

```

{
  "sections": [
    {
      "title": "Landslide Clearance for Construction",
      "content": [
        "Construction on land with a ground slope exceeding 31° is strictly prohibited unless a comprehensive risk assessment is obtained from NBRO (National Building Research Organization). Any construction must adhere to the recommendations and conditions outlined in the Risk Assessment Report.",
        "For slopes ranging from 11° to 31°, specific recommendations detailed in Structural Requirements for Landslide Resilient Houses must be followed.",
        "To mitigate the risk of landslide disasters and ensure the safety of life and property against future slope instabilities, certain construction restrictions are imposed on slopes. NBRO's concurrence is mandatory for construction activities on slopes, especially in the ten districts prone to landslides: Badulla, Galle, Hambantota, Kalutara, Kandy, Kegalle, Matale, Matara, Nuwara Eliya, and Ratnapura. Depending on the slope steepness and other conditions, local authorities may require builders to obtain landslide clearance for construction, even if the land is situated outside the known hazard-prone areas in the aforementioned districts. Upon issuing the landslide clearance for construction, NBRO will provide additional conditions, if necessary, that the builder must satisfy."
      ]
    },
    {
      "title": "Basic Requirements for a Safe Structure",
      "content": [
        "Houses built on slopes or in hilly areas are susceptible to various natural hazards such as landslides, high winds, flash floods, and mudflows. Hazard-resilient houses should be located outside any land prone to landslides and sufficiently distant from unstable or vulnerable areas to avoid collapse, burial, or severe damage.",
        "Despite proactive location planning, unforeseen ground movements or vibrations from neighboring areas may impact the house. A hazard-resilient house should be able to withstand:",
        "Minor ground movements without structural damage.",
        "Moderate ground movements with non-structural damage.",
        "Larger movements without collapse, albeit with some structural and non-structural damage."
      ]
    }
  ]
}

```

"While some degree of damage may be acceptable during an unexpected event, the loss of life is intolerable. Therefore, house structures must be designed to withstand large ground movements with adequate strength, appropriate rigidity, and structural integrity."

"Flexible structures, primarily composed of steel or timber, are recommended for hilly areas as they can accommodate movements without significant distress. In landslide-prone areas, the recommended structure is a reinforced concrete framed structure with brick walls and stiffened foundations, as specified in Section B, along with additional recommendations provided herein."

]

},

{

"title": " Land Selection",

"content": [

"Important!",

"Areas unsuitable for housing must be avoided, including:",

"Areas prohibited or restricted by law",

"Unsafe designated areas",

"Areas with a history of landslides",

"Areas where landslides are imminent",

"Areas prone to landslide hazards",

"The suitability of land for housing depends on two critical factors: the type of terrain and the landslide potential."

"a) Type of Terrain",

"Terrain types are categorized based on measurable ground slope. Steeper slopes have a higher instability tendency, with problems often arising on terrain exceeding 10°-15° in slope."

"Five broad categories based on ground slope are identified:",

"Type I: Flat Land (slope angle < 5° or ground slope < 8%)",

"Type II: Gentle Slopes (slope angle between 5°-11° or ground slope between 8%-20%)",

"Type III: Moderate Slopes (slope angle between 11°-17° or ground slope between 20%-30%)",

"Type IV: Moderate Slopes (slope angle between 17°-31° or ground slope between 30%-60%)",

"Type V: Steep Slopes (slope angle > 31° or ground slope > 60%)",

"Construction restrictions and conditions vary according to the terrain type, as outlined below"

"b) Structural Requirements for Landslide Resilient Houses",

"These do not apply to the 10 districts designated as landslide prone by NBRO.",

"For Slope angle < 11° (0% - 20%):",

"Restriction on construction: No special restrictions apply. Design and construction shall be in accordance with Section B of the manual.",

"Dimension perpendicular to contour: No special restrictions apply. Design and construction shall be in accordance with Section B of the manual.",

"Longer side of building to be parallel to contours: No special restrictions apply. Design and construction shall be in accordance with Section B of the manual.",

"Maximum height of the vertical cut: No special restrictions apply. Design and construction shall be in accordance with Section B of the manual.",

"Minimum horizontal distance to the proposed house: No special restrictions apply. Design and construction shall be in accordance with Section B of the manual.",

"Minimum horizontal distance to the nearest building: No special restrictions apply. Design and construction shall be in accordance with Section B of the manual.",

"Retaining wall: No special restrictions apply. Design and construction shall be in accordance with Section B of the manual.",

"Restriction on slope: No special restrictions apply. Design and construction shall be in accordance with Section B of the manual.",

"Development of surface drainage of land: No special restrictions apply. Design and construction shall be in accordance with Section B of the manual.",

"For Slope angle between 11° – 17° (20% -30%):",

"Restriction on construction: Guidelines to be followed.",

"Dimension perpendicular to contour: Recommended.",

"Longer side of building to be parallel to contours: Recommended.",

"Maximum height of the vertical cut: 1.5m for residual soil, 1.0m for colluvium. No unsupported cuts in colluvium.",

"Minimum horizontal distance to the proposed house: 2.0m.",

"Minimum horizontal distance to the nearest building: Mandatory.",

"Retaining wall: Mandatory (See Section C 1.7 for retaining wall construction techniques).",

"Restriction on slope: Mandatory (gradient should not exceed 60°).",

"Development of surface drainage of land: Mandatory if development obstructs the natural surface drains.",

"Turn or other erosion control measures: Recommended.",

"For Slope angle between 17° – 31° (30% -60%):",

"Restriction on construction: Guidelines to be followed.",

"Dimension perpendicular to contour: Mandatory.",

"Longer side of building to be parallel to contours: Mandatory.",

"Maximum height of the vertical cut: 1.0m for residual soil. No unsupported cuts in colluvium.",

"Minimum horizontal distance to the proposed house: 3.0m.",

"Minimum horizontal distance to the nearest building: Mandatory.",

"Retaining wall: Mandatory and designed by a technically qualified person.",

"Restriction on slope: Mandatory (gradient should not exceed 45°).",

"Development of surface drainage of land: Mandatory.",

"Turn or other erosion control measures: Mandatory.",

"For Slope angle > 31° (> 60%):",

"Restriction on construction: Restrictions on construction are mandatory. Essential development activities require NBRO's approval.",

"Dimension perpendicular to contour: Mandatory.",

"Longer side of building to be parallel to contours: Mandatory.",

"Maximum height of the vertical cut: Restrictions on construction are mandatory. Essential development activities require NBRO's approval.",

"Minimum horizontal distance to the proposed house: Restrictions on construction are mandatory. Essential development activities require NBRO's approval.",

"Minimum horizontal distance to the nearest building: Mandatory.",

"Retaining wall: Restrictions on construction are mandatory. Essential development activities require NBRO's approval.",

"Restriction on slope: Restrictions on construction are mandatory. Essential development activities require NBRO's approval.",

"Development of surface drainage of land: Restrictions on construction are mandatory. Essential development activities require NBRO's approval.",

"Turn or other erosion control measures: Restrictions on construction are mandatory. Essential development activities require NBRO's approval.",

"b) Landslide potential: Suitability of a site in respect of landslide potential shall not be judged merely from the characteristics of the site itself in isolation, but of a broader area which encloses and

influences the site. Select the site only after proper assessment of the land and its surrounding area to identify the level of risk from landslide hazards, if any.",

"A site selected for a house shall be free of any features that are indicative of landslide threats or slope instability. Therefore, the land should be located sufficiently away from such potential risk areas and features such as steep slopes, cliffs, escarpments, rivers, perennial or ephemeral streams and mountain channels."

]

},

{

"title": " Areas Not Suitable for Construction of Building",

"content": [

"a) Areas Prohibited or Restricted by Law",

"The land chosen for building a house may be within a safe zone permitted for human settlement and construction of residential buildings, or it may fall within a zone designated as prohibited or restricted for such activities.",

"It's essential for the reader to seek advice from the local authority to determine whether the land use is restricted or not.",

"b) Areas Designated Unsafe",

"Building in areas designated or declared as unsafe should be avoided. These areas are indicated in Landslide Hazard Zonation Maps as zones where:",

"Landslides are most likely to occur (High Risk).",

"Landslides are likely to occur (Moderate Risk).",

"Landslides may occur (Low Risk).",

"These maps indicate areas prone to slope failures and should be referred to before selecting a site for construction.",

"c) Areas with Previous Landslide Activity",

"Avoid building in areas where landslides have occurred. Indicators of previous landslides include:",

"Irregular topography.",

"Disruption of vegetation.",

"Visible slide planes.",

"d) Areas Prone to Future Landslides",

"Building in areas where landslides are likely to occur should be avoided. Indicators include:",

"Presence of tension cracks.",

"Water seepage from the ground.",

"Bulging ground surfaces.",

"e) Areas with Landslide Threat",

"Building in areas threatened by landslides should be avoided. Such areas are likely to be indicated in Landslide Hazard Zonation Maps."

]

}

{

"title": " Layout Arrangement and Orientation of the House",

"content": [

{

"subsection": "a) Orientation of the House",

"details": [

"Houses founded on a single platform should preferably be planned to have their longer sides running parallel to the natural contour lines. This can avoid encountering large differences in sub soil conditions and reduce cutting and filling work."

]

},

{

"subsection": "b) Shape of the Structure",

"details": [

"Simple and symmetrical shapes such as square or rectangular shapes are preferable to minimize adverse effects from possible ground movements or ground disturbances."

]

},

{

"subsection": "c) Land Space requirements",

"details": [

"The house shall be located at a sufficiently safe distance away from the toe of steep slopes, protected or unprotected natural or manmade slopes. The distance so required shall be decided on the advice of the engineer.",

"Additional land space needed for the provision of access roads, garage and other facilities, such as for sewage disposal and the space required for cut and fill slopes, berms, retaining structures etc., shall be taken into due consideration at the planning stage."

]

}

]

},

{

"title": " Land Preparation",

"content": [

"Minor ground movements without structural damage.",

"Moderate ground movements with non-structural damage.",

"Larger movements without collapse, albeit with some structural and non-structural damage.",

"While some degree of damage may be acceptable during an unexpected event, the loss of life is intolerable. Therefore, house structures must be designed to withstand large ground movements with adequate strength, appropriate rigidity, and structural integrity.",

"Flexible structures, primarily composed of steel or timber, are recommended for hilly areas as they can accommodate movements without significant distress. In landslide-prone areas, the recommended structure is a reinforced concrete framed structure with brick walls and stiffened foundations."

]

},

{

"title": " Reinforced Concrete Walls",

"content": [

"Walls made of reinforced concrete in the shapes of 'L' or 'Inverted T' can also be used to retain soils. The weight of the soil lying above the base is added to the weight of the wall to maintain stability. Therefore the wall should be of sufficient base width. The wall stem should be adequately reinforced to withstand the bending moment exerted by the retained soil.",

"Walls can be in the cantilevered form or laterally stiffened by counterforts or buttresses. This lateral stiffening will reduce the bending moments on the wall stem. The resistance to sliding can be enhanced by providing a shear key."

]

},

{

"title": "Embedded Walls",

"content": [

"Walls embedded to an adequate depth can be used to retain soil. This type is particularly useful for supporting excavations. Embedded wall sections can be of preformed from timber, steel or masonry and driven to the ground to an adequate depth before excavation commences.",

"Walls made of steel (steel sheet piles) are the most widely used type. Alternatively, a wall of necessary depth can be constructed with insitu concrete in the form a diaphragm wall or by a continuation of a line of bored piles. Diaphragm walls are constructed in the form of interlocking panels.",

"Bored pile walls can be constructed with an overlap (secant pile wall), touching each other (contiguous wall) or with a gap between piles (intermittent walls). If an excavation is extended below the ground water table, use of a secant pile wall is recommended.",

"Embedded walls can be done in the form of cantilevered walls or laterally supported at one or more levels by anchors or props. With the usage of lateral supports, the required depth of embedment is reduced. Lateral supports will reduce the deformations as well.",

"The stability of an embedded retaining wall is derived from its depth of embedding and lateral support. The wall section should be of adequate structural stiffness to withstand the bending moments developed."

]

},

{

"title": " Drainage behind Retaining Walls",

"content": [

"Due to rainfall or other wet conditions, the backfill of a retaining wall may become saturated. Saturation will, in effect increase the pressure on the wall and creates an unstable condition.",

"Adequate drainage must be provided by means of weep holes and/or perforated drainage pipes. Minimum diameter of a weep hole is about 100mm and they should be placed sufficiently close (1.5m to 2.0m horizontally and vertically).",

"There is always a possibility that the backfill material may be washed into weep holes or drainage pipes. This will ultimately clog up the drainage facilities and may cause the earth fill on top to subside. Thus, a filter material should be placed behind the weep holes or around the drainage pipes. Filters may be constructed from graded aggregate or with a geotextile."

]

},

{

"title": " Soil Erosion Control and Drainage",

"content": [

"Most of the landslides in Sri Lanka have occurred when heavy storms and prolonged rainfall have been experienced. Rains, while contributing to surface erosion of the soil on a slope, also percolate into the soil filling the voids. This reduces the matric suction of the soil and saturates it, making it more heavy in turn. The groundwater level can also rise. There will be a reduction in the strength of soil. Even a slope that appears to be stable under dry conditions may become unstable due to poor drainage of the slope. Therefore, it is extremely important to manage both surface and subsurface drainage of a slope.",

"The areas that should be avoided when building on slopes and the areas that may be considered as suitable for housing construction are recommended in Section C 1.2.3 of this manual. Even if the land is carefully selected, all precautions shall be taken to ensure that soil erosion is controlled and the surface and subsurface drainage is properly managed in order to sustain the stability not only of the premises of the house but also of the surrounding lands."

]

},

{

"title": " Soil Erosion Control",

"content": [

"Soil erosion can happen as a result of rain splashing against the soil surface, flow of surface runoff and formation of gullies. Erosion of banks and bottom of gullies and streams occur due to rapid water flow. These conditions can eventually contribute to slope instability.",

"Minimize disturbance to existing terrain as far as possible by matching development to the terrain and limiting adjustments to existing ground contours.",

"Minimize exposure to soil erosion by planning the construction and scheduling so that the extent of exposed areas and the duration of the exposure are minimized and the grading works can be done during relatively dry seasons.",

"Minimize clearing of site by retaining existing vegetation as vegetation helps reduce run off velocities and volumes. Use plants like Vetiver grass (savandara variety) for re-vegetating.",

"Optimize slope angle and length.",

"Divert runoff away from cleared areas and minimize runoff velocities by grass lining of diversion trenches, use of broad and shallow flow areas, network of surface drains and rock fragments on slopes."

]

},

{

"title": " Surface Drainage",

"content": [

"Ensure that natural drainage, stability and environment of the land and surrounding area is not adversely affected during and after construction. All water from rain, springs and waste water shall not be released on or in to the slope and shall be properly directed away from the slope appropriately into natural water courses or the local storm water drainage system or the wastewater drainage systems as applicable.",

"Provide interceptor drains to collect and divert runoff and springs to prevent surface flow within any unstable or cleared area.",

"Provide diversion drains to prevent water flowing into any unstable or cleared area across its periphery.",

"Provide silt traps / silt fence to prevent blockage of drains due to siltation.",

"Line the trenches and channels to minimize erosion.",

"Utilize flexible material or flexible joints if pipes are used to drain water.",

"Provide structures to dissipate energy and reduce the flow velocities in channels.",

"Provide adequate reservation for existing natural streams or drains.",

"Provide culverts, concrete pipes etc., as required for access or internal road crossings.",

"Provide adequate flow capacity and slope and drops in all drains, channels, pipes etc., to prevent blockage."

]

},

{

"title": "Sub-surface Drainage",

"content": [

"Rise in ground water table within the land due to rains or any other reasons can result in instability particularly of any cut slopes or generally unpleasant environment with sodden ground around the house. It is, therefore, necessary to control groundwater table and/or seepage flows.",

"Intercept the groundwater and properly divert it away from the land using a French drain or sub surface drains. French drain consists of a perforated hollow pipe wrapped around with a filter of geotextile fibre and surrounded by permeable material such as sand and gravel packed within a lateral trench. The pipe should have a proper gradient and an outlet to a suitable surface drain for the intercepted water to flow away swiftly. These drains are more suited when the groundwater rises to within about 1.5m from ground surface as deeper excavation could be costly.",

"Provide sub-surface drains to help lower the ground water table and prevent build-up of hydrostatic pressure against the walls.",

"Sub surface drainage can also be provided for cut slopes. This consists of horizontal drains comprising perforated pipes laid within permeable material packed within a trench of appropriate depth and gradient. The water collected from such drains should be directed to a suitable surface drain."

]

},

{

"title": " Construction Material",

"content": [

"For the construction of a house in hilly areas, materials that can be used are as follows:",

"1. Cement stabilized earth blocks.",

"2. Soil cement blocks.",

"3. Mud blocks.",

"4. Bricks.",

"5. Random rubble masonry.",

"6. Burnt clay bricks.",

"7. Un-burnt clay bricks.",

"8. Compressed earth blocks.",

"9. Hollow cement blocks.",

"10. Cement blocks."

]

}

