and height.

6.3.4 The height of building shall be minimum. Maximum height of double sotreyed building shall be restricted to be 6.0 m.

6.4 Roof Design

6.4.1 A pitched roof having hip and four side slopes is recommended. A gable roof having hip and two side slopes may be designed, provided adequate diagonal bracing is used between trusses and gable walls are reinforced. Flat roofs in reinforced concrete are recommended. Ferrocement shall also be permissible. Roofs made of earth supported by a wood and timber frame shall not be preferred.

6.4.2 The roof pitch angle shall not be less than 30° or about one metre in three. Outside overhangs of more than half metre shall be avoided. All trusses shall rest on and be structurally secured to the upper ring beam of the wall. No truss shall rest directly on the wall itself. Roofing materials, sheets or tiles shall be secured rigidly with top ties.

7 DISASTERS RESISTANT CONSTRUCTION

7.1 Human settlement in urban or rural are often subjected to the vagaries of natural calamities such as cyclones, earthquakes and floods. Hilly areas face the risk of great disasters like landslides, floods, earthquake and avalanches etc. There are several regions which are faced with risk of combined disasters. The nature of damage due to natural disasters in case of fully engineered and partially engineered are not so severe as in case of marginally engineered or non-engineered buildings.

7.1.1 With the advancement in the science of hydrology, weather forecasting and technological developments in the field of building materials and construction technology, it shall now be possible to use engineering principles of disaster resistant design and constructions with professional input in their planning, design, construction and supervision. Some of the following principles shall serve as guidelines for disaster resistant construction.

7.2 High Wind Resistant Buildings

a) Buildings shall be well anchored to their foundations.

b) All elements in a structure shall be tied together.

c) Wall to wall framing, posts, beams, rafters, columns, purlins, battens and roof tiles/sheets etc.

d) The fixing method between elements shall be good enough. The method employed should stop the structure from breaking up into separate.

e) The structure shall be diagonally braced. The bracing of roof shall also be required.

f) Large open verandahs and part open areas shall be braced diagonally in the roof, and also in planes of the walls.

g) The natural wind breaks such as stands of trees, small hills or hedges should be made.

h) Due consideration of shape and wind direction shall be taken. Square shape shall be avoided. Corners of building shall preferably be chamfered to break wind pressure.

7.3 Earthquake Resistant Buildings

a) The shape of house plan shall preferably be rectangular. L, T or U shape planning shall be avoided. In case unavoidable, shall be made by non-structural sections/units.

b) The mud or adobe walls and brick piers, corners and perimeters of opening shall be reinforced.

c) The foundations shall be continuously reinforced.

d) The projections and parapet walls shall be well tied with main structure.

e) The walls shall be capped by continuous ring beams at top and bottom.

f) The walls and corners shall be strengthened by wall plasters or buttresses.

g) Hipped roof shall be preferable.

h) Verandah and its roof shall be structurally separated from the main roof.

j) Avoid building on filled-up land or on the edge of a slope.

k) The diaphragm forces in walls must be transmitted directly through the wall-floor connection.

7.4 Flash Flood Resistant Buildings

a) Selection of site shall be made on basis of general flood level.

b) The width of openings shall be minimum for blocking during flood by sand bags.

c) The structure shall be raised on stilts.

d) Lower part of structure shall be built with permanent materials like burnt clay bricks in cement mortar, stone walls in cement mortar.

e) Posts (wood, metal or concrete) shall be placed on stone or concrete stand.

f) Foundation design should take care of horizontal and vertical forces.

8 STRENGTHENING FEATURES

8.1 There will be often great similarity between recommendations to improve particular types of house, against different types of natural disasters prevalent in the region. Thus actions taken to improve resistance of the house against one type of disaster shall have beneficial results in improving its performance against the other type. There shall be no conflict between recommendations for earthquake or high wind resistant construction for new building designs. In such circumstances the most prevalent type of threat shall be deciding factor. Common features are given in **8.2**.

8.2 Following basic features shall be incorporated in design and construction of new buildings:

a) *Anchorage* — It shall be necessary to hold the roof on. This means that the roof shall be tied down to the walls, or foundation by an adequate and continuous chain of strength. In wind-resistant construction, the purpose is to hold the roof down. In earthquake-resistant construction, trusses shall be braced at the beam. In avalanche-resistant construction, design of roof and roofing materials shall be strong enough to carry the static load of snow. Smaller roof area and stepping shall be preferred.

b) *Bracing* — It shall be necessary to brace the walls to withstand the lateral wind loading and racking effect. Strength shall be added not only at the corners of the building, but also at key locations throughout each wall. In timber structure, diagonal bracing, in brick or abode structure, horizontal and crossed timber or metal members to act as bracing at top and in the structural wall shall be provided.

c) *Continuity* — It shall be ensured that all building components and elements are properly connected so that their functions are performed satisfactorily. Normally, forces are often much larger, and in the opposite direction these shall require adequate provision of connections between members and components of a house.

9 SAFETY

9.1 The hazard is a natural phenomenon and is related to identifiable geographic areas. The design of safe houses shall start with the understanding of the nature of the hazard that has to be resisted. Hazard proofing of individual house is possible but shall be highly inter-related to the social and economic level of inhabitants.

9.2 Safety Measures Against High Wind, Snow Storms

9.2.1 Doors and windows shall be so designed that storm shutters can be placed over them during wind storms.

9.2.2 Window shutters shall be so designed that glass panes are relatively small.

9.2.3 Window frame shall be so designed that if screens are used on the outside, they can be easily removed and attached to the inside to provide protection against flying glass or other debris.

9.2.4 Any small room of the house shall be strengthened so that it can be used as in-house shelter during the hazard.

9.3 Safety Measures Against Earthquakes

9.3.1 Doors and windows shall be so designed that they will not fall or jam in an earthquake.

9.3.2 All houses shall have doors which open outward.

9.3.3 All doors inside the house shall open in the direction of nearest exit to the outside.

9.3.4 High chimneys, cornices or any ornamental structure shall be avoided on the roof top or elsewhere which can fall into the building or obstruct a door or window.

10 APPROPRIATE BUILDING MATERIALS

10.1 The choice of appropriate construction materials and technologies shall directly be related to the availability of skills and materials in a particular region. In determining the choice of materials to be used for building a house, it needs to be related to past traditional

usage, availability in time, and on required scale the possibility of upgrading quality.

10.2 The traditional/conventional building materials used for walling, roofing and flooring are indicated below.

a) *Walling* — Earth, soil, wood, timber, bamboo, bamboo mat, corrugated galvanized iron sheets, stone, bricks, concrete, asbestos cement sheets, lime, cement, ekra, slates.

b) *Roofing* — Wood, timber, bamboo, bamboo mat, corrugated galvanized iron sheets, reinforced cement concrete, concrete, thatch, asbestos cement sheets, slates, country tiles, lime, cement, plastic sheets.

c) *Flooring* — Earth, soil, wood, timber, stone, bricks, concrete, slates, lime, cement.

10.3 Properties of Materials

10.3.1 From the seismic view point the following material properties and characteristics shall be most important:

a) *Unit weight* — Lighter materials consistent with strength, shall be better.

b) *Strength* — Compression, tension and shear including dynamic effects, if any, induced to strain rates.

c) Modulus of elasticity including strain-rate effects.

d) Damping value at various strain level, higher the better.

e) Lateral load displacement characteristics of elements and components under reversed loading including plastic deformation.

f) *Durability* — Resistance against weathering action, corrosion, insect attacks, etc.

g) Fire resistance.

10.3.2 The status of determination of the properties as stated in **10.3.1** for common building materials shall be presented in a matrix form as given in Table 1.

Table 1 Properties of Common Building Materials Matrix

(*Clause* 10.3.2)

Sl No.	Materials	Mass Density	Compressive Strength	Tensile and Shear Strength	Elastic Modulus	Damping	Hysterosis Shape	Highstrain Rate Effect
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	Adobe	—	o	×	×	×	×	×
ii)	Burnt brick in mud mortar	—	o	o	o	o	×	×
iii)	Burnt brick in cement mortar 1: 6	*	*	—	—	o	×	×
iv)	Burnt brick in limesurkhi	—	—	o	o	o	×	×
v)	Random rubble, in cement or lime or mud mortar	—	×	×	×	×	×	×
vi)	Dressed stone	*	—	×	×	×	×	×
vii)	Timber	*	*	*	*	o	×	×
viii)	Cement concrete 1 : 2 : 4	*	*	*	*	—	o	—
ix)	Mild steel	*	*	*	*	—	*	*

* Excellent, o Poor, — Fair, × No information.

10.4 Traditional Construction Practices

10.4.1 Traditional building materials and their properties are mentioned in **10.2** and **10.3**. The availability of these materials in hilly regions of different states and their predominant usage in varied items of works are indicated in Table 2.

10.5 Alternate Building Materials

10.5.1 New building materials developed for walling and roofing and found suitable after field tests may be permitted in the hilly regions. The performance of such materials, however, may be evaluated by the users after taking into account of engineering principles of disaster resistant, design and construction practices with professional inputs.

10.5.2 *Walling Materials*

a) Hollow concrete blocks [*see* IS 2185 (Parts 1 and 2)].

b) Precast stone blocks (*see* IS 12440).

c) Concrete block [*see* IS 2185 (Part 1)].

d) Stabilised soil blocks.

10.5.3 *Floor/Roofing Materials*

a) Precast reinforced concrete 'L' panel (*see* IS 14241).

b) Partially precast reinforced concrete planks and joists (*see* IS 13990).

c) Precast reinforced concrete channel units (*see* IS 14201).

d) Fire retardant thatch (*see* IS 12506).

e) Aluminium/fibre reinforced plastic roofing sheets.

10.5.4 *Joinery*

a) Precast reinforced concrete frames for doors and windows.

b) Ferrocement shutters.

c) PVC Door shutters.

Table 2 State-wise Availability and Usage of Materials in Hilly Areas

(*Clause* 10.4.1)

State	Foundation	Walling	Roofing
J & K	Brick or stone work in mud/ cement/lime mortar.	Unburnt/burnt bricks/stone, mud/ abode in mud/cement lime mortar.	Gable/hipped roof made of slates tiles of corrugated galvanized sheets
		Timber planks and above walls with thick layer of mud/lime plaster.	Wooden planks with thick layer of mud plaster.
Himachal Pradesh	Stone work in mud/cement/ lime mortar.	Slate, stone in mud/cement/ lime mortar.	Sharply inclined gable roof using slates over wooden structure.
		Thick wooden beams in between inside mud plaster.	
Uttar Pradesh	Stone work in mud/cement/ lime mortar.	Random rubble stone masonry in mud/cement/lime mortar.	Gable two sides sloped with slates.
Sikkim	Stone work in mud/cement/ lime mortar.	Mud wall, stone in mud/cement, lime mortar. Wooden planks.	Gable roof corrugated galvanized iron sheeting on wooden frame work.
West Bengal	Stone work in mud/cement/ lime mortar.	Mud walls stone masonry in mud/ cement/lime mortar.	Gable roof corrugated galvanized iron sheeting on wooden frame work.
		Wooden planks and posts.	
Assam	Stilts of bamboo or wooden poles or posts.	Plaited or split bamboo or reeds with equidistant poles or posts.	Thatched slopped roof.
		Plastered with mud and cow dung or lime and sand.	
Arunachal Pradesh, Meghalaya, Manipur, Tripura, Mizoram	Wooden stilts or piles of timber poles or bamboos. Random rubble stone masonry mud wall.	Woven bamboo matting or bamboo/wood walls covered with mud or 'Tarja' wattle and daub walls. brick walls.	Sloped thatched roof using bamboo and grass. Corrugated galvanized iron sheet on wooden substructure.

11 CONSTRUCTION MATERIALS, SYSTEMS AND METHODS

There are three main components of the house; foundation, wall and roof. The foundation is closely related with the type of walling materials and surrounding type of soil and roof structure is quite independent. Those commonally used for residential houses along with some variations in their materials and methods are described in **11.1** to **11.5.3**.

11.1 Earthen Houses

11.1.1 The basic materials for construction shall be clayey earth either in mud lump form, rammed earth in wooden forms or rectangular shaped blocks, called adobe. Some fibrous materials like straw, hay, human or animal's hair shall be mixed in natural soil. Normally 300-350 mm thickness shall be adopted for low rise houses. Sometimes the thickness of wall shall be tapered upwards. In some variations, wood elements or splitted bamboos shall be inserted between courses particularly at the corners and T-junctions of the wall.

11.1.2 The '*Dhajji Diwari*' construction in J&K region, pillars of adobe 600 × 600 mm in size shall be built at 1.5 to 2.0 m centres. The intervening space shall be filled with bricks or stone

11.1.3 The floor shall be of wooden joists and planks. The joists shall rest on wooden wall plates and also sometimes, will have wall plates on top of them. These wooden wall plates shall form runners all round the house.

11.1.4 A composite wall construction can be adopted. This will have burnt bricks on outer face and unburnt bricks on innerface, built in mud mortar and both are bonded together by header bricks.

11.2 Burnt Brick Houses

11.2.1 The basic materials for construction shall be clay burnt bricks hand or machine moulded and fired in different type of clamps and kilns. The dimensions, quality, strength etc, shall be as per IS 1077.

11.2.2 The room sizes shall depend on the types of roof. The room width shall be restricted to 3.0 to 3.4 m and length from 4.0 to 8.0 m where flat roofs/ floors are constructed with wooden joists and planks.

11.2.3 The English bond, shall be used for the construction of one brick thick wall. Mud mortar for single storeyed and cement or lime mortar for double storeyed load bearing walls shall be used.

11.2.4 Foundations shall consists of stepped type footings over rammed earth and brick bats. Slightly under or over burnt bricks shall be permitted in foundation.

11.2.5 The one and half brick piers thickness having independent footing at 3.0 m centre-to-centre projecting by half bricks and infill unburnt brick panels shall be permitted in composite construction. Wooden ring beams on top of walls shall be provided to receive the hipped roof.

11.3 Stone Masonry Houses

11.3.1 The natural stones in masonry work shall be used in form of random rubble or half-dressed or fully dressed state. The mortars shall be cement or lime.

11.3.2 The wall thickness shall vary from 400 to 750 mm, depending upon loading and mortars used.

11.3.3 Single storey laterite stone unit walls shall be 250 to 300 mm thick with hipped roof. Rooms may be wide and long having inner row of wooden posts.

11.3.4 Single storey stone house with reinforced concrete slab roof and 2 400 mm height shall be typical design.

11.4 Wooden Houses

11.4.1 Wooden houses shall include those in which the main load bearing structure consists of wooden posts and frames although the cladding may be of brick or stone. The wood used in construction shall also include logs, sawn timber of different species as well as bamboo.

11.4.2 The system of construction shall be classified into two forms:

a) stud wall, and

b) nogged timber frame.

11.4.2.1 Stud wall construction shall be of wooden sill plates laid at plinth level and wooden posts framed at short distance of 800 to 1 200 mm centre-to-centre. The studs shall also carry wooden plates at their top. The corners and junctions of walls shall be stabilized by connections between plates and framing. The sill plates shall be rigidly fixed to masonry plinth by means of iron bolts or wires. Horizontal wooden members of lighter cross-section shall be inserted between the studs at regular intervals by notching into the studs or spiking to them. The roof shall be pitched or hipped type having wooden rafters and purlins to which the sheeting in nailed or bolted. The wall cladding shall consist of planks, sheets, boards, bamboo mats, etc. The panels shall be diagonally braced.

11.4.2.2 The brick nogged timber frame shall consist of heavy corner columns, piers or posts, sills, intermediate verticals at 1 000 mm centres. The wall plates, horizontal nogging members and diagonal braces in alternate panels shall be framed into each other. The space between framing members shall be filled

with tight fitting burnt or unburnt half brick masonry in stretcher bond. Flat stones like slates or laterite shall also be used. The roof shall be pitched or hipped with sheeting or tile covering. Thatch shall also be used.

11.4.2.3 The foundation of both type of wooden houses shall usually be random stone masonry in mud mortar. These type of houses shall have an intermediate and attic floor for double storeyed construction.

11.5 Concrete Frame and Infill Construction

11.5.1 Concrete constructed houses shall include the method of reinforcing, a continuous, running frame of *in-situ* reinforced cement concrete. The adobes, hollow concrete blocks, stone blocks, concrete blocks or stabilized soil blocks shall be used as a non-loading bearing, non-structural infill.

11.5.1.1 The house shall be constructed on strong, level foundation with moisture barrier. Reinforced cement concrete columns shall be in each corner and spaced at appropriate intervals throughout each wall and on each side of doors and windows. All columns shall be firmly implanted in the foundation at least 750 mm deep. Reinforced cement concrete ring beams at bottom, middle and tip of wall shall be provided. Intersecting walls shall be joined to exterior wall at a vertical column. Intersecting walls shall be made continuous by means of the bars and or horizontal reinforcement that extend into neighbouring walls and partitions.

11.5.1.2 In case of load-bearing structure using alternate building materials for walling as mentioned in **10.5.2** the construction methods shall be as described in **11.3**. Additional reinforcement or mild steel bars in each third layer and vertical reinforced on each side of opening shall be provided.

11.5.2 For alternate building materials for roofing as mentioned in **10.5.3** the construction methods would not differ. However, additional gable wall of bricks on joints shall be provided.

11.5.3 Partially precast reinforced concrete planks and joists system for floor/roof shall require additional strengthening measures for diaphragm action.

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
875 (Part 4) : 1987	Code of practice for design loads (other than earthquake) for buildings and structures : Part 4 Snow loads (*second revision*)
1077 : 1992	Specification for common burnt clay buildings bricks (*fifth revision*)
1893 : 1984	Criteria for earth quake resistant design of structures (*fourth revision*)
2185	Concrete masonry units :
(Part 1) : 1979	Hollow and solid concrete blocks (*second revision*)
(Part 2) : 1983	Hollow and solid light weight concrete blocks (*first revision*)
6523 : 1983	Specification for precast reinforced concrete door and window frames (*first revision*)
12440 : 1988	Precast concrete stone masonry blocks
12506 : 1988	Code of practice for improved thatching of roof with rot and fire retardant treatment
13990 : 1994	Precast reinforced concrete planks and joists for roofing and flooring
14201 : 1994	Precast reinforced concrete channel units for construction of floors and roofs
14241 : 1995	Precast reinforced concrete L-panel for roofing
14458 (Part 2) : 1997	Retaining wall for hill area — Guidelines : Part 2 Design of retaining/ breast walls

ANNEX B

(*Clause* 6.1.4)

HOUSE FORMS AND PATTERNS PREVAILING IN DIFFERENT HILLY REGIONS

B-1 Common house types in Jammu and Kashmir have an east orientation. The houses are square or rectangular in plan. A typical feature in all the rural houses is to have a small front verandah. Plinth is raised. Commonly the houses are two or three storeyed and multi-roomed tenements. Gabled roof are preponderant in these houses which are purposefully constructed to shed-off the snow.

B-2 Generally in Himachal Pradesh, plinth is not raised, doors are small in size and minimum ventilation is provided. Ground level/floor is used for storage purposes and keeping cattles. A *TAND* that is, a small room between two floors is designed for retiring during extreme cold weather. Besides, a provision for a verandah all around the central area is preferred.

B-3 The house types in hilly regions of Uttar Pradesh are generally double-storeyed in character and multi-room tenments. A covered verandah on ground floor in front facade is an integral part of the house. Generally a covered balcony on upper floor is a common feature. Raised plinth and stone flab flooring is common practice.

B-4 The housing typology in the state of Sikkim and West Bengal is quite similar to the other hilly regions. The houses are multi-roomed, two or three storeyed structures erected with high plinth ranging from 600 to 900 mm. Covered verandah and balcony on ground and upper floors respectively are common features. A few small holes or small windows in front walls, are provided for ventilation.

B-5 Generally, house types in Assam are one roomed having two or three low level partitions to divide the available space according to functional usage. Cooking space is inside the room. Normally, there is an open court yard space in front demarcated with bamboo fencing. This space is used as cattle shed and granary. The plinth height is usually 300 to 900 mm with filled up earth. Floor finish is done with mud and cow dung.

B-6 In all States of North Eastern region, the house types built on stilts are common. These are one-roomed with scare ventilation. The room-space is designed for built-in bed-stead along the walls, kitchen/fire place in the centre. The provision of *TAND* (projected shelves) for storage is made inside the room.

B-7 In Meghalaya, the stilt-huts are 900 to 1 200 mm above surrounding level. The room space is partitioned in 2-3 rooms. Tong-ghars of Tripura have stilt height between 1 200 to 1 800 mm. The house have a covered bamboo platform in front used as portico and uncovered platform at the back.

B-8 '*AO*' house of Nagaland are usually two roomed units with an open platform of interlaced split bamboo at the back. Mizoram houses are spacious single roomed structures with front covered verandah and back open verandah.

B-9 The tribals of Arunachal Pradesh construct their-stilt houses with provisions of front verandah, main hall and back verandah. In some cases, a provisions of corridor all along the house to connect front and back is made.

ANNEX C

(Foreword)

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