ANALYTICAL STUDY AND DESIGN GUIDELINES FOR MID-RISE BUILDINGS IN HILL REGIONS

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF ARTHITECTURE

By

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CANDIDATE'S DECLARATION

I hereby certify that the work, which is being presented in the dissertation entitled **ANALYTICAL STUDY AND DESIGN GUIDELINES FOR MID-RISE BUILDINGS IN HILL REGIONS** in partial fulfillment of requirement for the award of degree of **Master of Architecture** submitted in the **Department of Architecture and Planning** of the Indian Institute of Technology, Roorkee is an authentic record of my own work carried out during the period from July 2008 to June 2009 under the supervision of **Dr. Pushplata** and **Dr. D.K. Paul.**

The matter embodied in this dissertation has not been submitted by me for the award of any other degree.

Place: Roorkee

Dated: 30th June 2009

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CERTIFICATE

This is to certify that the above statement made by the candidate **Ashwani Kumar** is correct to best of my knowledge.

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ABSTRACT

Hills are the most difficult yet most interesting and challenging features to carry any development work. Construction of buildings in Hilly terrain is constrained by their difficult terrain, steep gradients, complex geological structure, climatic conditions and rich flora. In response to these settings various built form construction techniques and patterns of development have emerged in different hill regions of country. There are some very interesting and outstanding examples of buildings on hill sites throughout the history of human civilization which reflect the sensitivity and geniuses of the builders.

Though, the traditional built form of hill settlements in India is characterized by low rise buildings with sloping roofs; mid rise structures have been built for religious and civic purposes. Similarly mid rise shop cum residential buildings in the market areas were built for local population in hill stations developed by British like Shimla, Mussorie, Nainital, though the predominant pattern of development consisted of low rise cottages for European and elite. Thus most of the hill settlements have been essentially low density low rise.

The tremendous increase of population of select hill towns due to improved accessibility and transport facilities, increase in domestic tourism and various employment generation schemes for local population has resulted in new pattern of development consisting of mid rise buildings. These mid rise buildings along with low rise, high density development almost cover the entire hill slopes, which results in congestion, overcrowding, insufficient infrastructural facilities and leads to unhealthy living and working conditions. Mid rise buildings are coming up in core areas of towns and in newly developed areas on the periphery of town. Mid rise buildings are mainly preferred in hill towns primarily for Public buildings, office buildings, hotels, hospitals, institutions and also preferred for new residential apartment construction. Due to the increased need of mid rise buildings in hill towns , there is a need to understand the planning and design issues, formulation of planning and design guidelines focusing on site planning, functionality, space requirements, structural safety against fire and natural hazards, services, energy conservation, aesthetics in hill towns to ensure a better, safer, and healthy environment .

In this research attempt is made to understand types of mid rise buildings in hill sites. Considering the significance of site development, methods of site development in hill regions are discussed. Various factors affecting planning and design of mid rise buildings in hill towns and issues of mid rise buildings in hill towns in general and particularly in context to Shimla, the capital of Himachal Pradesh and the former summer capital of India during British period and the largest hill town of north India. In view of the energy crisis and climatic change the energy efficient buildings in hill regions have been discussed.

Safety against natural hazards is major concern in hill regions, various problems related to hill buildings regarding safety are highlighted. Detailed study of factors responsible for landslides and remedial measures are discussed along with landslide hazard zonation. Safety considerations against earthquake to be adopted at various stages of buildings are discussed. Various problems in the prevailing development controls for mid rise buildings in hill towns are identified.

Study of SDA complex Shimla is conducted to highlighting various issues of site election planning and development for mid rise buildings in hill regions. Existing mid rise buildings at Shimla are studied in order to highlight the various issues related to sitting, building design, structural safety, energy efficiency and aesthatics. Various buildings selected for the study are; Railway board building (oldest mid rise building in Shimla), high court building (tallest building in Shimla), Police headquarter complex and Nirman bhawan (a newly under construction building). Comparative study of these buildings is made focusing on site selection and planning, Building design and functions, Structure safety against earthquake and landslides, Building services, Climatic response and appearance in order to highlight / understand the problems or shortcomings in the existing buildings.. Various aspects and criteria for design of mid rise buildings in hill regions are identified in the study. Based on these criteria design guidelines for mid rise buildings in hill regions are suggested.

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INTRODUCTION

1.1 OVERVIEW

21% of total land area of India is hilly or mountainous, which includes the northern mountains of the Himalayas, the Central Highlands, the Deccan Plateau, the north eastern hill ranges. Hills are the most difficult yet most interesting and challenging features to carry any development work. Construction of buildings in Hilly terrain is constrained by their difficult terrain, steep gradients, complex geological structure, climatic conditions and rich flora. In response to these settings various built form construction techniques and patterns of development have emerged in different hill regions of country.

1.1.1 General Pattern of Development in Hills

The hilly regions are famous for their traditional low rise development, indigenous construction materials and technology. Whereas the predominant patterns of development in hill stations developed by Britishers at different locations in the mountain region of India like Shimla, Nainital, Dalhousie and Mussorie, were low- rise cottages for the Europeans and elite and mid- rise shop cum residential buildings for the local population. At that time these were very small settlements catering to few hundreds of people, the construction activities were quite limited. The built to open ratio in hill towns was very less and lot of space was kept vacant for landscaping. This helped in the maintenance of ecological balance. The construction materials matched the environmental conditions

However some mid rise buildings have been built in earlier periods as well. These include religious buildings like Bhimakali temple at Sarahan, district Shimla from ancient period and public building in the British period like The Railway board building at Shimla and shop cum residential buildings built near the mall roads of these hill towns are some examples of mid rise buildings before independence.

After independence these small settlements in hill regions were developed as hill towns and became preferred tourist locations due to the cold climate and availability of infrastructural facilities. These towns also served the purpose of regional commercial activity centres and employment generators for the people living in the nearby villages. The migration of people from the surrounding villages and higher population growth rate resulted in change in size of these small settlements into low rise low density towns, which were environmental friendly, generated very little pollution and the suitable place to live and relax.

With further increase in population after 1980s and more migration from villages to these regional towns, in search of employment and better living conditions and due to increased tourist activity which required the shelter for short period. Population of these towns was increased rapidly; as a result, the infrastructure facilities provided in these towns became inadequate. The increased population of these hill towns resulted in a new pattern of development, which is low rise and high density, characterised by small houses, narrow streets, lacking in basic amenities etc. Further increase in population resulted in the unhealthy living, working condition and degradation of existing buildings due to congestion, overcrowding, improper constructional technology and lack of maintenance.

1.1.2 Present Scenario of Construction

There is a lot of pressure on land for new houses and work places but due to the undulating topography the buildable land is less and results in high land prices in these towns The existing pattern of development is insufficient to cater the increased demand for residential, work places, recreational, commercial and educational areas for both residing and floating population. There is a shift from the low rise buildings to the mid rise buildings in hill towns. Mid rise buildings are coming up in core areas of towns and in newly developed areas on the periphery of town.

1.1.3 Mid-rise Buildings in Hills

As per classification given by Charles H Thornton **"building which has 4 to 10 storeys comes in the category of mid rise buildings.**

Mid rise building construction is preferred in important hill towns due to population growth, greater need of buildings, less available buildable land, high cost of land and materials. These buildings are generally located in the main core area of town or in those areas where population density is very high and in newly developed areas on the periphery of town due to high demand of buildings in hill towns.

Mid rise buildings are mainly preferred in hill towns primarily for Public buildings, office buildings, hotels, hospitals, institutions and also preferred for new residential apartment construction. These buildings are generally cubical in shape having split ground floor at different levels as per the topography. Linear shapes having stepped facade and sky line are generally preferred for hills.

1.2 IDENTIFICATION OF PROBLEM

Due to lack of proper understanding of planning and design issues, guidelines and development controls related to mid rise buildings in hills. There are problems for mid rise building construction in hill towns related to:

i) Site planning and development
ii) Architectural design
iii) Earthquakes and landslides consideration
iv) Building services and parking
v) Energy conservation
vi) Aesthetics considerations

1.3 NEED OF STUDY

Due to the increased need of mid rise buildings in hill towns and problems in planning and designing of mid rise building due to the absence of proper guidelines. There is a need to study and understand the planning and design issues and formulation of planning and design guidelines for the mid rise buildings focusing on site planning, functionality, space requirements, structural safety against fire and natural hazards, services, energy conservation, aesthetics in hill towns to ensure a better, safer, and healthy environment within the built mass, so that the planning and designing of mid rise buildings for new constructional activities in and around hill towns can be done efficiently.

1.4 AIM AND OBJECTIVES

i) To understand the factors affecting planning and design of mid rise buildings in hill towns and issues of mid rise buildings in hill towns in general.

ii) Identification of various constraints, factors affecting mid rise buildings in case a specific context (Shimla is the capital of Himachal Pradesh and the former summer capital of India during British period and the largest hill town of north India)

iii) a) Identification of problems or shortcomings in the existing mid rise buildings in case of a specific context (Shimla)

b) Identification of problems in the prevailing development controls for mid rise buildings in hill towns

iv) Identification of various aspect and design issue of mid rise buildings in hill regions based on the above.

v) To formulate the design guidelines for mid rise building to ensure safety, functional and cost effectiveness and energy efficiency for contextually appropriate and sustainable mid rise buildings in Shimla.

1.6 RESEARCH METHODOLOGY

The methodology for the dissertation will include:

i) **Literature review:** The review of available literature to study:

a) Mid rise buildings in hill regions
b) Type of buildings on hill slopes
c) Methods of site development in hills
d) Provisions in various IS codes related to mid rise buildings in hill regions
e) Factors affecting planning and design of mid rise buildings in hills.
f) Energy efficient buildings in hill regions
g) Safety considerations for earthquakes and landslides for mid rise buildings in hill areas
h) Existing guidelines and norms for mid rise buildings in different hill towns
i) Development controls for mid rise buildings in different hill towns

ii) **Case study:** This will include the detailed study of:

a) selected areas with mid rise buildings in Shimla

b) selected mid rise buildings in Shimla with respect to :

- Site planning
- Building design and functions
- Structure safety against earthquake and landslides
- Building services
- Climatic consideration
- Appearance

iii) **Formulation of Guidelines**: this will include the formulation of design criteria and guidelines with respect to

a) Site planning

b) Building design and functions

c) Structure safety against earthquake and landslides

d) Building services

e) Climatic consideration

f) Appearance

1.7 SCOPE AND LIMITATION

The dissertation is limited to the analytical study of design aspects of existing mid rise buildings in Shimla and formulation of design guidelines for new mid rise buildings in Shimla, focusing on site planning, building design, safety against natural hazards like earthquakes and landslides and appearance.

CHAPTER II

LITERATURE REVIEW

2.1. INTRODUCTION

This chapter discusses the types of mid rise buildings on hill sites. Considering the significance of site development, methods of site development, provisions for mid rise buildings in Indian Standard (IS) Codes have also been discussed, factors affecting mid rise buildings in hills have been summarised based on the literature study. In view of the energy crisis and climatic change the energy efficient buildings in hill regions have also been discussed.

2.2. MID RISE BUILDINGS IN HILL TOWNS

Mid rise buildings have been built in started in earlier/ ancient periods in hill regions. These include religious buildings like Bhimakali temple at Sarahan, sumer construction multi-storey buildings in Uttarkashi. During the British period public building like The Railway board building at Shimla and shop cum residential buildings built near the mall roads of various hill towns (Shimla, Nainital, Dalhousie and Mussorie) are some examples of mid rise buildings before independence.

After independence, especially in last two decades, mid rise buildings are built in the hill towns due to high pressure for development and limited available land resources. These buildings are generally located in the main core area of town or in those areas where population density is very high and in newly developed areas on the periphery of town due to high demand of buildings in hill towns. Mid rise buildings are mainly preferred in hill towns primarily for Public buildings, office buildings, hotels, hospitals, institutions residential, work places, recreational, commercial and educational buildings for both the permanent and the floating population and also preferred for new residential apartment construction.

2.3 TYPE OF BUILDINGS ON HILL/ SLOPING SITES

The site conditions prevailing in the hill regions are responsible for the classification of buildings designed and constructed in the hills into:

i) Buildings along contours

ii) Buildings across contour

2.3.1 Buildings along Contour is the one of the easiest and most commonly adopted method for designing or placing the building in hill region. In this method the building stands on the same leveled ground and the orientation of the buildings and settlement pattern is generally follows the profile contours.

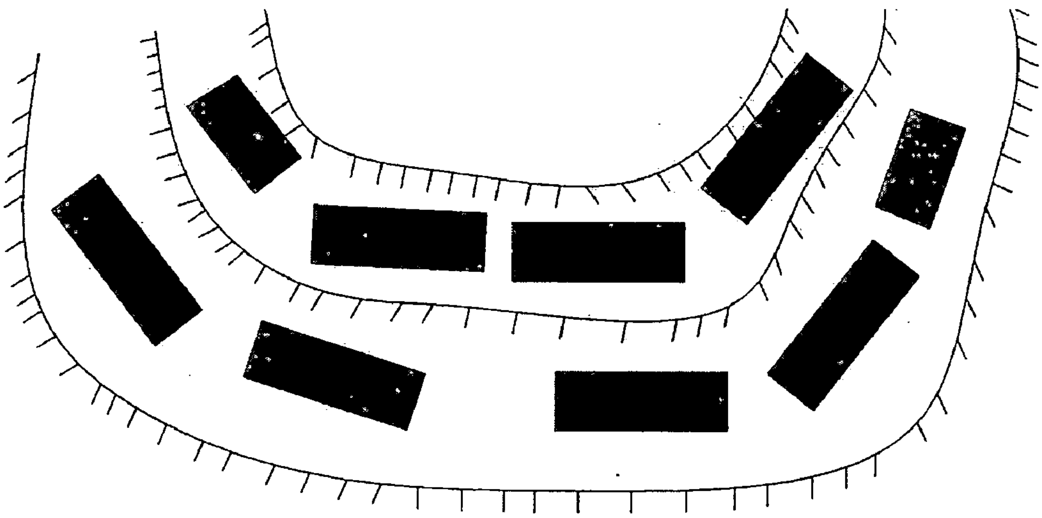


Fig. 2.1: Buildings along the contours

This the buildings falls in this typology are further divided into two categories; as horizontal or continuous configuration buildings and set back buildings

2.3.1.1 Rectangular/regular Configuration Buildings: these are the building configurations which have regular configurations and built on flat grounds the foundations of all the columns rest on the sane grounds and the roof is also at the same level. Buildings of this configuration are most popular in plainer region. Before erecting of the building the ground surface is leveled to have foundation at same level.

2.3.1.2 Set Back Building: in this type of building, the foundation or base is at the same level but series of steps are formed in elevation due to different sized upper floors. In this type of building different leveled terraces are formed.

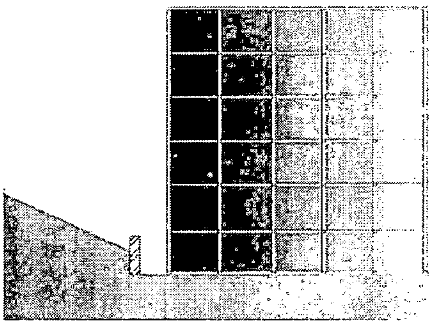


Fig. 2.2: Rectangular buildings
Source: Satish Kumar, 1996

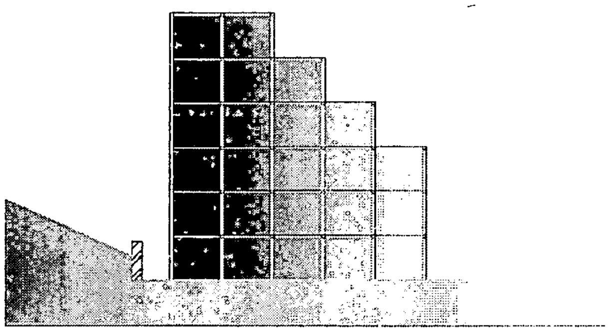


Fig. 2.3: Set back building
Source: Satish Kumar,1996

2.3.2. Buildings across Contours: buildings across the contours are one of the most challenging yet most interesting feature of hill development. In this, building is constructed perpendicular to the contours/ slope results in the multileveled bas of the building.

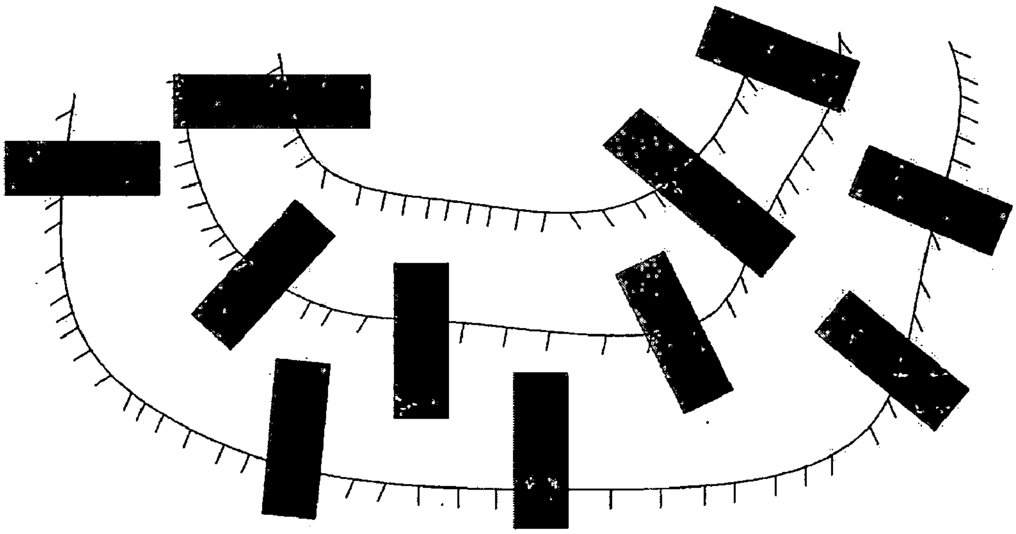


Fig. 2.4: Buildings across the contours

This category can further be classified in step back buildings and step back set back buildings.

2.3.2.1 Step back building: this type of buildings are constructed on sloping grounds and have foundation at different levels, usually on different levelled terraces are made for the foundation of different columns of a frame structure. The upper floors of the buildings have the continuous roofs.

2.3.2.2 Step back and Set back: this is a combination of step back and set back building. The foundation of the building is on different levelled terraces whereas a series of steps is also formed in the elevation of the building due to different sized floors.

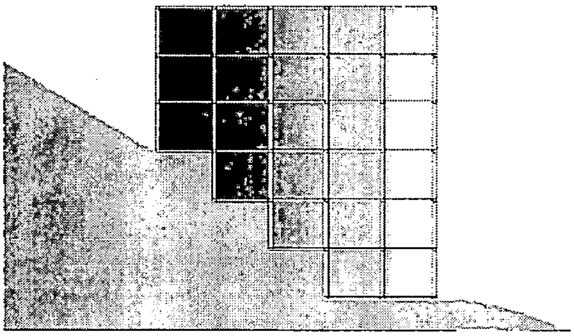


Fig 2.5: Step back building
Source: Satish Kumar, 1996

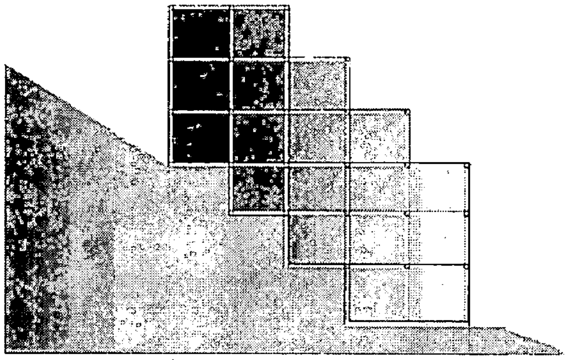


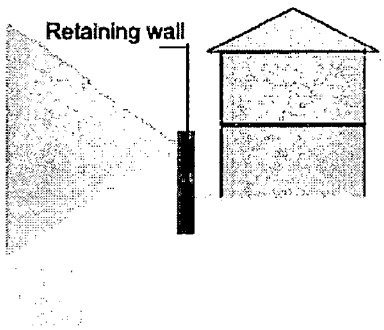
Fig 2.6: Step back and set back building
Source: Satish kumar,1996

2.4 METHODS OF SITE DEVELOPMENTS ON SLOPING SITES

In the hilly regions the flat sites for construction are not available everywhere. The earth surface is sloping which can be made flat in order to commence construction work. The construction activity may be carried out in low or moderated sloped hills but any type of construction in hills having high degree of slope is not advisable. Any constructions work in hills may be carried out in one of the following ways.

2.4.1 Cut Method of Site Development: in order to achieve the required flat surface for the construction work the hills are cut to some height. The vertical cut surface is retained by providing retaining walls. The natural drainage pattern of the site is maintained before commencement of the construction work. The advantage of the cutting hills for development is that the construction is carried out on the hard strata or ground not on fill up areas.

2.4.2 Fill Method of Site Development: in order to achieve a specific level of ground for construct a building. The site may be filled up with soil with the help of retaining wall. And construction will be carried out on this filled ground after sufficient compaction.



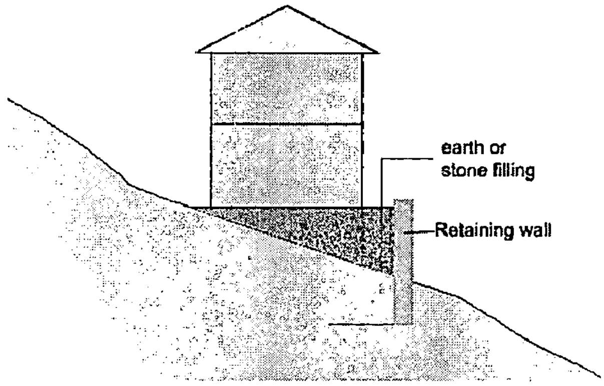
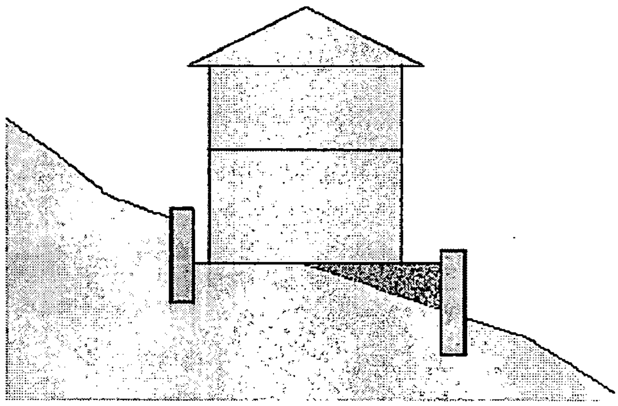


Fig 2.7: Cut method of site development

Fig 2.8: Fill method of site development

2.4.3 Cut and fill Method of Site Development: this process is combination of above explained two methods, in which in order to achieve a flat surface for construction, some part of the site is cut and filled in the other portion of the site. The earth which is produced after the cutting of certain part of the hill site is utilized for filling other part of same site so there is no wastage and no concern towards the dumping of earth after cutting or availability of earth for filling.

2.4.4 Stepped Method of Site Development: in a large building project it is not feasible to achieve a flat site for the designing or construction of building on one level, In that case building may be designed at various levels and after completion the overall profile of building is like a series of steps after construction. In order to minimize the cutting and filling on the site this method is most suitable.



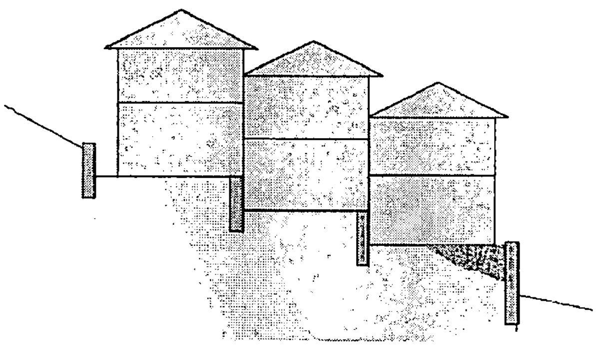


Fig 2.9: Cut and fill method of site development

Fig 2.10: stepped method of site development

2.5 FACTORS AFFECTING MID RISE BUILDINGS

The various factors affecting planning and design of mid rise buildings in hill regions are:

i) Natural factors

ii) Built environment factors

iii) Emerging issues of critical significance

2.5.1 Natural Factors

The various natural factors which affect the planning and design of mid rise buildings in hill regions are as follows:

i) Geo- technical factors

ii) Climatic factors

2.5.1.1 Geo-technical Factors: the various geotechnical factors affecting the development of mid rise buildings in hill regions are:

i) **Topography:** this includes the slope of the hill site, steepness of the site i.e slope gradient, availability of flat lands. Presence of high slope gradient in the site renders the site undesirable for any constructional activity.

ii) **Geology:** this deals with the type of rock presents in the site and the geological structure, presence of any faults, fissures on the site.

iii) **Soil Type:** this deals with soil type of site, its bearing capacity and other properties.

iv) **Proneness to Natural Hazards:** this deals with susceptibility of the site towards the occurrences of earthquakes and landslides.

v) **Hydrology:** this deals with presence or proximity of any surface water source or underground water source in or near the site, presence of natural drain and drainage pattern of site.

vi) **Existing Vegetation Cover:** this deals with the extent of vegetation, quality of vegetation present on site available

2.5.1.2 Climatic Factors: this includes the macro climatic conditions prevailing in the region, like temperature, rainfall, snowfall and micro climatic factors like orientation of site w.r.t sun and wind, shade by surrounding building, proneness to cold winds and extent of solar exposure.

2.5.1.3 Visual context: this includes the extent of visibility of the site from different places/ distances and different views available from the site of the surroundings features.

2.5.2 Man- made factors

The various man made factors affecting the development of mid rise buildings in hill regions are as follows:

i) Built environment factors

ii) Existing architectural character

iii) Socio- economic factors

2.5.2.1 Built Environment Factors: the various man made factors affecting the development of mid rise buildings in hill regions are:

i) **Architectural/ development Controls:** this deals with the type of developmental controls prevailing in an area, the existing landuse patterns and permissible heights of the buildings

ii) **Location in urban context:** it deals with the proximity of site from the core area of town, proximity of community facilities like schools, hospitals and recreational facilities and proximity to work places.

iii) **Surrounding landuses:** this deals with the landuses prevailing in the surrounding of the site and compatibility of the landuse proposed for the new development.

iv) **Accessibility:** it deals with the type of roads and their conditions, accessibility through vehicles, pedestrian access, accessibility/ proximity to public transport system and accessibility of emergency vehicles to the site.

v) **Infrastructural Facilities:** this deals with the availability of basic infrastructural facilities on site like road, water supply, electricity, garbage collection, sewage system and telecommunication.

2.5.2.2 Existing Architectural Character: The buildings designed should be merged properly with the existing character of the place. If the building is of prime importance than it should be in contrast to the existing character and serves as the landmark in the area. The use of locally available and traditional materials and adoption of same design features are attempts to maintain the character of area.

2.5.2.3 Socio-economic factors: the various socio-economic factors affecting the development of mid rise buildings in hill regions are

i) Cost for development: this includes cost of land available, cost of construction and materials, cost for road construction, site development cost

ii) Income background of majority of people is low and middle income group.

iii) Tenants to owner's ratio.

iv) Social infrastructure like parks, gardens, playgrounds

2.5.3 New Emerging Issues of Critical Significance

This includes the various emerging issues which are the guiding principles for new development. Sustainability, energy efficiency, green buildings and ecological/ environmental friendly are some such issues.

2.6 ESSENTIAL ASPECTS OF SUSTAINABILITY OF BUILDINGS

Sustainable development is a pattern of resource use that aims to meet human needs while preserving the environment **so** that these needs can be met not only in the present, but also for future generations to come. The most common definition of sustainable development is development that "meets the needs of the present without compromising the ability of future generations to meet their own needs. The field of sustainable development can be conceptually broken into three constituent parts: environmental sustainability, economic sustainability and sociopolitical sustainability. The sustainability in built environment can be achieved through the proper consideration towards the following aspects.

i) **Sustainable sites:** in order to achieve the sustainability, the development should be compact and the mix use of the building or spaces should be encouraged to minimise the travel distance and transportation cost. Pedestrian movement should be encouraged and facilities are provided for ease of pedestrians. The horizontal spread of the building should be minimum with proper infrastructure facilities for the comfort of people. Topography and drainage pattern should have minimum disturbance. Soil erosion control measures are necessarily taken and natural features on site should be maintained.

ii) **Energy:** energy being one of the critical factors for sustainability as significant resources is consumed for its production. Buildings should be designed for energy efficiency with the use of passive energy efficiency design features. The buildings should have proper orientation to gain required amount of solar radiations and heat. Large openings should provide on southern side to allow maximum solar gain. Daylight should be used for general lighting in building. Photovoltaic panels are used for energy storage. The use of renewable sources of energy should be increased in the buildings.

iii) **Water efficiency:** in order to achieve water efficiency in buildings, less water consuming fixtures are used in buildings. The waste water should be recycled and used for different purposes like gardening. Rain water harvesting techniques should be used in buildings.

iv) **Indoor air quality:** the indoor comfort conditions should be made through passive techniques of heating/ cooling. Desired illumination level should be maintained and day light should be used as general lighting in buildings. Open able windows should be provided for proper ventilation.

v) **Materials:** materials used should have low embodied energy and should be locally available. Energy efficient and cost effective construction techniques should be adopted.

Energy efficiency being one of the most critical issues for sustainability of mid rise buildings in hill towns. As more energy is consumed for heating the indoor environment for maintaining comfort conditions.

2.7 ENERGY EFFICIENT BUILDINGS IN COLD CLIMATE

Energy demand of buildings is dependent upon the climatic conditions and the use of buildings. Demand for energy consumption in buildings in hill regions, is significantly high on account of energy required for maintaining comfortable indoor temperatures in cold climates. Mid rise buildings are being built in some of the hill towns of north India due to increased pressure for development at shortage of buildable land at preferred locations. These include offices, hotels as well as residential buildings. These buildings require higher energy consumption for maintaining comfortable indoor environment on account of higher occupancy. There is a need to design the buildings as energy efficient in order to reduces the pressure on the energy production sources ensures lesser use of scarce resources and less deterioration of environment and helps in minimizing the climate change.

Energy efficiency in buildings can be achieved through a multipronged approach involving adoption of bioclimatic architectural principles responsive to the climate of the particular location; use of materials with low embodied energy; reduction of transportation energy; incorporation of efficient structural design; implementation of energy-efficient building systems; and effective utilization of renewable energy sources to power the building.

An energy-efficient building balances all aspects of energy use in a building – lighting, space-conditioning, and ventilation – by providing an optimized mix of passive solar design strategies, energy efficient equipment, and renewable sources of energy. Use of materials with low embodied energy also forms a major component in energy efficient building designs. Himurja building Shimla, Himachal Pradesh state Cooperative Bank Shimla, MLA hostel Shimla and LEDeG Trainees' Hostel, Leh are few examples of energy efficient buildings designed and constructed in cold climatic zone in India

2.7.1 Himurja Office Building: An Energy Efficient Building in Shimla

This is office building of Himachal Pradesh Energy Development Agency located in sda complex Shimla, Himachal Pradesh. Himurja building is designed by Ar. Arvind Krishan and Kunal Jain in cold and cloudy climatic region. Total built up area of building is 635 m^2. The initial cost of the building was estimated at Rs 7 million (without incorporation of passive or active solar measures). Additional amount of Rs 1.3 million was incurred due to incorporation of passive and active solar measures. Thus there was an increase of 18.6% over initial cost by adoption of these measures

Design Features: the main design features incorporated in the building are:

i) Air heating panels designed as an integral part of the south wall provide effective heat gain. Distribution of heat gain in the building through a connective loop that utilizes the stairwell as a means of distributing heated air.

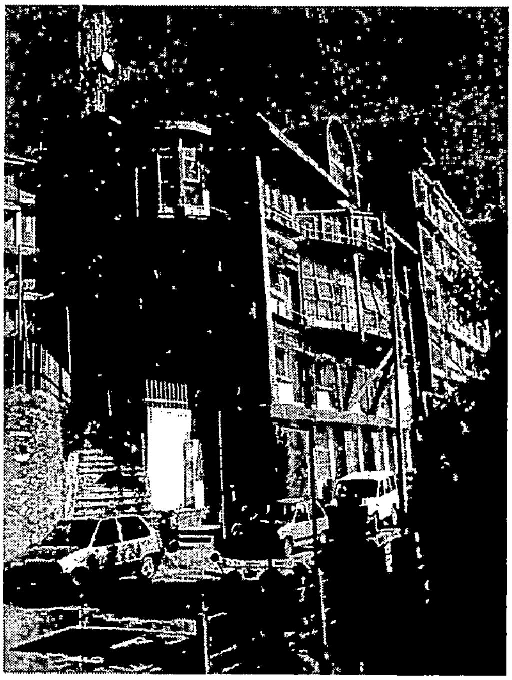
ii) Double-glazed windows with proper sealing to minimize infiltration.

iii) Insulated RCC diaphragm walls on the north to prevent heat loss.

iv) Solar chimney and Solar water heating system and solar photovoltaic system are provided

v) Specially designed solarium on south for heat gain

vi) Careful integration of windows and light shelves ensures effective daylight distribution.



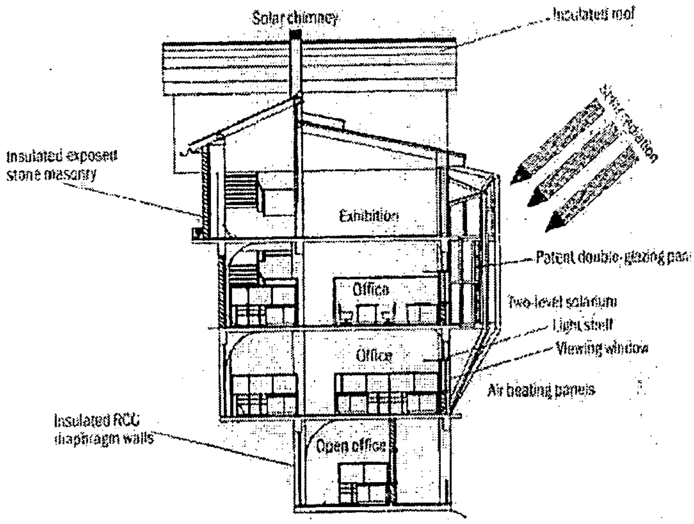


Fig 2.11: Energy efficient HIMURJA Building, Shimla
Source: Representative designs of energy-efficient buildings in India, TERI, 2001

2.7.2 Himachal Pradesh State Co-operative Bank: Energy Efficient Building in Shimla

Office building of Himachal Pradesh state Cooperative Bank located on mall road Shimla. This building is designed by Architect Ashok B Lall in the Cold and cloudy climate of Shimla. Built-up area of building is 1650 m^2 (about 35% is heated by solar air heating system) and area of solar air heating panels 38 m^2.

The external walls are 23-cm thick masonry construction with 5 cm thick glass wool insulation. The windows are double glazed and the total area is about 155 m^2. The roofing is made of corrugated galvanized iron sheeting. Total building cost Rs 22 million (including solar passive and active features). The initial cost of the bank building without incorporation of passive solar measures was Rs 12 666/m^2, which was increased by Rs 680/m^2 to Rs 13 346/m^2 thus resulting in 5.6% increase in cost due to incorporation of passive solar measures

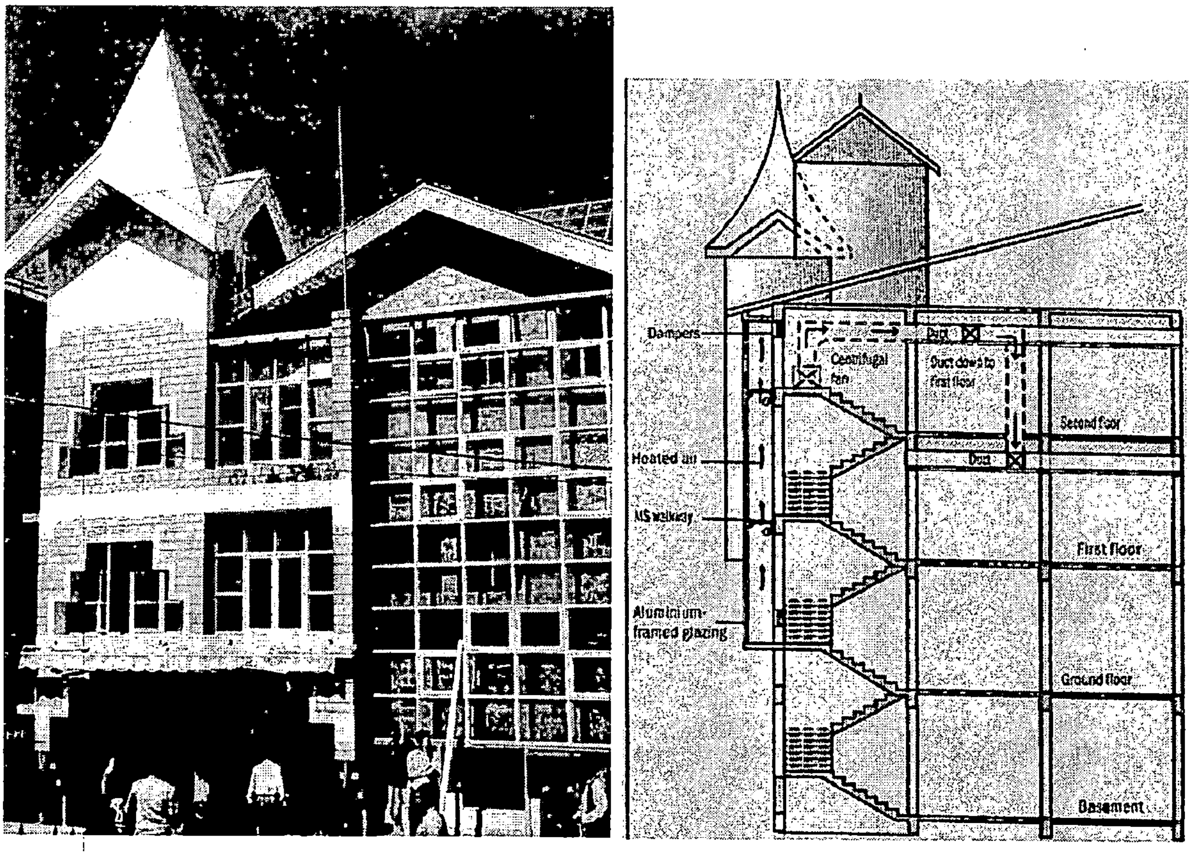


Fig 2.12: Himachal Pradesh state cooperative bank, Shimla
Source : Representative designs of energy-efficient buildings in India, TERI,2001

Design Features

The main energy efficient design features adopted in the building are as follows.

i) Sunspaces are provided on the southern side of the building.

ii) Solar wall on the southern side to entrap maximum sun from the southern direction throughout the day

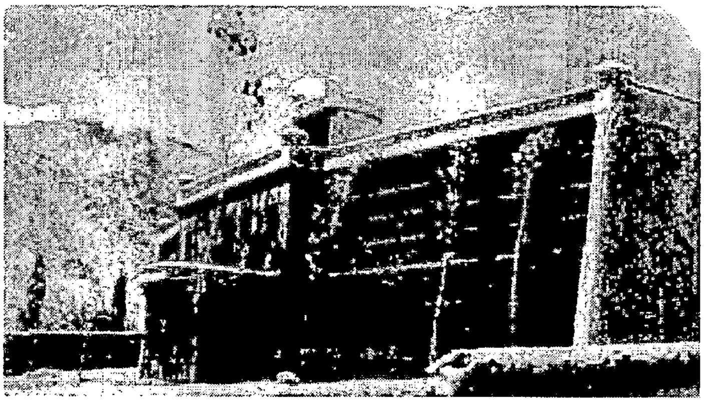
iii) Specially designed solar air heating system – solar heat collector on roof-top with duct system for supply to various rooms

iv) Double-glazed windows are provided in the building to have better insulation.

v) Air-lock lobby at the main entrance to minimise the leakage of indoor air.

2.7.3 LEDeG Trainees' Hostel: Energy Efficient Building in Leh

Hostel building for trainees in appropriate technology is designed by Ar. Sanjay Prakash in the Cold and sunny climate of leh.



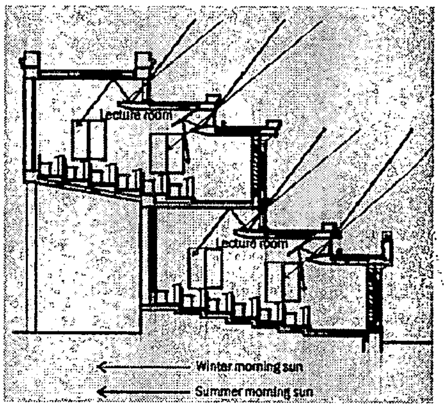


Fig 2.13: stepped method of site development
Source : Representative designs of energy-efficient buildings in India, TERI, 2001

Design Features

i) The main energy efficient design features incorporated in the building are as follows

ii) Traditional materials and methods of construction have been modified and adapted to achieve energy efficiency

iii) Predominantly south exposure with no overhangs for maximum winter gains.

iv) Entrance lobby designed as a solarium on the south side.

v) Bedrooms are provided with various types of Trombe walls (half Trombe, unvented Trombe, vented Trombe) or direct gain systems for passive heating.

2.7.4 Inferences

The most significant planning and design aspects for making energy efficient buildings are as follows

i) Proper site selection and planning

ii) Orientation to allow maximum solar exposure and minimum wind exposure.

iii) Building design and envelope

iv) Passive design elements for energy efficiency

Based on the study of above factors for energy efficient mid rise buildings in hill regions guidelines are suggested.

2.7.5 Guidelines for Designing of Energy Efficient Mid rise Buildings in Cold Climatic Regions

Various guidelines for the planning and design of energy efficient mid rise buildings in hill regions focusing on site selection and planning, Spatial Arrangements and architectural design are as follows:

Guidelines related to Site selection and Planning

i) The site chosen for settlement should have maximum southern slopes and lesser northern slopes.

ii) The settlement should be well compacted and should not have long horizontal spread.

iii) Row development should be preferred over detached construction as it results in lesser surface area exposed to environment

iv) The preferred locations of tall buildings are mid land areas having southern slope and on the lee ward side of the hill.

v) The orientation for internal roads in a site/ complex should be east west to reduce cold wind.

vi) Road widths should be in relation to building heights

Guidelines related to Spatial Arrangements

i) North South orientations for buildings should be preferred

ii) Compact building forms having surface-to-volume ratio minimum should be used.

iii) Solar access to all buildings should be ensured.

iv) No entrance or circulation of cold wind in interiors

v) Landscape elements should be used to minimise the impact of climate. buffers and wind screens should be provide.

vi) Hard landscape materials to absorb heat should be used.

Guidelines related to Architectural Design

i) Maximum windows/ glazing shall be provided on southern walls and minimum on north walls of the buildings.

ii) Depth of buildings should be decided with due consideration to natural daylight.

iii) Use of day lighting for generalised lighting in buildings

iv) skylights, light shelves shall be to ensures effective daylight distribution

v) Use of low embodied and transportation energy construction materials and energy efficient construction techniques.

vi) Building materials should be medium to dark coloured to absorb the sun's warmth,

vii) The volume of building for heating shall be minimised by providing false ceiling.

viii) Sloping roofs shall be provided for increasing heat gain and easy runoff rainwater and snow.

ix) Solar passive techniques for heating in building design should be used.

x) All external surfaces should be well insulated and double-glazed windows, Sun-porch, trombe wall for heat entrapment from solar radiation.

xi) Energy-efficient lighting, heating systems and electric equipments should be used.

Safety considerations against landslides and earthquakes in hill regions are one of the critical issues due to high vulnerability of hill regions to these disasters and high loses of human life and property/ buildings during these disasters. There is a critical need to understand safety considerations for mid rise buildings in hill regions in details. Therefore, various safety considerations against landslides and earthquakes in hill regions are discussed in detail in next chapter

CHAPTER III

SAFETY CONSIDERATIONS FOR MID RISE BUILDINGS IN HILLS

3.1 INTRODUCTION

Hill regions of India are highly prone to natural disasters like landslides earthquake and cloud burst. Most of the hill areas are falls in seismic zone IV and V which are most venerable. The human loss and damage to the buildings and other structures is very high. Therefore in order to understand the various safety considerations against these natural hazards, it is important to understand various natural disasters, their causes, effects and remedial measures. In light of this, this chapter includes landslides, types and the causes of landslides, and effects of landslides, landslide hazard zonation, and remedial measures for landslides. This chapter also discusses the venerability of earthquakes in hill regions and various planning and design measures taken for making the buildings earthquake resistant. The impact of rain on hill stability and effect of cloud burst are also considered.

3.2 LANDSLIDES: A MAJOR CONCERN FOR MID RISE BUILDINGS IN HILLS

A landslide is a geological phenomenon which includes all varieties of mass movements of hill slopes and can be defined as the downward and outward movement of slope forming materials composed of rocks, soils, artificial fills or combination of all these materials along surfaces of separation by falling, sliding and flowing, either slowly or quickly from one place to another. The common type of landslides includes; Falls, Flows, Creep, Debris flow, Debris avalanche, Mudflow, Lateral spreads and Slides

3.2.1 Causes of Landslides

Many factors contribute to slides, including geology, gravity, weather, groundwater, wave action, and human actions. Although landslides usually occur on steep slopes, they also can occur in areas of low relief. Landslides can occur as ground failure of river bluffs, cut and-fill failures that may accompany highway and building excavations, collapse of mine-waste piles, and slope failures associated with quarries and open-pit mines. Underwater landslides usually involve areas of low relief and small slope gradients in lakes and reservoirs or in offshore marine settings. Typically, a landslide occurs when several of these factors converge.

3.2.1.1 Natural Factors

The various Natural factors which are responsible for landslides can be divided into two different categories as inherent factors and external factors. Inherent factors represent the inherent characteristics of the hill slopes of the region. These include lithology, Geological structure, slope morphometry, landuse and land cover, relative relief and hydrological conditions are responsible for the occurrences of landslides in an area. The external factors are external factors and acts as triggering agents; which are responsible for the initiation of landslides. These factor includes earthquakes rainfall and cloud burst.

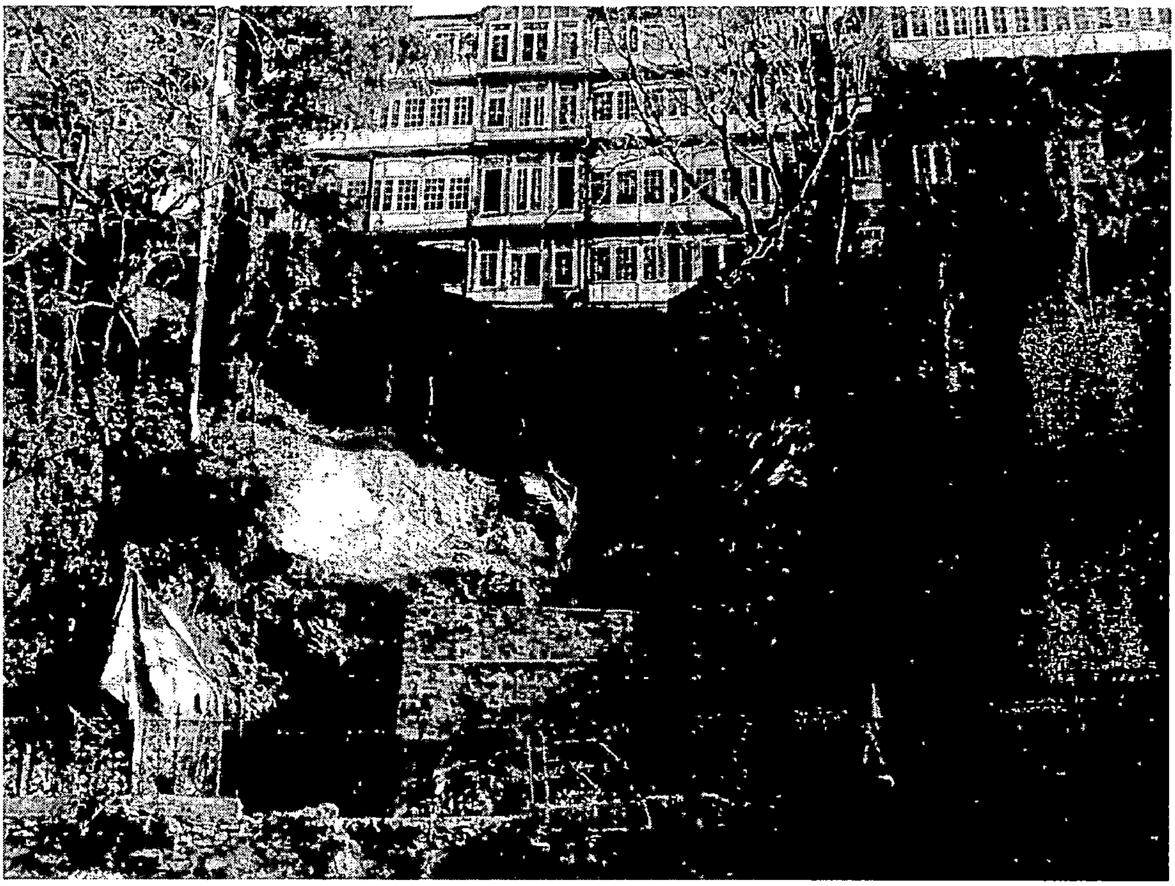


Fig 3.1: Landslide near the core area of Shimla Town

3.2.1.2 Anthropogenic Factors

Human actions most notably those that affect drainage or groundwater, can trigger landslides eg are Inappropriate drainage system, change in slope/land use pattern, deforestation, agricultural practices on steep slopes, cutting & deep excavations on slopes for buildings, roads, canals & mining ,inappropriate disposal of debris after excavations are examples.

i) **Inappropriate drainage system:** Natural drainage lines on slopes are blocked by terracing/ contour bounding adopted to prevent soil erosion and to enhance percolation during dry season for cultivation, without adequate provision for surface drainage of excess storm water during high intensity rains increase the landslide vulnerability.

ii) **Cutting & deep excavations on slopes for buildings, roads, canals & mining:** Developmental activities like construction of buildings, road cutting, embankments, cut and fill structures causes modification of natural slopes, blocking of surface drainage, loading of critical slopes and withdrawal to toe support promoting vulnerability of critical slopes.

iii) **Change in slope/land use pattern, deforestation, agricultural practices on steep slopes:** Deforestation and cultivation of seasonal crops and increase in settlements. Improper land use practices such as heavy tilling, agricultural practices and settlement patterns have contributed to creep and withdrawal of toe support in many cases

iv) **Loading of slope or its crest:** due to excess loading on the sloping site or excess loading on the edge of the slope lead to occurrence of landslides

3.2.2 Effects of Landslides

Landslides cause property damage, injury and death and adversely affect a variety of resources. For example, water supplies, fisheries, sewage disposal systems, forests, dams and roadways can be affected for years after a slide event. The negative economic effects of landslides include the cost to repair structures, loss of property value, disruption of transportation routes, medical costs in the event of injury, and indirect costs such as lost timber and lost fish stocks. Water availability, quantity and quality can be affected by landslides. Geotechnical studies and engineering projects to assess and stabilize potentially dangerous sites can be costly.

3.2.3 Landslide Investigations

Landslide investigations are carried out mainly based on three different approaches namely analytical methods, observational methods and empirical methods. Depending upon the importance of investigation, details used for analysis, scale, nature of output data required as well as budget, appropriate method of investigation is adopted.

Analytical method: this method is used to carry out detailed study of unstable slopes on the scales of 1:1000 and 1:2000. This approach is also called microzonation approach. It requires data related to properties of rock/soil particularly shear strength properties.

Observational method: this method is based on monitoring of the slopes through instruments or repeated ground observations.

Empirical method: it is rapid hazard assessment technique, which involves identification of causative factors of landslides and their influence in inducing instabilities. In this technique large areas are covered in relatively short durations and therefore they are comparatively economical. Various techniques like landslide hazard zonation (LHZ), rock mass rating (RMR), Slope mass rating (SMR), and Q system are falls in this method.

3.2.4 Landslide Hazard Zonation

In order to access the susceptibility of any area towards the landslides, the landslide hazard zonation maps are prepared for that area at macro scale and then for further identification of more sensitive areas zonation can be done on meso scale. In case of macro scale landslide hazard zonation (LHZ) map are prepared on scale of the order of 1:25 000 or1:50000, whereas, on meso scale landslide hazard zonation maps are prepared on the scale of 1: 10 000 and 1:5000. The smallest unit of study shall be slope facet. A slope facet is a part of hill slope which has more or less similar characters of slope, showing consistent slope direction and inclination. The slope facets are generally delimited by ridges, spurs, gullies and rivers. The primary factors that govern the selection parameters for macro-zonation LHZ mapping shall include the major causative factors of the slope instability, namely, lithology, structure, slope morphometry, relative relief, land use and land cover, and hydrogeological conditions. Stability of an area depends on the combined effect of these factors. These factors are varies for urban area due to the paving of surface/extent of development, changed landuse and terracing

Table 1: Factors for landslide hazard zonation in an area

S no	Factors for land slide hazard zonation in open areas	Factor for landslide hazard zonation in urban areas
1	Lithology	Lithology
2	Structure	Structure
3	Slope Morphometry	Slope Morphometry
4	Relative Relief	Relative Relief
5	Land Use and Land Cover - Vegetation density	Urban Land Use - Extent of development -Extent of terracing and paving
6	Hydrogeological Conditions	Hydrogeological Conditions

Source: I.S code. 14496 Part 2 Preparation of Landslide Hazard Zonation Maps in Mountainous Terrains –Guidelines

Lithology: It is scientific study and description of rocks, especially at the macroscopic level, in terms of their colour, texture, and composition. The erodibility or the response of rocks to the processes of weathering and erosion shall be the main criteria in awarding the ratings for the sub-categories of the lithology. The rock types such as unweathered quartzite, limestone and granite are generally hard and massive and more resistant to weathering. These form steep slopes.

Structure: Structure includes primary and secondary discontinuities in the rocks such as bedding planes, joints, foliations, faults and thrusts. The discontinuities in relation to the slope inclination direction have greater influence on the stability of slopes.

Slope Morphometry: Slope morphometry map defines slope categories on the basis of frequency of occurrence of particular angles of slope. The slope morphometry map shall be prepared by dividing the larger topographical map into smaller units within which the contour lines have the same standard spacing, that is, the same number of contour lines per kilometre of horizontal distance. Five categories representing the slopes of escarpment/cliff, steep slope, moderately steep slope, gentle slope and very gentle slope shall be used.

Relative Relief: The relative relief map represents the local relief of maximum height between the ridge top to the valley floor measured in the slope- direction within an individual facet. Three categories of slopes of relative relief shall be used for hazard evaluation purposes namely low, medium and high.

Land Use and Land Cover: The nature of land cover is an indirect indication of the stability of hill slopes. Forest cover in general smoothers the action of climatic agents on the slope and protects them from the effects of weathering and erosion. A well spread root system increases the shearing resistance of the slope material. The barren and sparsely vegetated areas show faster erosion and greater instability. Agriculture in general is practiced in low to very low slopes though moderately steep slopes are also used at some places. In case of urban land use the extent of development and extent of terracing and paving is considered.

Extent of Development on Hill Slopes: The extent of development, type of development in hill regions is to be ascertaining for landslide hazard zonation. Unplanned urban development may lead to excessive constructions in certain selected zones thereby causing instability of slopes, while leaving other potential areas suitable for constructions nearby. The existing buildings if not provided with adequate and proper drainage facilities, may cause excessive saturation of the sub-surface formations creating adverse conditions. Moreover the construction of buildings should not obstruct the existing surface drainage courses.

Extent of Terracing and Paving: Cuttings and excavations on stable hill slopes are made to locate buildings, such cuttings often require protection works. It is essential to ensure stability of such cuttings to have adequate safety of the buildings. The higher extent of cutting or height of cut slope leads to instability. And the extent of paving helps in determining the percolation of rain water in soil and water need to be drained.

Hydrogeological Conditions: Since the groundwater in hilly terrain is generally channelized along structural discontinuities of rocks, it does not have uniform flow pattern. The observational evaluation of the groundwater on hill slopes is not possible over large areas. Therefore for purposes of quick appraisal the nature of surface indications of water such as damp, wet, dripping and flowing shall be used for rating purposes.

3.2.5 Remedial Measures for Landslides

The various remedial measures considered in the design, site planning and development of buildings in hill regions for landslides are as follows.

i) **Drainage Corrections:** The most important triggering mechanism for mass movements is the water infiltrating into the overburden during heavy rains and consequent increase in pore pressure within the overburden. Hence the natural way of preventing this situation is by reducing infiltration and allowing excess water to move down without hindrance. As such, the first and foremost mitigation measure is drainage correction. This involves maintenance of natural drainage channels both micro and macro in vulnerable slopes. It includes

a) The collection of run-off at the uphill boundary of any unstable area,

b) Maximizing run-off from the unstable area and controlling and collecting the runoff.

c) Road side drains are provided on the road side at the foot of the hill slope to drain out water from the road surface and the water from the portion of the hill slope below the catch water drains.

Ground water in other major causes of the slope instability, therefore sub surface drainage is essentially required to avoid the slope failure. Horizontal drains, vertical drainage wells and drainage tunnels are to be installed at proper location to avoid the surface erosion due to the ground water

ii) **Proper Landuse Measures:** Adopt effective land-use regulations and building codes based on scientific research. Through land-use planning, discourage new construction or development in identified hazard areas without first implementing appropriate remedial measures.

iii) **Structural Measures:** Adopt remedial techniques (buttresses, shear keys, sub-drains, soil reinforcement, retaining walls) of existing landslides that are in close proximity to structures

iv) **Afforestation:** The afforestation programme should be properly planned so the little slope modification is done in the process. Bounding of any sort using boulders etc. has to be avoided. The selection of suitable plant species should be such that can with stand the existing stress conditions of the terrain.

v) **Anchor System:** anchor system is the back wall which carries the back fill forces on the wall by a tie system to transfer the imposed load to an area behind the slide mass where satisfactory resistance can be established. The ties may consists of pre or post tensioned cables, rods ar wires or other method to develop adequate passive earth pressure.

vi) **Stabilization of Soils:** if the sub surface drainage methods are inadequate to drain the water of the slope, then the methods such as chemical treatments, electro osmosis and thermal treatments are to be used. Chemical treatments are the lime, lime soil mixture and cement grout. The electro osmosis has the same effect as the sub surface drainage, the difference is that water is drained by electric field than by gravity. The use of thermal treatments for preventing landslides causes a permanent drying of the embankments and cut slopes.

The areas/ sites which falls in low or moderate landslide hazards areas in landslide hazard zonation maps in macro and meso level are to be considered for mid rise buildings with proper remedial measures.

3.3 Impact of Rain on Hill Stability

Hill areas are usually receives high rain, during rain some water percolate through the ground whereas remain water ran off to low lying areas. The effect of rainfall infiltration on slope could result in changing soil suction and positive pore pressure, or main water table, as well as raising soil unit weight, reducing anti-shear strength of rock and soil. Landslides are occurred due to the rain infiltration in hilly regions.. The main destabilizing factors of groundwater on slope stability are as follows:

i) Reducing or eliminating cohesive strength.

ii) Producing pore water pressures which reduce effective stresses, thereby lowering shear strength.

iii) Causing horizontally inclined seepage forces which increase the driving forces and reduce the factor of safety of the slope.

iv) Providing for the lubrication of slip surfaces. Trapping of groundwater in soil pores during earthquakes or other severe shocks, which leads to liquefaction failures

There are many different construction methods that can be used to mitigate the effects of groundwater on slopes. During construction of slopes, built-in drainage systems can be installed. For existing slopes, drainage devices such as trenches or galleries, relief wells, or horizontal drains can be installed. Another slope stabilization method is the construction of a drainage buttress at the toe of a slope. A drainage buttress can consist of cobbles or crushed rock placed at the toe of a slope. The objective of the drainage buttress is to be as heavy as possible to stabilize the toe of the slope and also have a high permeability so that seepage is not trapped in the underlying soil.

The runoff extra water during the rain flows towards the low lying areas towards valleys and met with the channels, steams lakes or rivers adopting a particular natural pattern. Due to rain, saturation of the soil takes places which results decrease in the stability of a slope and accelerate erosion. Due to insensitive constructional activity the natural pattern of surface drainage is disturbed or changed which results in stagnation of water due to creation of large terraces for construction. Due to stagnation of water at a particular place, more infiltration of water in soil take place. Which increase the positive pore pressure and more it results in landslides or surface slippage in that area and loss in property wealth and human life.

3.4 CLOUDBURST

Cloud burst is natural calamity-a-crucial problem, not only because it depletes the natural resources of pivotal importance to the people of the region but also affects adversely in numerous ways. Like deforestation by biotic means, cloud burst is also a major factor contributing to a variety of other environmental problems, which include landslides, floods, soil erosion, loss of human and animal lives, loss of property, siltation and sedimentation, habitat destruction and sometimes species extinction.

Cloudburst is more devastating and foremost natural phenomenon in hill region. It occurs in the highly elevated regions, mostly in the water parting areas. These areas are densely covered by forests, mostly coniferous, but are more instable. Due to dense forest cover and high elevation, rainfall is more intense and occurs in violent form. Along with heavy rainfall, instability of the land and violent nature of stream flowing through the gorges, the process of landslide gets violent, often resulting to hazards and disasters. Areas prone to cloudburst should not be selected for mid rise buildings.

3.5 EARTHQUAKE: A MAJOR SAFETY CONCERN FOR MID-RISE BUILDINGS IN HILL REGIONS

An earthquake is a sudden shift or movement in the tectonic plate in the Earth's crust. It is a phenomenon of release of energy stored in the interface rocks. On the ground surface, this is manifested by shaking of the ground, and can be massively damaging to poorly built structures. The subterranean point of origin of an earthquake is called its focus. The point on the surface directly above the focus is the epicenter. Earthquake damage depends upon many parameters like, intensity of earthquake, duration, frequency, content of ground motion, geological and soil conditions, planning and design of buildings, quality of construction and materials.

Hill regions in India come under most seismic venerable zones, zone V and IV, which are susceptible to high magnitude earthquakes. Earthquakes are not only results in the loss of human life and wealth but, it also leads to some other disasters like landslides in hilly regions. The frequency of occurrence of landslides is increased in an area which had experienced earthquake shocks earlier.

As discussed in Satish kumar (1996) many mid rise reinforced concrete framed buildings are constructed on hill slopes. Buildings constructed on hill slopes poses special structural and constructional problems. The various floors of the building on hill slope may be supported on two types of columns as; columns resting on the floor below and columns resting on the sloping ground.

3.5.1 Various Problems Associated with Hill Buildings

As discussed in Satish Kumar (1996) buildings on hill slope have additional problems as compared to buildings in plain areas. These problems are listed below.

i) Buildings in hill areas are irregular and asymmetric and therefore are subjected to severe torsion in addition to lateral forces under the action of earthquake

ii) Many buildings on hill slope are supported by columns of different lengths. The shorter columns attract more forces as the stiffness of the short columns is more and undergo damage when subjected to earthquake.

iii) Buildings in hill areas are subjected to lateral earth pressure at various levels in addition to other normal loads as specified on buildings in plain areas.

iv) Building loads transmitted at the foundation level to the slope creates problem of slope instability and may result into total collapse.

v) The soil profile is non uniform on the hill slope and result into different properties of soil at different level. It may result into unequal settlement of foundations and local failure of slopes.

vi) Climatic considerations and heavy rains are big problems for buildings in hill areas requiring special attention for drainage, temperature control and lighting arrangements in the buildings.

The proper measures for safety against earthquake should be considered for buildings in these high seismic sensitive areas. Measures should be taken at the following stages:

i) Site selection stage
ii) Planning and design stage
iii) Strengthening measures

3.5.2 Site Selection Stage: The first requirement to achieve building safety is a proper selection of the site. The building loads are transferred to the hill slope terrain at the foundation level, which may cause hill slope failure. Therefore, buildings must be placed on soils able to bear the stresses caused by their weight and all other actions, while avoiding excessive or differential settlements. The stability of hill slope with building loads must be checked. The site selected must have permissible slope gradient. Additionally, there are other potentially destructive earthquake effects on buildings which are associated to improper site selection, some of them are directly related to failure or severe disturbance of the ground at or near the building site, whereas other may be considered as indirect effects. The micro hazard zonation of the site as per IS code 14243 part 1 shall be done and site selected for mid rise buildings should have less or moderate hazard potential.

While constructing mid rise buildings on hill slopes following measures will be beneficial for reducing/ avoiding slope failures and subsequently the damage to the buildings is reduced.

i) The plinth beam system should be as heavy as possible. The heavy plinth beam system will help in reducing the cracks and failure of the structure in case some local failure of slope takes place at some point under the building foundation

ii) The foundation system of the structure should be taken deeper into the slope thereby the local failure of slope is avoided as the deeper foundation system gives a lateral support to the soil and avoids any landslides or slope failures.

iii) The drainage system should be very good; in addition a pucca apron must be constructed around the whole building area to avoid any water seepage into the soil system under the building area.

iv) The foundation across the slope for columns in one row should be continuous strip type instead of isolated type. The combined/ continuous type of footing will distribute the load uniformly and the pressure intensity on the slope will be less and avoid slope failure.

v) The building is to be constructed adjacent to hill slope, then the building should be so designed that heavier part of the building should be located on the uphill side to provide better stability.

vi) When the footing are adjacent to the sloping ground or where the bottom of the footing of a structure are at levels different from those of the footing of adjacent buildings, the provision as per I.S 1904 (1986) should be followed.

3.5.3 Planning and Design of building: at this stage while designing a mid rise building the following principles for earthquake resistant design should be followed.

i) Symmetry and Simplicity

vii) Structural design

viii) Location of service core

ix) Slenderness ratio

x) Buildings on sloping sites

3.5.3.1 Symmetry: the symmetrical structural are considered to be more stable and having better earthquake resistance. As unsymmetrical structures causes eccentricity which results in high shearing stresses due to torsion. To avoid the concentration of stresses, it is an advantage to have the structure as simple as possible. Symmetry is desired about both axis of the building, in plan as well as in elevation. Internal details like stairs, lifts, lobbies etc should be located so as to maintain near symmetry if not full symmetry. Symmetry and simplicity in complex plans can be achieved by splitting the building into smaller blocks, through the use of separation seismic joints.

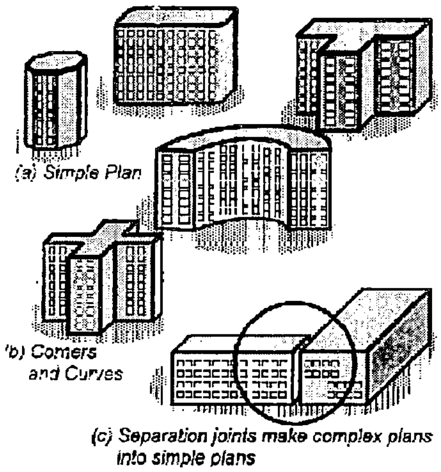


Fig 3.2: Forms of buildings for earthquake resistant design
Source: IITK earthquake tips

3.5.3.2 Structural Design: the structure of the buildings should be simple as far as possible. For mid rise buildings frame structure shall be used and columns shall be in a regular grid for. Columns should be continuous on all the floors. Omission of any structural column from the grid leads to development of extra stresses on others. The structure should have stiffness in both directions.

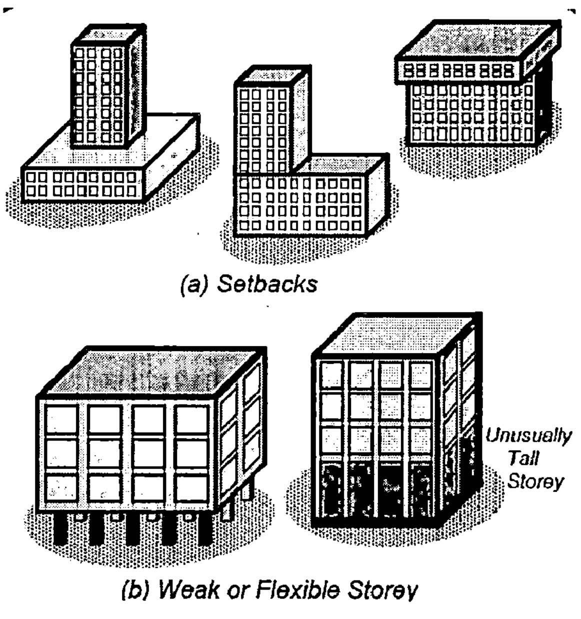


Fig 3.3: Buildings having poor earthquake response
Source: IITK earthquake tips

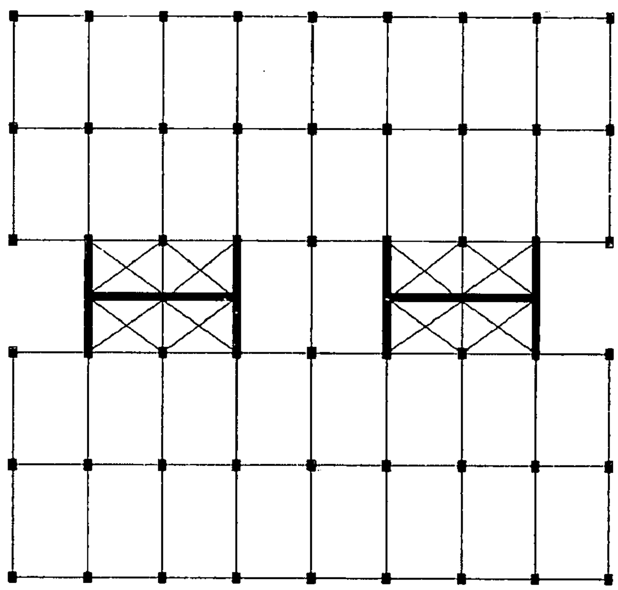


Fig 3.4: Buildings having simple and symmetrical structur
Source: Q.I.P Short term course on earthquake engineerin
for architects and planners, IITR, 1992

3.5.3.3 Location of service core: the concentration of shear walls in the form of rigid cores with very flexible columns has led to severe damage or collapse, due to inadequate means of horizontal means of shear transfer from floor to cores. It is god planning for the shear walls to be well distributed over the plan across both principal axes, results in symmetric distribution of stiffness. If single core is used it should be placed in centre and if multi cores are used than the distribution of cores should be in such a way that that centre of mass of the building of each floor coincides with the centre of stiffness.

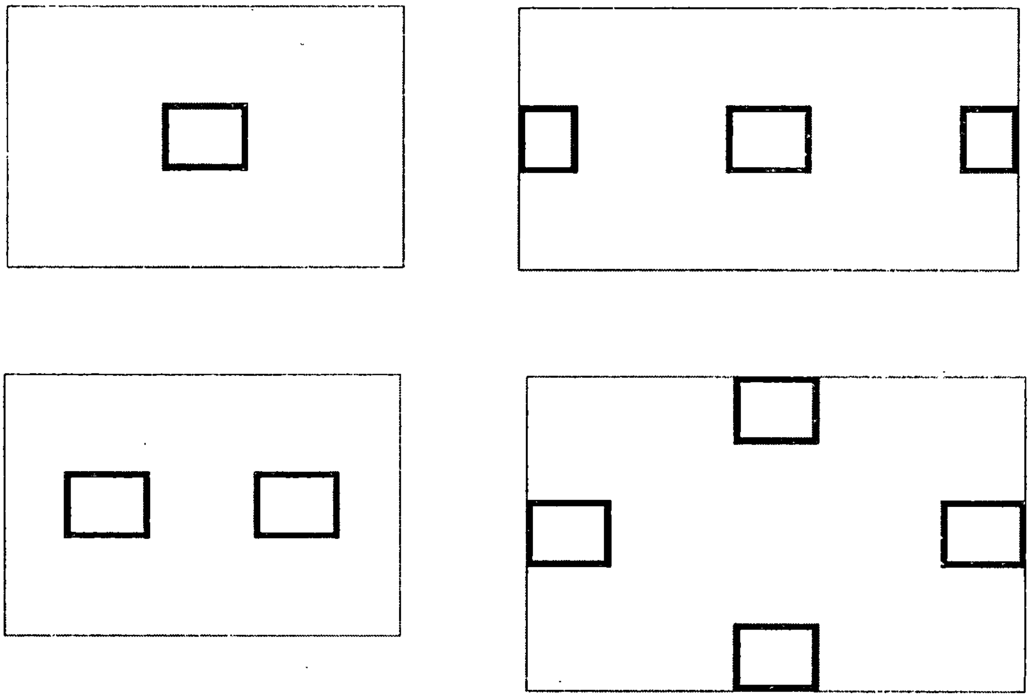


Fig 3.5: Location of service cores for symmetric distribution of stiffness
Source: Q.I.P Short term course on earthquake engineering for architects and planners, IITR, 1992

3.5.3.4 Slenderness Ratio: the slenderness ratio of the building should be small. The height and base of the buildings should be in proportions. Buildings having height to base ration very low or high results affects its performance during the earthquake. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path, any deviation or discontinuity in this load transfer path results in poor performance of the building. Buildings with vertical setbacks cause a sudden jump in earthquake forces at the level of discontinuity. Buildings that have fewer columns or walls in a particular storey or with unusually tall storey tend to damage or collapse which is initiated in that storey.

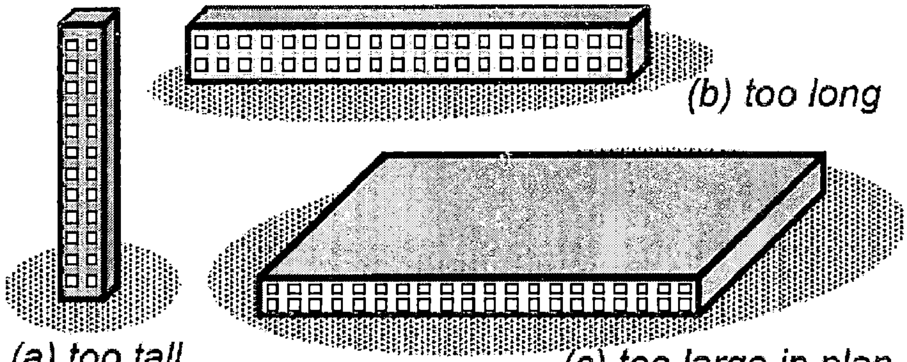


Fig 3.6: Buildings with different slenderness ratio
Source: IITK earthquake tips

3.5.3.5 Buildings on sloping sites

There are two ways of construction of buildings on sloping sites. Buildings constructed on flat ground created by cutting the slope and levelling the ground and secondly, on sloping ground with little cutting and filling of the hill slope in stepped manner. The earth on uphill side may be in contact with the building at various levels which will supported by rcc panels retaining walls or separating the earth from the building by providing stone masonry retaining walls at different levels. These buildings need to be analysed completely for the super structure and the sub structure. The super structure means the framed structure and the sub structure means the foundation which has to be checked for bearing capacity and stability of slope with building loads. Buildings on slopy ground have unequal height columns along the slope, which causes twisting and damage in shorter columns in case of earthquake. Buildings with columns, that hang or float on beams at an intermediate storey and do not go all the way to the foundation, have discontinuities in the load transfer path.

Various types of buildings on sloping sites are discussed in detail in 2.3. As discussed in Satish (1996), the combination of step back and set back buildings are less affected by torsion as compared to step back. The damage and ductility requirement of r.c members of stepback and setback type buildings are less as compared to stepback type buildings. Incidentally the outer profile of the step back and setback type buildings follows the natural slope of the ground which is architecturally more acceptable in hill areas. The short columns are worst affected. The problem of short columns can be avoided either by eliminating the use of short columns or by properly designing these members.

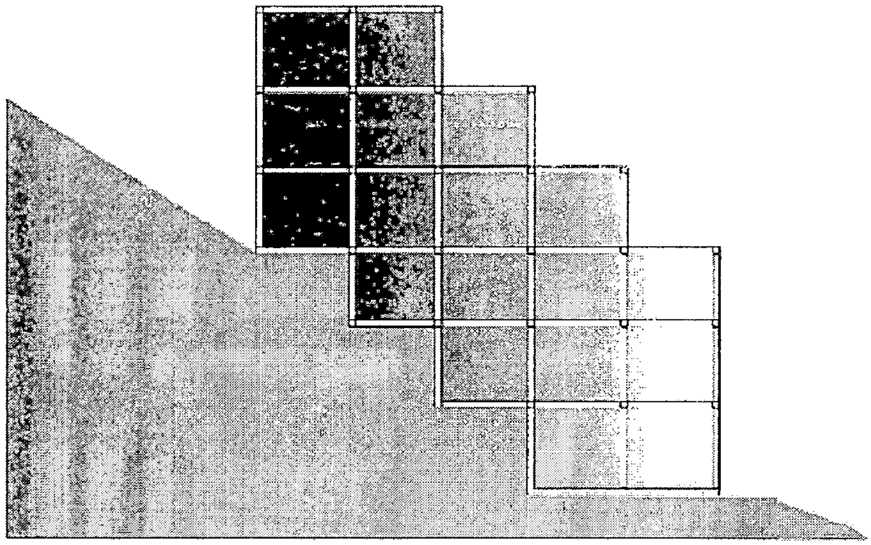


Fig 3.7: Step back set back buildings on sloping site
Source: Satish Kumar, 1996

The provision of deeper foundation into the slope on the upstream side increases the stability of the slope. Stability analysis of slope suggested that the buildings on flat ground adjacent to hill slope should have setback type configuration and buildings on sloping ground should have stepback type configurations to achieve better stability.

3.5.4 Strengthening Measures: the various strengthening measures taken in mid rise buildings for earthquake resistance area as follows

i) High quality and well protected materials
ii) Shear Wall Building
iii) Shaking isolation

3.5.4.1 High quality and well protected materials: Quality of materials used is essential for better seismic response of any structure. Properties such as strength, toughness, ductility, elasticity, lightness, viscous energy dissipation and resistance to weather effects are necessary and convenient under normal conditions and crucial in the event of severe earthquakes or other extreme events. Quality of construction and adequate protection against their decay are essential to guarantee that the materials will be able to attain and maintain their expected behaviour.

3.5.4.2 Shear Wall Building: a shear wall may be defined as a structural wall, which has high in plane stiffness by virtue of its form. It may consist of a solid plane wall, a perforated wall. The stiffness of shear wall in a building is 30 to 100 times more than the stiffness of all frames together. Shear walls should be distributed about both axes to provide adequate resistance against torsion.

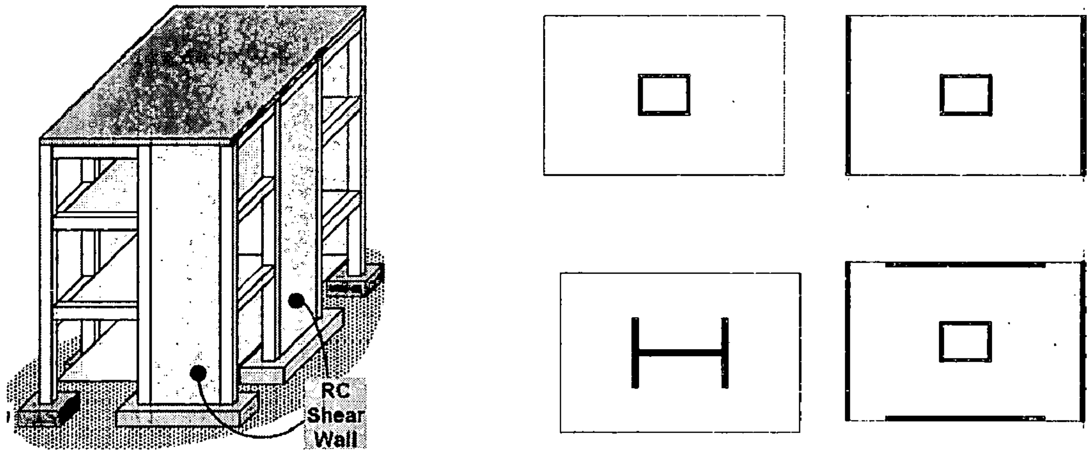


Fig 3.8: Symmetric location of shear walls in buildings
Source: Q.I.P Short term course on earthquake engineering for architects and planners, IITR, 1992

3.5.4.3 Shaking isolation

The strategy of reducing the structural deformations and internal forces caused by earthquakes by means of base isolation, energy dissipation or mass damper devices is a promising trend in earthquake engineering.

3.5.5 Base Isolation

A base isolated structure is supported by a series of bearing pads, which are placed between the buildings and building foundation. Base isolation is the most powerful tool of the earthquake engineering pertaining to the passive structural vibration control technologies. It is meant to enable a building or non-building structure to survive a potentially devastating seismic impact through a proper initial design or subsequent modifications. In some cases, application of base isolation can raise both a structure's seismic performance and its seismic sustainability considerably.

Usually ground motions are predominant in certain range of frequency. Buildings that fall in that range are more vulnerable to damage. In the base isolation, we shift the fundamental frequency of the structure by putting some flexible material under the structure. This material has strength as high as that it can take the gravity load of the structure in vertical direction and it is flexible in lateral direction. Elastomeric bearing commonly used for base isolation. Therefore, base isolation system, is a collection of structural elements which should substantially decouple a superstructure from its substructure resting on a shaking ground thus protecting a building or non-building structure's integrity.

The objective of seismic isolation systems is to decouple the building structure from the damaging components of the earthquake input motion, i.e. to prevent the superstructure of the building from absorbing the earthquake energy. The entire superstructure must be supported on discrete isolators whose dynamic characteristics are chosen to uncouple the ground motion. Some isolators are also designed to add substantial damping. Some of the commonly used isolation systems are laminated rubber (or elastomeric) bearings and sliding isolation systems. Laminated rubber bearings are used with passive dampers for control of excessive base displacement. Laminated rubber bearings with inherent energy dissipation capacities are also developed.

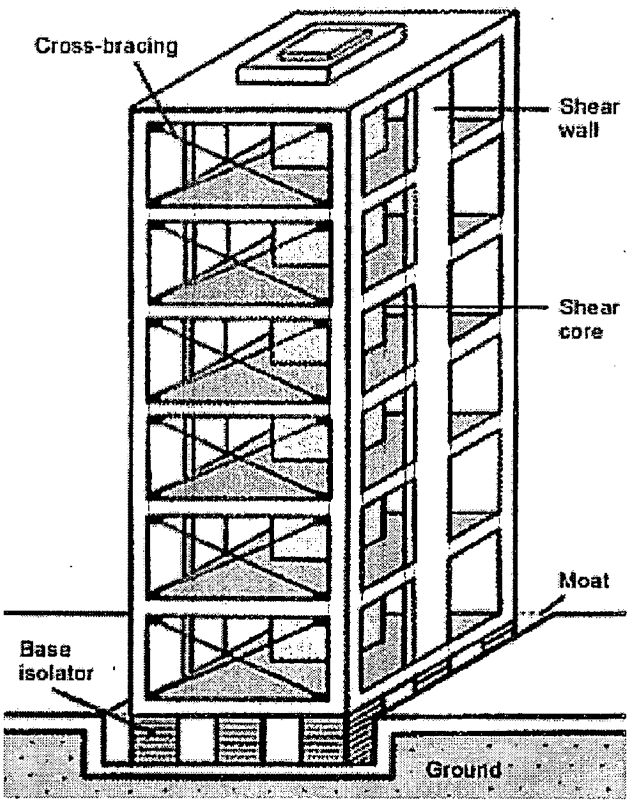


Fig 3.9: Base isolation in Buildings

Source: www.world-housing.net

The main feature of the base isolation technology is that it introduces flexibility in the structure. Due to the flexibility in the structure, a robust medium-rise masonry or reinforced concrete building becomes extremely flexible. The isolators are often designed, to absorb energy and thus add damping to the system. This helps in further reducing the seismic response of the building. Many of the base isolators look like large rubber pads, although there are other types that are based on sliding of one part of the building relative to other. Also, base isolation is not suitable for all buildings. Mostly low to medium rise buildings rested on hard soil underneath; high-rise buildings or buildings rested on soft soil are not suitable for base isolation. In order to design mid rise buildings in hill regions, which are highly susceptible to seismic activities, should be with proper consideration of earthquake resistant design elements.

Hill regions are prone to different disasters, with the proper consideration against these disasters for the planning and design of mid rise buildings, a safer built environment can be created/ made in the hill regions, so that the loss of human life, resources and damage to the buildings should be reduced. Various provisions related to the planning and design of mid rise buildings in hill regions are presented in the Indian Standard codes and Building byelaws or developmental controls of prevailing in hill towns. The various provisions presented in Indian Standard codes and Building byelaws or developmental controls of prevailing in hill towns are discussed in detail in next chapter.

CHAPTER IV

REGULATIONS FOR MID RISE BUILDINGS IN HILL REGIONS

4.1 INTRODUCTION

This chapter deals with the various provisions available in different Indian standard (IS) codes presented in the country for planning and design of mid rise buildings in hill regions. This chapter also deals with the various regulations or building bye laws related to design of mid rise buildings prevailing in major hill towns like Shimla, Manali, nainital, Gangtok and Guwahati. This chapter also discusses the various lacunas/ shortcoming in the prevailing building byelaws in hill towns.

4.2 PROVISIONS FOR MID RISE BUILDINGS IN INDIAN STANDARD (IS) CODES.

In national building code 2005, specific provisions related to set back conditions for different heights of buildings and fire protection requirements for buildings more than 15m height are given as discussed in detail below. Provisions related to stability of hill slopes and terrace development are given in IS code no 14243 part 2 1995.

4.2.1 Setback Conditions for Buildings: In accordance to National building code 2005 for buildings of height above 10 m, the open spaces (side and rear) shall be as given in Table 1.

Table 2: Side and rear open spaces for different height of buildings

S no.	Height of building (m)	Side and rear open space to be left around building (m)
1.	10	3
2.	15	5
3.	18	6
4.	21	7
5.	24	8
6.	27	9
7.	30	10

8.	35	11
9.	40	12
10.	45	13
11.	50	14
12.	55 and above	16

Source: Part III National building code 2005

The buildings considered in this case have height from 18m to 30m. There are no separate set back provisions for mid rise buildings are present in the byelaws of hill towns. However the set back provisions given by NBC 2005 are far more than the practical situations in present hill towns.

4.2.2 Fire Protection Requirements for High Rise Buildings — 15 m in Height or Above

The fire protection measures given in Part IV National Building code 2005 can be divided into following catagories:

i) Provisions related to Construction

ii) Provision of first-aid fire fighting Appliances

iii) Provisions related to fire alarm system

iv) Provision related to lightning protection of buildings

v) Provision of fire control room

vi) Provision of fire officer for hotels, business buildings with height more than 30 m

vii) Provisions related to house keeping

viii) Provisions related to fire drills and fire orders

ix) Provisions related to compartmentation

x) Provisions related to materials for interior decoration/furnishing

4. 2.3 Stability of Slopes

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. Field survey and stability analysis of hill slopes and cuttings should be carried out and buildings located on stable hill slopes.

Cutting of Slopes: 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.

4. 2.4 Terrace Development on Sloping Sites

As per the code Building sites in hilly areas are located on slopes and hill tops with roads girdling in between levels to provide access to the residences. Hill sides with less than 30° slope in general are noted to be stable as the gradient corresponds to safe angle of repose of slope forming material. 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

Table 3 : Maximum heights of cutting in hill slopes

S no	Nature of Soil/Soil Strata	Max. Heights of Cutting
1	Loose soil or boulders with soil matrix	4m
2	Compact soil or boulders with soil matrix which remains vertical in 4m high cutting when dry	6m
3	Soil or boulder with soil matrix overlain on loose, soft or fractured rock strata	5m
4	Soil or boulders with soil matrix overlying firm hard rock	6m
5	Hard stable rock with or without compact soil or boulder with soil matrix up to 2 m thick	8m

Source: I.S code 14243, Selection and Development of Site for Building in Hill Areas- Guidelines

Site development in hilly regions consumes about 30 to 40 percent of total cost of building complex. Following points shall be kept in mind during development of terrace for a building site.

i) Height of Cutting

ii) Clearance Around Buildings

iii) Blasting

iv) Proper Drainage

4.2.5 Stepped Terrace Development

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,

4.3 REGULATIONS FOR MID RISE BUILDINGS IN BUILDING BYELAWS OF SHIMLA

As per the Draft Development Plan 2021 for Shimla planning areas, the various regulations which can be applicable for mid rise buildings are as follow:

4.3.1 Safety Regulations

i) Where it is essential to develop a plot by cutting, it shall be the responsibility of the plot owner to provide according to the engineering specifications, retaining and breast walls, so that such cutting of natural profile of the land may not harm the adjoining uphill side properties. However, cutting of natural profile shall not exceed more than 3.00 meters in any case having a provision of diaphragm/retaining wall for step housing, with a minimum dry area/ gali of 1.00 m wide for proper ventilation and passage.

ii) All building plans in respect of building of above 15 metres of height shall require "No Objection Certificate" from the Director of Fire Services or Chief Fire Officer, as the case may be, on the basis of recommendations of Divisional Fire Officer or Station Fire Officer concerned.

4.3.2 Disaster Mitigation Regulations

The buildings which have come up on vital slopes with more than 45^0 shall have to be got examined by a competent institution and accordingly the requisite local bodies/SADAs shall take effective measures to ensure safety and security of people living therein as well as those who has structures down below on the slopes.

4.3.3Provisions Related to Lifts in Buildings

For the buildings with more than 15.00 metre in height one lift shall be provided for the wheel chair user with the following clear dimensions:-

Clear internal depth is 1100 mm, Clear internal width is 2000 mm, Entrance door width is 910 mm. A handrail not less than 600 mm long at 900 mm above floor level shall be fixed adjacent to the control panel. The lift lobby shall be of an inside measurement of 1800 mm x 2000 mm or more. Operational details of lifts shall conform to the National Building Code of India

4.3.4 Environmental Regulations

i) No construction shall be allowable within a radius of 5.00 metre from a tree and upto 5.00 metre distance from the Forest/Green belt boundary. The distance shall be measured from the circumference of the tree. No lopping shall be allowable.

ii) In case any unauthorised construction involves cutting/drying/lopping of any tree, electricity, water supply and sewerage connections shall remain disconnected till clearance is given by the Forest Department.

iii) No construction shall be allowed on land/plot having slope more than 45^0

iv) No drainage line or nallahs shall be allowed to be covered by any private construction. However, strategic locations adjacent thereto along the highways may be utilized for parking purpose either by the Government or by Municipal Corporation or by Development Authorities for community purposes.

4.3.5 Solar Passive Building Regulations

Provision of Solar Passive heating and cooling features shall be mandatory in Government and Semi-Government buildings, Industrial Complexes, Tourist Resorts and Hotels in private sector also. Solar lights shall be used for lighting the premises of above complexes. The map for the building should accompany a statement giving details of Solar Passive Heating/Cooling/Day Lighting features along with technical specifications of Solar Space Heating/ Cooling System, Solar Photo Voltaic, Energy Efficient and other renewal resource devices to be installed along with expected energy saving in the building.

4.3.5.1 Site Selection: The site should preferably be selected on southern slopes/ side. Survey of the site has to be got done to determine adequate solar energy availability and solar access along with data on climatic conditions.

4.3.5.2 Orientation: The longer axis of the building should lie along east/west directions to trap maximum solar energy

4.3.5.3 Integrating Solar Space Heating Systems in Building Design: Passive solar heating systems like Solar Air heating/ Water heating/Sun space/Solar walls/Solar Trombe wall etc. are to be integrated in the building design on southern side so as to allow maximum direct solar access to the system.

4.4 PROVISIONS FOR SITE DEVELOPMENT IN BUILDINGS BYELAWS OF NAINITAL

As per Nainital Lake Region Special Area Development Authority, the various provisions related to site selection and development for the construction of buildings prevailing in nainital town is as follows.

i) No cutting or excavation for construction or for any other purpose should be allowed on state dripping down the hill or slate rubble where the slope of the hill is more than 26.5 degree i.e. 1 in 2.

ii) Construction of building on steeper slopes more than 26.5 degree it states may be permitted if the bedding and division planes dip into the hill slope.

iii) Cutting or excavation for construction of building may be allowed on slope with gradient greater than 26.5 degree at Ayarpatta comprising of fire dolomite and quartzite, provided rock cutting does not leave overhanging messes or unsupported talus to slips.

iv) No cutting or excavation or quarrying stones projected or deep for construction of building or for any other purpose may be allowed in the area composed quartzite dolomite rubble where the angle of hill slope is greater than 30 degree or 1:1:73 gradients. Suitable breast walls in accordance with the recognized Public Work Department specification, at the back, are essential.

v) The apparent dip of the dominant divisional plane is into the hills, at angle greater than 10 degree from the horizontal and construction is permissible, slopes of less than 26.5 degree upto within 30 ft of the steeping of the gradient below this site.

vi) The apparent dip of the dominant divisional plane is inclined down the slope but at an angle of ground slope construction in permissible.

vii) The apparent dip of the dominant divisional plane is inclined down the slope an angle roughly coincident with or less than the maximum slope of the hill slope below the site. Construction should only be permissible well away from the slope of the steeper convex slope so as to avoid any slips that might occur in the below the divisional plane and the steep portion of the hill side.

4.5 PROVISIONS FOR MID RISE BUILDING IN BUILDINGS BYELAWS OF GANGTOK

As per Urban Development & Housing Department, Gangtok, maximum height of buildings constructed in allotted sites within a notified area shall be in accordance with the suitability and profile of the locations based on the stability map of the area as prepared by the Mines and Geology Department from time to time which shall be as follows:

Table 4: Admissible number of floors in buildings in Gangtok development area

Stability Zone	Admissible number of floors
1.	5 ½ storeys
2.	4 ½ storeys
3.	3 ½ storeys
4.	2 ½ storeys
5.	1 ½ storeys
6.	No construction is allowed.

Source: Gangtok development plan 2021

4.6 PROVISIONS FOR MID RISE BUILDINGS IN BUILDING BYELAWS OF GUWAHATI

As per the building byelaws 2006 for Guwahati metropolitan area, the various regulations which can be applicable for mid rise buildings are as follow:

4.6.1 Setback Regulations: As per the various building byelaws prevailing in the guwahati planning area are:

i) Front setback

Every building fronting a street shall have a front space from the prescribed street line forming an integral part of the site as below-

Table 5: Front set back in accordance to street width and building height in Guwahati

Width of street fronting the plot as per Master Plan	Minimum front open space		
	Height of the building		
	Upto 9.6 Metres*	9.6 to 15.8 Metres*	Above 15.8 Metres*
Upto 6.6 Metres	3.0 Metres	4.5 Metres	6.0 Metres
Upto 15 Metres	3.0 Metres	6.0 Metres	7.5 Metres
Above 15 Metres	3.0 Metres	7.5 Metres	9.0 Metres

Source: Building byelaws for Guwahati metropolitan development authority 2006

4.6.2 Regulations for Apartment Buildings

The various set back conditions applicable for different heights of apartment buildings in Guwahati metropolitan area are as below:

Table 6: Setback conditions for apartment buildings of different heights in Guwahati

Height of building	Minimum plot size (k=268 sqm)	Minimum front set back	Minimum rear set back	Minimum side set back
Apartment upto 11.5 m.	3 K.	4.5 m.	3.6 m.	2.4 m.
Apartment above 11.5 m.	4 K.	6 m.	3.6 m.	2.4 m.
Mixed use building of residential apartment and commercial above 15 m.	5 K.	6 m.	3.6 m.	2.4 m.

Source : Building byelaws for Guwahati metropolitan development authority 2006

4.6.3 Special Regulations for Construction in Hilly Areas

The Authority may ask for detailed topographic survey map of the site, showing the proposed ground levels of the plot and the remedial construction measures to check the undesired erosion that may affect the adjoining areas. The Authority may also give special direction for framing the proposal in such a way which involves least disturbance to the natural terrain and keeping of bare land which is not allowed.

i) If terrace cutting is done for building constructed on hill the depth and slope of the cut should be restricted according to the soil characteristic of the area.

ii) Adequate drainage provision should be kept to the satisfaction of the Authority so that rain water and waste water can drain out from the plot without causing soil erosion.

iii) In hill areas with slope greater than 10^{o}special protection measures will have to be provided as specified by the Authority. Local ground conditions shall be taken into account in the determination of the appropriate precautionary work and protection walls as well as relevant code of B.I.S.

iv) The maximum height of cutting for development should generally be 4 m. to 6m and cutting of slope over a height of 6m shall not be ordinarily permitted. Height of 6m earth cutting should be from face of 1st cutting.

v) If however Authority feels that special protective measures are required in the plot prior to any construction in the plot, no construction of building may be allowed by the Authority in such plot unless the protective measures are completed as directed by the Authority first.

4.7 SHORTCOMINGS IN PREVAILING BUILDINGS BYELAWS FOR MID RISE BUILDINGS IN HILL TOWNS

After the study of prevailing building byelaws in hill region the main problems identified are as follows:

i) Most of the byelaws prevailing in hill towns are borrowed from the Delhi Master Plan for which the regional context is drastically different from the hill towns. The geo-environmental conditions at hill towns are different from that Delhi.

ii) There are no specific provisions related to design of mid rise buildings in hill regions. Only in case of Gangtok byelaws maximum number of storeys allowable is 5½.

iii) There are no specific provisions regarding selection of safer sites for building mid rise buildings.

iv) The set back conditions are not specific to the site conditions, such as orientation, slope gradient and slope material. However sites with in same locality with different orientation and slope gradient require different setback provisions.

v) The byelaws prevailing are at zonal level, they should be in made specific to site condition or site level.

vi) There is no specific provision for development of sites in the proximity of any natural drainage channel and no specific provision for channelization of upstream water.

vii) There is no specific codal requirement for structural deigns of buildings rather than it should be made/ designed by a civil engineer. No specialization of the designer is mentioned.

viii) There is no provision regarding the facade treatment, colour, texture and roofscape of the buildings being constructed in hills.

ix) There are not any provisions for site development work. There is no references related to applicability of IS codes.

x) No specific provisions related to the structural design of the buildings except that it should be designed and signed by engineer posses a B.Tech Degree.

In spite of having no specific regulations related to mid rise buildings in the prevailing building byelaws of hill regions. A lot of new mid rise buildings are being constructed in the core areas or newly developed areas of the hill towns (especially Shimla). There is a need to study the context of Shimla to identify the various reasons for the designing and construction of mid rise buildings in the town.

CHAPTER V

SHIMLA: THE STUDY CONTEXT

5.1 INTRODUCTION

This chapter includes the geographical setting of Shimla, geography, climate, historical evolution and demographic character of Shimla. This chapter also includes mid rise buildings in Shimla, present scenario of construction, problems for development. It also deals with the existing guidelines for mid rise buildings in Shimla and in other hill towns in India.

5.2 SHIMLE THE STUDY CONTEXT

Shimla is the capital of Himachal Pradesh and the former summer capital of India during British period and the largest hill town of north India. It was popularly known as 'Jewel of the Orient' in British period. Shimla with its salubrious climate, mountainous topography and enchanting landscape is a major centre of attraction for national and international tourists. It is the largest hill top city of its own type in the Himalayan region.

As per 2001 census, Shimla is the only Class I town in entire State of Himachal Pradesh with majority of towns falling under Class IV category. This explains the dominance of this town in the State in terms of facilities, amenities and opportunities. Shimla is a multifunctional city with dominance in tourism, administration and institutional activities. The multifunctional activities are putting heavy stress on development activities leading to unregulated development and congestion in the town.

5.3 GEOGRAPHICAL SETTING OF SHIMLA

Shimla is situated on the last Traverse spur of the Central Himalayas, south of the river Satluj at $31^0 4'$ North to $31^0 10'$ North latitude and $77^0 5'$ East to $77^0 15'$ longitude, at an altitude of 2130 metres above mean sea level. In shape, it has been described as an irregular crescent as shown in fig. 4.1. It is spread over an area of 9950 Hectares along with its commanding position. The city is an unique combination of hills, spurs and valleys to the north and east, a network of mountain ranges which are crossed at a distance by a magnificent crescent of new peaks, the mountains of Kullu & Spiti in the North, the central range of the eastern Himalayas stretching East and South-east. The East-West axis have emerged major axis of development for the city.

5.4 GEOLOGY OF SHIMLA

Shimla town is situated on the rocks of Jutogh Group and Shimla Group. Jutogh group occupies main Shimla area and extends from Annadale-Chura Bazaar-Prospect Hill-Jakhoo-US Club and highland area. Shimla Group comprising of earlier Chail Formation and Shimla Series represented by shale, slate, quartzite greywacke and local conglomerate is well exposed in Sanjauli-Dhalli area. Shimla town and its surrounding areas have a complicated physiographic due to tectonic events, foldings, faulting and thrusting processes, resulting inversion of topography and formation of irregular landforms. On account of predominance of dolomite and lime stone rocks, landslides are common. As rocks are unstable, dislocation of buildings can occur. Being located in seismic zone, it is susceptible to earthquakes. The North-Western fringe of the Himalayas is bounded by two major thrusts namely Main Central Thrust and Main Boundary Fault running parallel to the axis. Shimla, in the central Himalayan zone, falls in seismic zone IV, which is very prone to earthquakes.

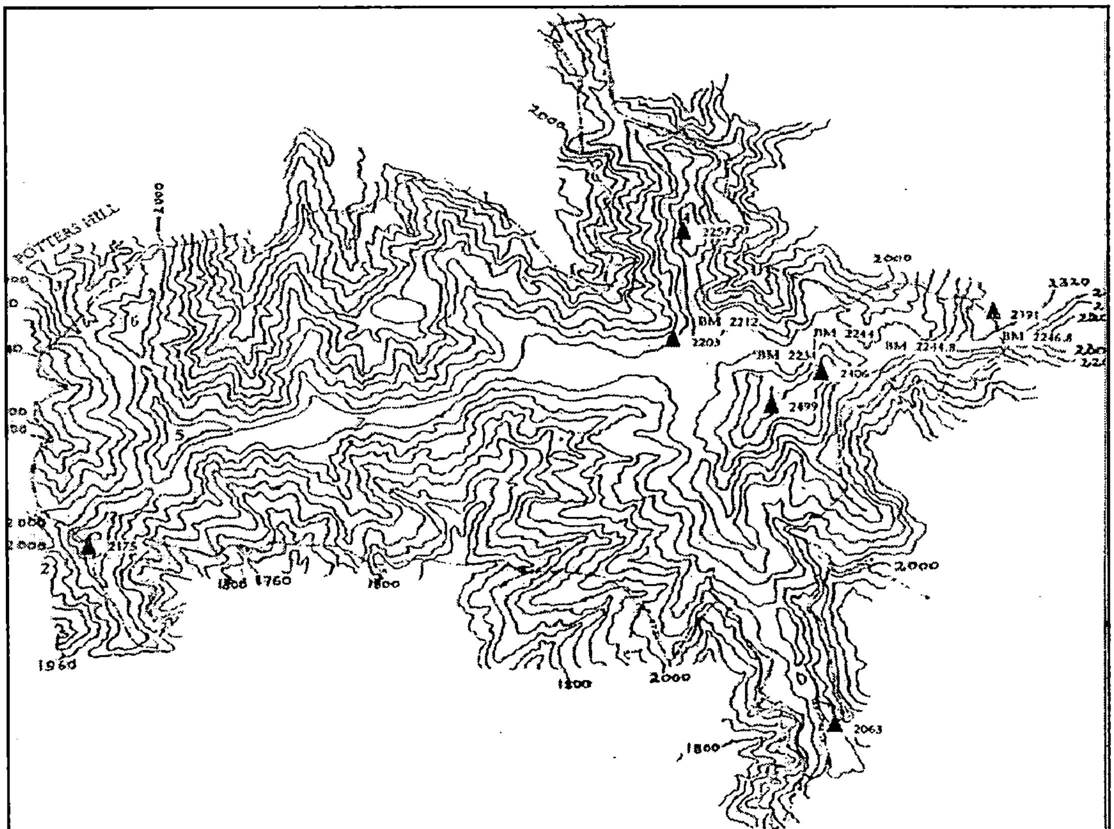


Fig. 5.1: Topographic map of Shimla
Source: City development Plan, 2021

5.5 CLIMATE OF SHIMLA

The climate in Shimla is predominantly cold during winters and moderately warm during summers. The average temperature during summer is between 14 °C and 20 °C and between -7 °C and 10 °C in winter. The average total annual precipitation is 1520 mm with snowfall in winters.

5.6 HISTORICAL EVOLUTION OF SHIMLA

Shimla, prior to its development as a hill station was described as an "obscure village. The village was named 'Shimla' after the temple of Goddess Shyamala located in the village. . At the beginning of last century, Shimla was taken from the Jhind Rana in 1815 and given to the Patiala Raja for assistance rendered by him to the British in the Nepal War. In 1819, Lt. Ross Assistant Political Agent in the Hill States built a cottage of wood and thatch. This was probably the first British House in Shimla. In 1825, Major Kennedy constructed a permanent house on a rent free site. It was named as Kennedy House. In 1828, Lord Combermere with his staff and the whole establishment of Army Head Quarters came upto Shimla. Afterwards, movement of the British Officers to Shimla in summers became a regular phenomenon, to escape the scorching heat of the plains. By 1831, Shimla had about sixty permanent houses and a bazaar. In 1844, the number of houses in Shimla had risen to 100, rapid growth led to necessity of providing amenities and services.

Municipal Committee at Shimla is constituted in 1851, which was responsible for establishment of the Town Hall with a library, Gaiety Theatre, Police Station, municipal Market and Fire Brigade Services in subsequent years. Shimla was declared the Summer Capital of Indian Govt. in 1864. In the following years, the older, narrower track from Kalka to Shimla was improved. A new road named Grand Hindustan-Tibet road, 58 miles in length was built.

The emergence of Shimla as the Summer Capital also resulted in the acquisition of several old buildings by the Govt. for its offices. In addition, construction of new buildings was also started. A new Secretariat building, very close to the Mall was constructed on the site of Gorton Castle. In 1840, Peter Hoff became the official residence of the Viceroy and remained so till 1888 when a new residence, Vice Regal Lodge was constructed. In 1871, the Punjab Govt. also decided to use Shimla as its summer capital. A lot of new buildings were constructed in Shimla.

After the independence, it became the capital of Punjab state and many of the Punjab Govt. Offices from Lahore in Pakistan were shifted to Shimla. In 1966, with the re-organisation of territory into Punjab, Haryana and Himachal Pradesh, Shimla became the capital of Himachal Pradesh. Since then Shimla has flourished as capital of the State and has continued to be an important tourist resort of India and the world.

5.7 DEMOGRAPHIC CHARACTER OF SHIMLA TOWN

The development of a particular city, town or a region depends upon natural, physical and socio-economic factors. Among these factors the population assumes significance in determining the future pattern of progress and development. As per 2001 census, population of Shimla Planning Area is 174,789 persons. The population of Shimla Planning Area has increased from 1,29,827 persons in 1991 to 1,74,789 in 2001, recording a decadal growth rate of 34.63 percent. The projected population of Shimla by 2011 and 2021 is likely to be 2,35,970 and 3,18,560 respectively. As per total number of households in Shimla are 45163 censes (2001) and 80000 number of households are expected in 2021. This huge increase in population requires a larger area and infrastructural facilities, houses, workplaces, health facilities and recreational areas.

Table 7: Decadal Population Growth of Shimla

Year	Persons	Decadal Variation	% Age Decadal Growth Rate	No. of Houses
1971	72870	-----	-----	17965
1981	95851	22981	31.54	23801
1991	129827	33976	35.54	33766
2001	174789	44962	34.63	45163
2011	235970	61181	35	60000
2021	318560	82590	35	80000

Source: Census of India, 2001

5.7.1 Floating Population

Shimla being the largest hill station in north India has large influx of local, national international tourists. The tourist population in Shimla is 11, 67,085 in 2001 and it is expected to 32,04,760 in 2021 which requires huge accommodation and infrastructural facilities. Average number of tourists who visit Shimla per day is 4000. In peak season, particularly in the month of June approximately 10000 tourists visits Shimla daily increases the accommodation demand and exert pressure on infrastructural facilities available.

Table 8: Tourists in Shimla

Year	No. of Tourists	Variation In Growth	% Variation
1998	912508	------	------
1999	962691	50183	5.21
2000	1063200	100509	9.45
2001	1167085	103885	8.90
2002	1265186	88775	7.75
2003	1418035	52000	10.77

Source: Census of India, 2001

5.8 AREA OF THE TOWN

In present scenario Shimla town is spread nearly 9.2 km from east to west over several hills and connecting ridges having an area of 9950 hectares. As per the projection the town required additional 12500 hectares of land to meet the demand by 2021. By 2021, the total area of the town will be 22450 hectares which includes, Municipal Corporation, Shimla, Special Area Development Authorities of Kufri , Shoghi and Ghanahatti and Additional Areas as under:

Table 9: Distribution of Shimla planning area in 2021

Settlement	Area in Hectare	% age
M.C. Shimla	2207	9.83
S.A Ghanahatti	1647	7.34
S.A Kufri	3173	14.13
SA Shoghi	2923	13.02
Additional Planning Area	12500	55.68
Total	22450	100.00

Source: City development plan for Shimla 2021

5.9 MID RISE BUILDINGS IN SHIMLA

The design and construction of mid rise buildings in Shimla started in pre-independence period. These were the religious buildings, public buildings, offices (Bhimakali temple as in Fig 4.2 and Railway Board Building 1897 in fig 4.3) and residential built near the core mall area of the town. These buildings are built with stone masonry or brick masonry in lime mortar. In some buildings structural frames are made with cast iron columns and beams. The sloping roofs are constructed with GI sheets.

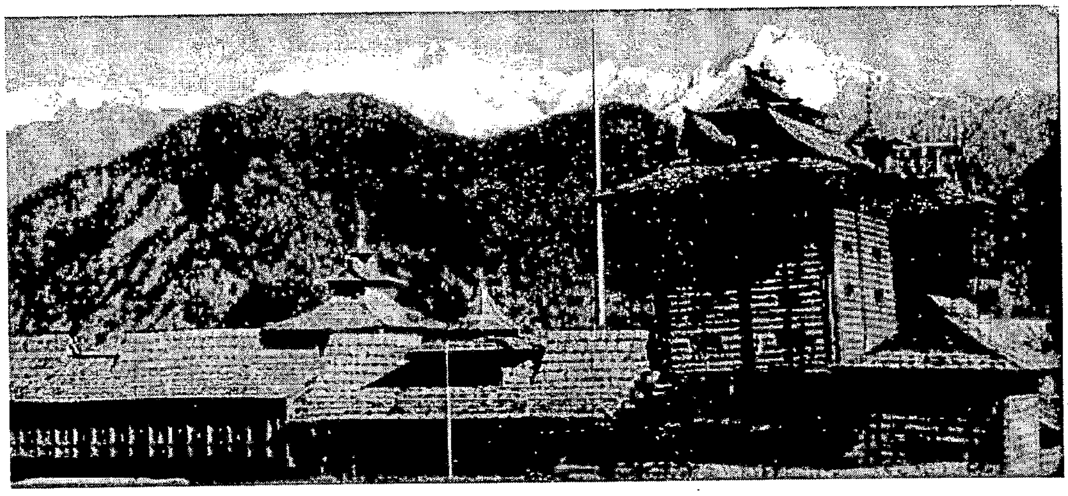


Fig. 5.2: Mid rise Bhimakali temple at Srahan, Shimla

Source: www.bhimakali.nic.in

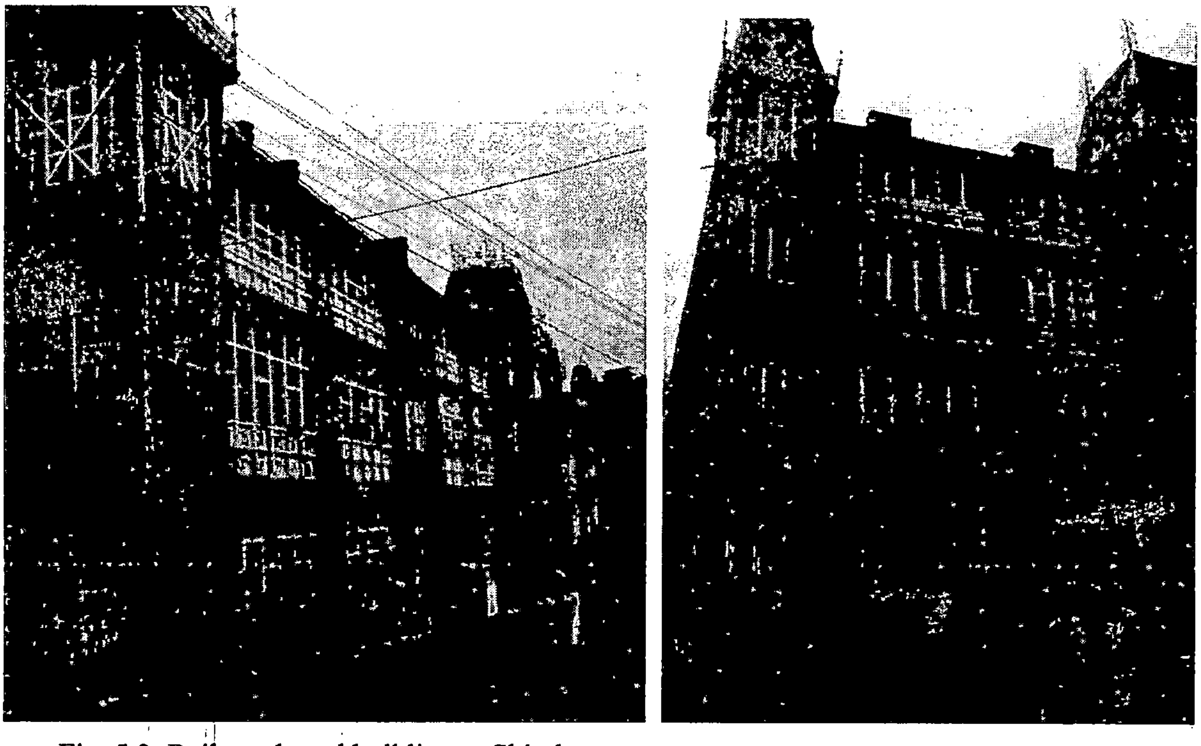
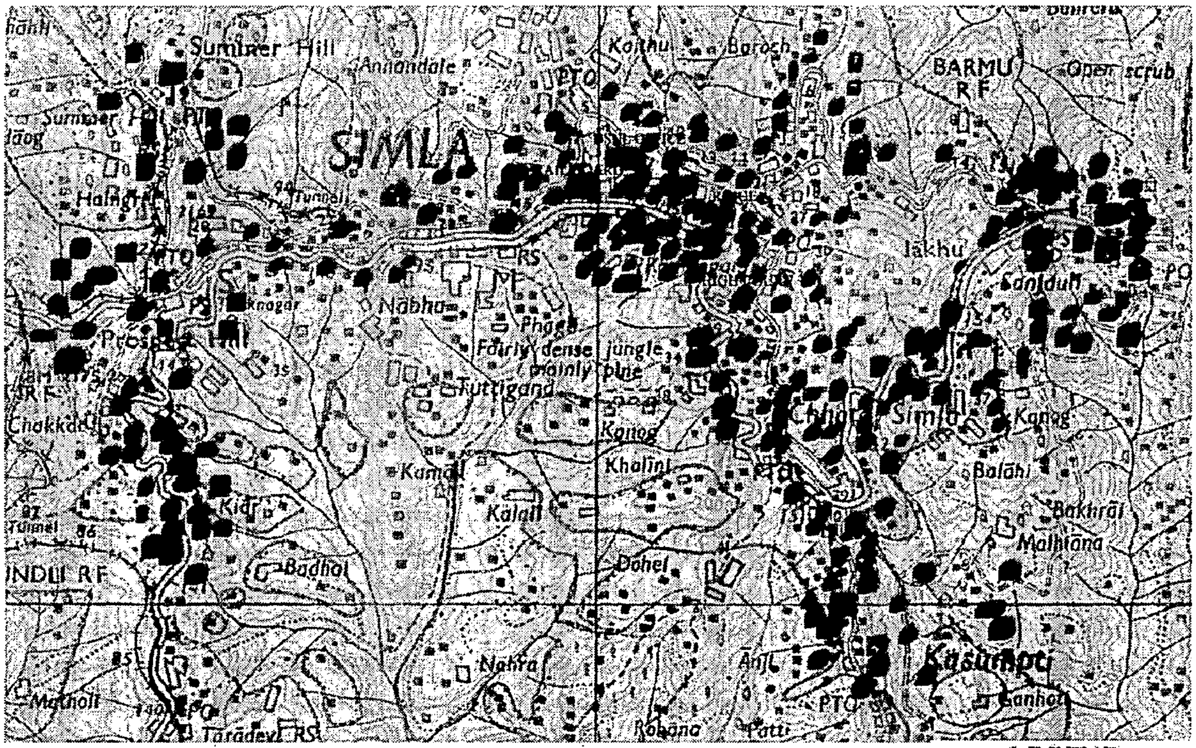


Fig. 5.3: Railway board building at Shimla

After independence, due to urbanisation and increase in population, mid rise buildings are constructed to meet the increased demand. In present scenario, due to tremendous growth in permanent as well as tourist population, limited land available for building purposes at preferred locations, high land costs, availability of new constructional materials and advances in constructional technologies results in increase in mid rise building construction (fig 4.5). These buildings are generally located in the main core area of town, near the mall road or in those areas where population density is very high and in newly developed areas on the periphery of town (fig 4.4).These buildings include public buildings, office complexes, hospitals, institutions, hotels and residences.

5.10 PRESENT SCENARIO OF CONSTRUCTION IN SHIMLA

In most parts of Shimla (Sanjauli, Lower Bazaar, Fingask and Ram Bazaar) massive construction of buildings is taken place on hill slopes without adhering to provisions of seismic building code and earthquakes resistance measures, are vulnerable to hazards (fig4.6). In some localities like Cemetery, Sanjauli, Jiunu Colony, Chakkar, Katchi Ghati and Lower Bharari) Constructions are carried on high slopes which are much higher than the tolerable limits which makes them susceptible to geo-hazards like earthquakes, landslides and dislocation of buildings.



PLAN OF SHIMLA TOWN

LEGEND

Fig. 5.4: Location of mid rise buildings in Shimla

MID RISE BUILDINGS

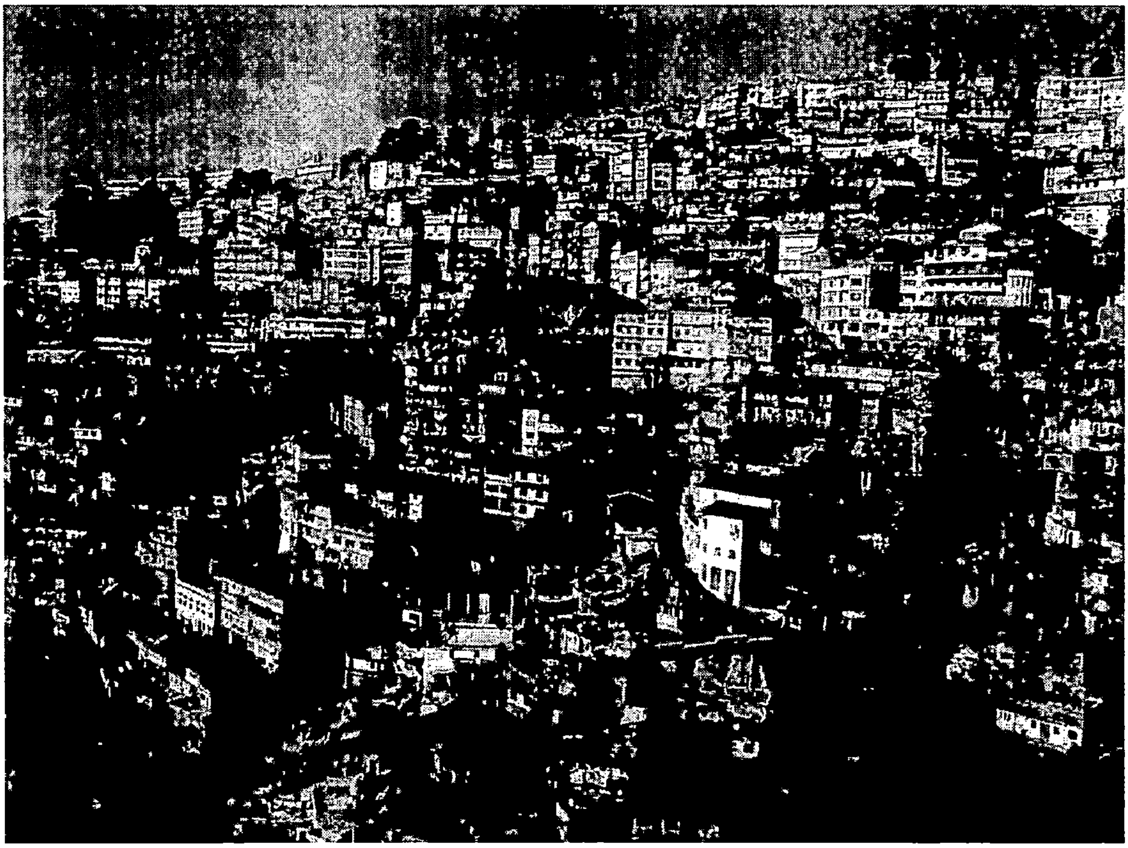


Fig. 5.5: Extent of development in Shimla

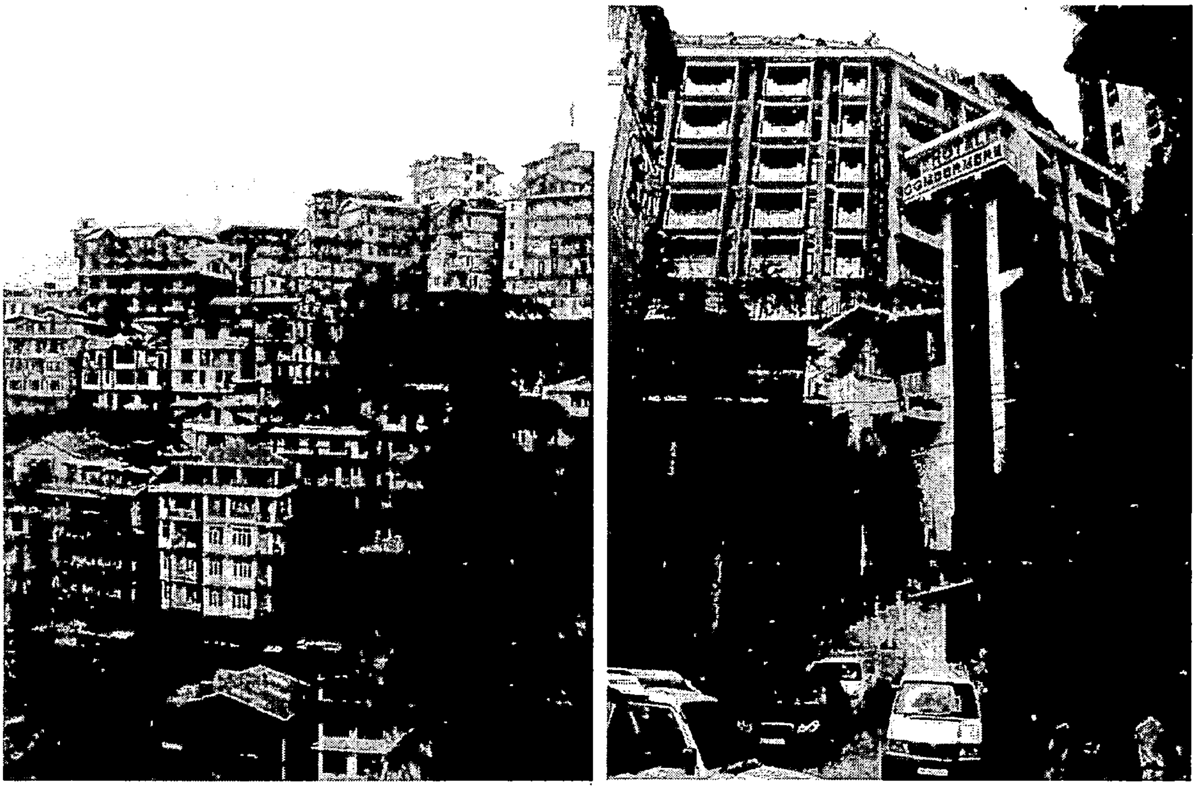


Fig 5.6: Mid rise buildings on steep slopes in Shimla

The impact of any natural disaster is increased by chain effect of collapse of building may affect many buildings on slopes down below. In view of empirical observations of various important localities, the average slope gradients, percentage coverage of hill slopes, average number of storeys in buildings and F.A.R used in the locality is assessed by the town and country planning department, Shimla and the same is given as under:

Table10: Constructions In Major Localities of Shimla

Locality	**Average Slope**	**Coverage**	**No. of Storeys**	**F.A.R of locality**
1.	**2.**	**3.**	**4.**	**5.**
Dhalli	70^0	60%	4	3.0
Cemetery	70^0	85%	4-5	3.5
Sanjauli	70^0	70%	4-5	3.0
Jiwanoo Colony	60^0	85%	4-5	3.5

New Shimla	35^0-45^0	70%	4	2.5
Vikas Nagar	30^0-40^0	60%	4	2.5
Khalini	45^0	65%	4-5	2.5
Chhota Shimla	45^0	65%	4-5	2.5
Central Shimla	60^0	90%	4-5	4.0
Krishna Nagar	70^0	70%	2-3	1.5
Bharari	50^0	70%	4	2.5
Kaithu	45^0	60%	4	2.5
Phagli	60^0	50%	4	2.0
Chakkar	65^0	60%	4-5	3.0
Katchighatti	75^0	80%	5-6	4.0
Totu	50^0	75%	4-5	3.0

Source: city development plan , shimla 2021

From this table it is evident that most of the localities have high slope gradients and commencement of construction on these high slopes is not suitable/ feasilble. Though majority of the hill slopes are covered with buildings. The FAR consumed in these localities is very high, which results in high density in these regions. During the occurance of any disaster these areas may be severly affected as the buildings construted are poorly planned and designed and having very less maintenance. However the effect of disaster will be increased by chain effect due to buildings constructed on different levels.

5.11 IDENTIFICATION OF PROBLEMS FOR MID RISE BUILDINGS IN SHIMLA

The various problems related to mid rise buildings in Shimla are listed as follows:

i) Population increase has become one of the main challenges in Shimla. Resident as well as floating population is exerting heavy pressure on the housing and infrastructural facilities in the town. This leads to construction of more mid rise buildings in Shimla for residential, office, commercial purposes. The infrastructural facilities provided like parking provisions, water supply, sanitation are insufficient to cater the increased population.

ii) High floating population requires more number of transitory accommodations, hotels, parking facilities and other infrastructural facilities.

iii) Coverage of high slopes, more than 35^0 to 40^0 which are likely to devastate during earthquake and multiply the damage due to chain effect.

iv) High percentage of coverage with no tree/ greenery amidst congested localities and utmost disregard to natural drainage and cleanliness may cause pollution menace and casualties in fire.

v) More number of storeys coupled with high FAR and coverage and thereby limited light, air and ventilation may lead to environmental chaos and thereby affect human health.

vi) Majority of buildings in Shimla do not have vehicular access or access for emergency vehicles.

vii) High peak density of population may lead to more casualties during earthquake. As localities are thickly built with utmost disregard to roads, setbacks etc., no relief and rescue operations can be carried

viii) Absence of developmental controls that are specific for mid rise buildings in Shimla.

ix) Buildable land, which can be used for building purposes is limited due to topographical features in Shimla.

Mid rise buildings are being constructed in Shimla, in order to understand the various issues and aspects of planning and design of mid rise buildings in a hill town (Shimla). There is a need to study the existing mid rise buildings in Shimla. This study is conducted in next chapter under two different categories as area level study of mid rise building complex to highlight the issues of site selection, site planning and development in hill regions. Second part is study of individual buildings to understand the various issues and aspects of mid rise building design in hill regions.

CHAPTER VI

AREA LEVEL STUDY OF MID RISE BUILDINGS IN SHIMLA

6.1 INTRODUCTION

This chapter comprises of study of SDA (Shimla development authority) Complex, Kasumpti Shimla, to highlight the various issues related to site selection and planning of the mid rise buildings such as Location, access, siting of buildings, parking, planning of building, structure, facade of buildings, services, safety against earthquakes and landslide, energy efficiency, streetscape, landscaping and roofscape. The implication of various issues identified is also discussed in this chapter.

6.2. CASE STUDY OF SDA COMPLEX, SHIMLA

SDA complex is a commercial cum office complex developed by HIMUDA (Himachal Pradesh Housing and Urban Development Authority) to decentralise the core city area and to increase the employment opportunities (commercial and workspaces). This complex has total 42 buildings designed to house more than 200 shops and offices. The major functional and integral activities associated with Government offices are Administration, Commerce, Technology, Research, Development, Tourism and transportation.

6.2.1 Location

SDA complex is located at Kasumpti, which is approximately 7 km away from the core area of Shimla town. It is located at the periphery of Shimla town near Shimla Rampur highway.

6.2.2 Site Area

SDA complex has a total site area of 46190 sq m and total level difference in site of 70 meters. The slope in the site varies from 15^{o} to 35^{o}. It spreads over mid slopes of two spurs of south sloping hill which has south and south west orientation.

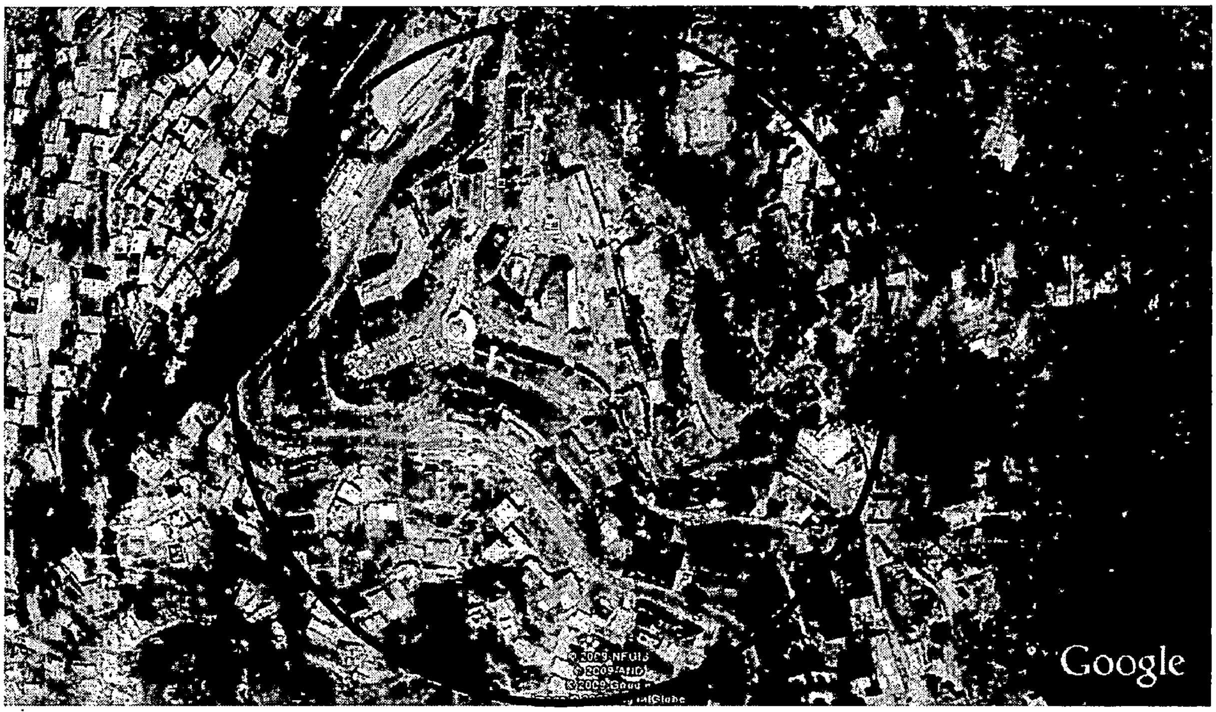


Fig 6.1: Google Image of the SDA Complex, Shimla
Source: Google earth

6.2.3 Access

The complex is connected with Shimla town through a 12 meter wide road which joins Kasumpti to Shimla. Internal roads in the complex have a varying width of 9 m, 7.5m 6m and 3m. Stepped pathways are used to connect different building blocks placed at varied levels whereas no consideration is given to the pedestrian movement along the roads. The slope gradient of roads in the complex is higher than the permissible. Internal roads are on the north side of the buildings aren't get any direct sunlight and are in shade whole of the day results in untidy conditions on these roads.

6.2.4 Area Calculations

Total Site Area	=	46190 sqm
Area cover under buildings	=	15253 sqm
Percentage coverage of site area for buildings	=	33.03%
Area under roads and pathway	=	11901sqm

Percentage coverage of site area under roads	=	25.77%
Open area and used for parking	=	41.2%
Total built up area	=	77152 sqm
F.A.R used in the complex	=	1.67

The open areas on the site have high slope gradient, which makes them unsafe for any development purposes

6.2.5 Siting of Buildings

Most of the buildings in the complex are linear in shape. Buildings are usually placed along the contours to reduce the site development work. Buildings are placed on manmade terraces on different levels. Retaining walls made up of stone, concrete or rcc are used to stabilise the soil and to achieve desired levels. Most of the buildings have one of their longer sides facing south. These buildings are placed on the abutting road without any set back from the road. Most of the buildings have access from two sides. The space between the two buildings is usually very less in the complex results in insufficient light and ventilation in buildings and buildings cast shadow on the adjoining one.

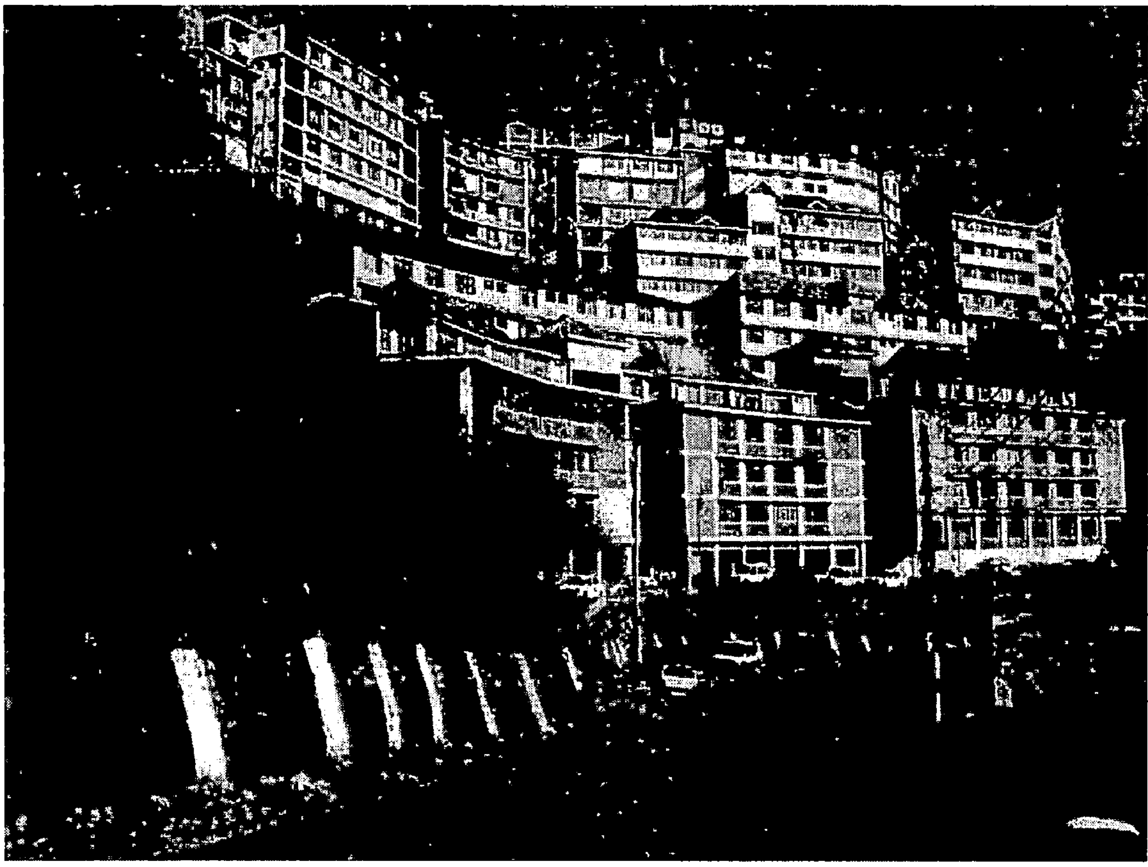


Fig 6.2: Mid rise buildings built on different terraces in SDA Complex

6.2.6 Parking

Parking facilities in the complex are provided at two different locations having a total capacity of 100 cars, but the numbers of vehicles coming to the complex are much higher. Vehicles are parked on the road in front of the buildings results in congestion and hindrance in movement of vehicles and pedestrians. Vehicles parked on the sloping roads may leads to accidents in the area

Fig 6.3: Public Parking Space

6.2.7 Planning of Buildings

Buildings on the main road are mix use buildings having shops on the road and offices on the upper floors. The plinth of every building varies according to the slope of the road. Shops have a 3 metre wide covered corridor in front adjacent to the road to facilitate the movement of people which, is encroached at places by the shopkeepers to extend their shops results in forcing peoples to move on the road. The width of shops varied from 3 to 4 metres. Whereas the office buildings in the complex have corridor planning, in which various spaces are arranged on both sides of a corridor in a linear manner. Buildings have solar access through the glazed openings provided on the southern side. Buildings as placed on different terraces block the sun of other buildings which is towards the north, as the distance between them is lesser.

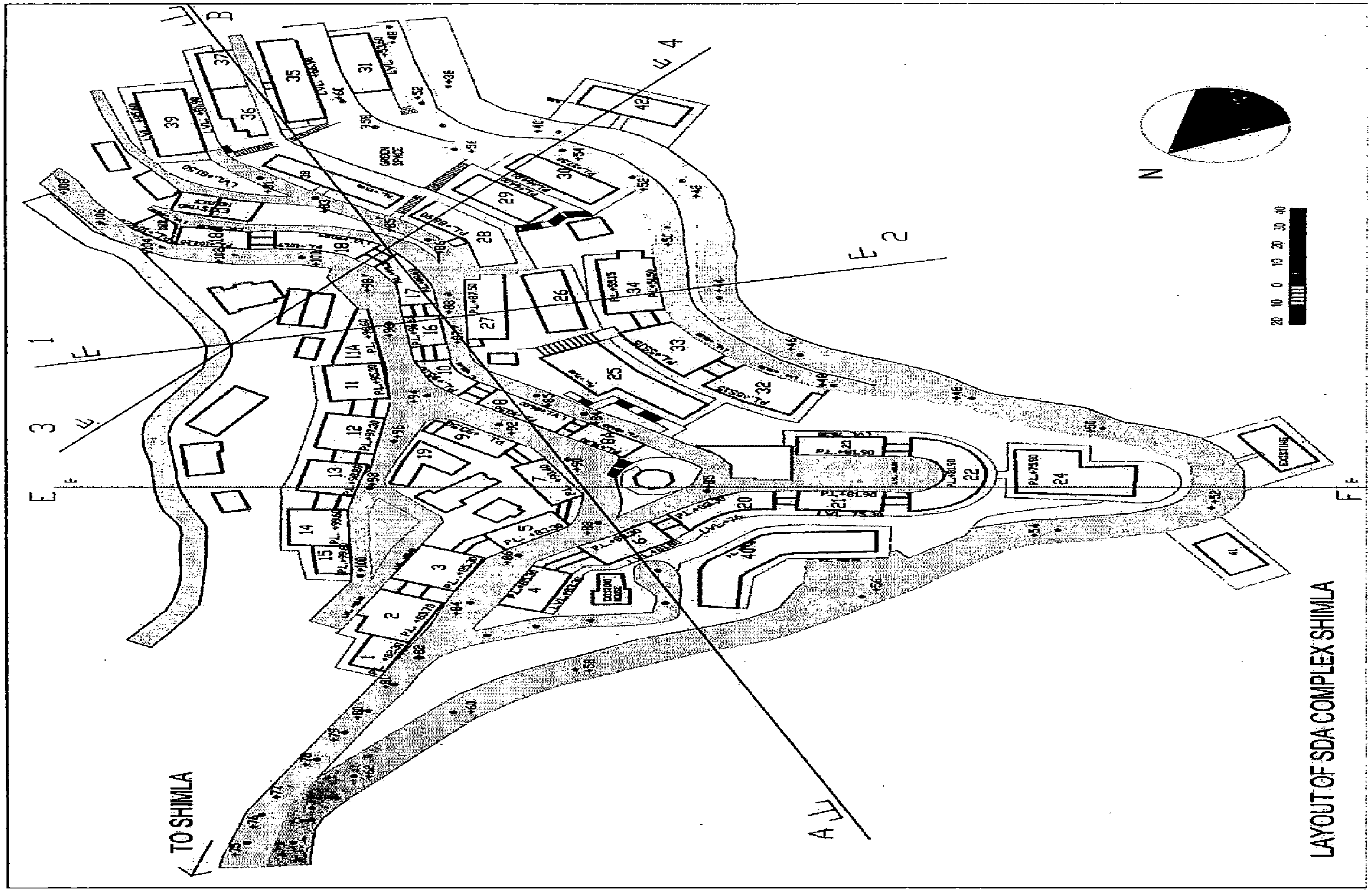


Fig 6.4: Layout plan of SDA complex
Source: HIMUDA, Shimla

6.2.8 Height of Buildings

SDA complex have a hierarchy in the heights of buildings varied from 12 meters to storied to 25 meters. In this complex one building is 3 storeys, 7 buildings are 4 storeys, 23 buildings are 5 storeys, 10 buildings are 6 storeys and 2 buildings are 7 storeys. The floor to floor height is taken as 3.20 meters.

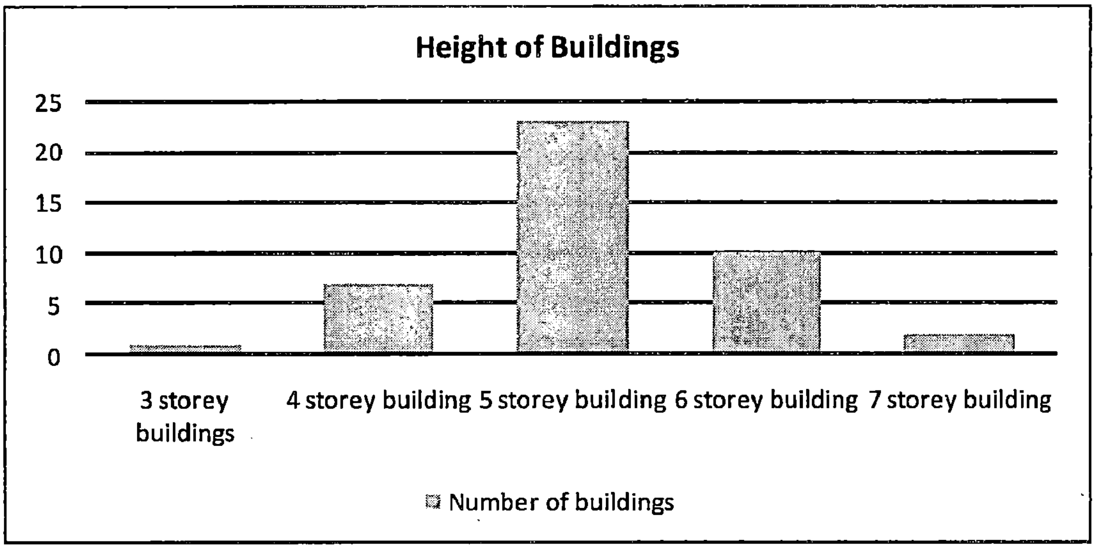


Fig 6.5: Height distribution of buildings in SDA complex

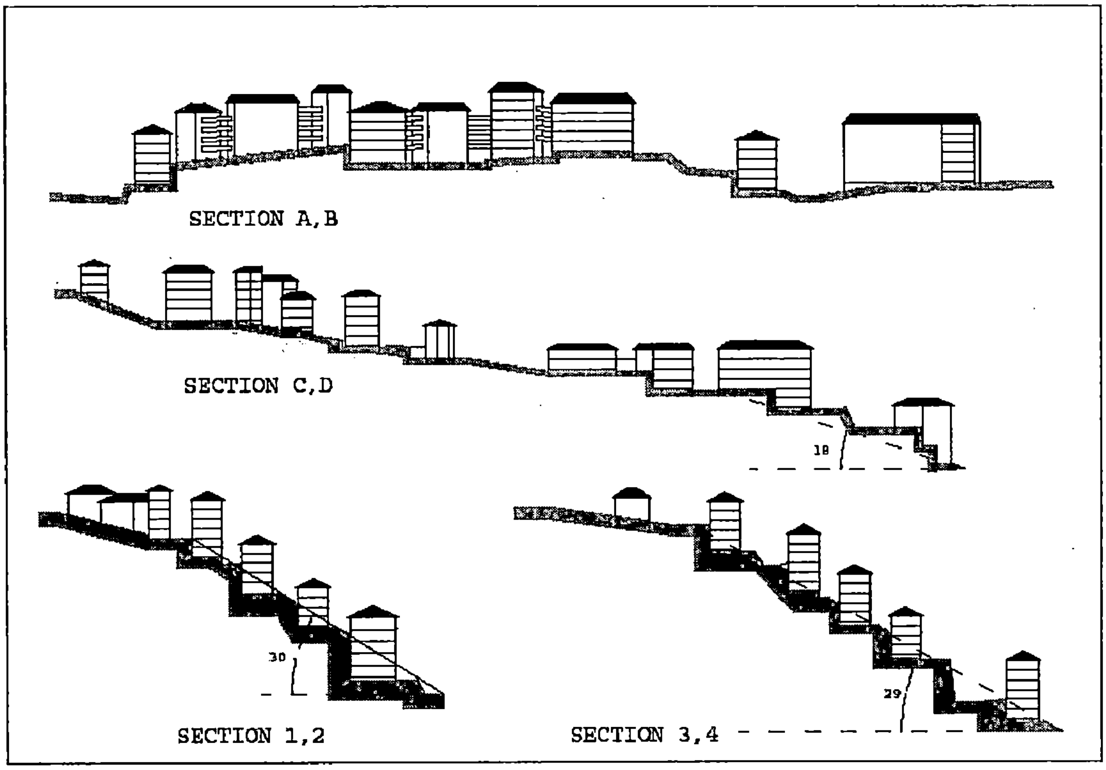


Fig 6.6: Schematic Site Sections

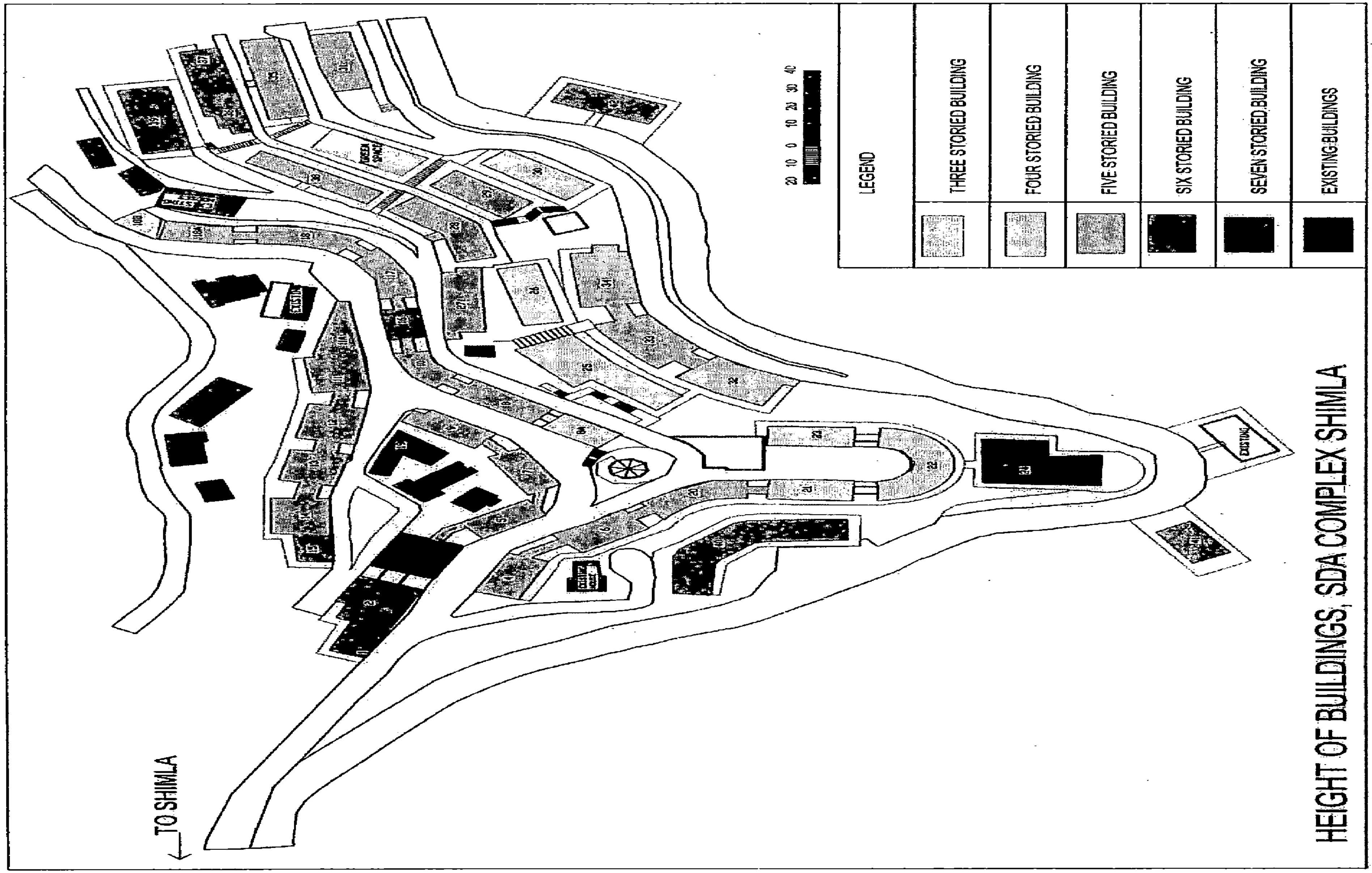


Fig 6.7: Plan showing heights of buildings in SDA complex

6.2.9 Structure

All buildings have R.C.C frame structure and sloping roofs are provided with GI sheets placed on steel trusses to facilitate the runoff of snow and rain and merges with the topographical profile/ backdrop of hills.

6.2.10 Facades of Buildings

Most of the buildings have horizontal and vertical bands of columns and beams and space in between is filled with stone masonry/ concrete blocks and glass. Some buildings have painted plastered surfaces as the exterior finishes whereas some have exposed stone work; new buildings are constructed in the complex which is in contrast to the overall character of the complex.

6.2.11 Services

Mid rise office buildings have elevators as the vertical means of circulations. No fire fighting provisions are provided in the complex. The garbage disposal system is inefficient and garbage is thrown towards the down slopes near the buildings causes environmental degradation. No sewage collection and system is provided in the area. The water supply demand of the residents is fulfilled by Shimla municipal council water supply scheme.

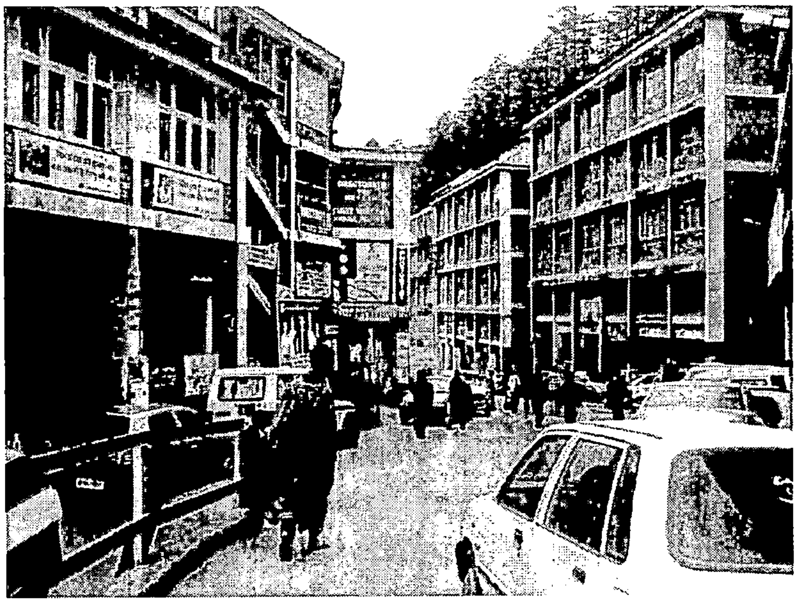


Fig 6.8: View of Main Road in SDA Complex

Fig 6.9: Building in Contrast to Whole complex

6.2.12 Public Spaces

No planned public space is provided in the complex and in buildings also interaction spaces are inadequate. No public infrastructural facilities or amenities like street furniture, drinking water facilities and public toilets are provided in the complex.

6.2.13 Safety Against Earthquakes and Landslides

buildings are designed on different leveled terraces, the slope of the site is more than the permissible for building development works, building blocks are designed in linear/rectangular shapes. Buildings are designed as R.C.C. frame structures in order to ensure better strength of structure. The minimum distance of the buildings from the edge of the hill is kept as 3 meters, however at some places it is 2 meters. Retaining walls are used to hold the cut slopes and filled areas.

6.2.14 Energy Efficiency

One of the famous energy efficient HIMURJA building designed by Arvind Krishan and Kunal Jain Is located in the complex. This buildings have sunspaces and trombe wall systems for heating the interiors. In other buildings also southern sun is captured by through glass windows to heat up the interiors. The buildings being on mid slopes and on the leeward side of the wind have protection from the cold chilling north winds.

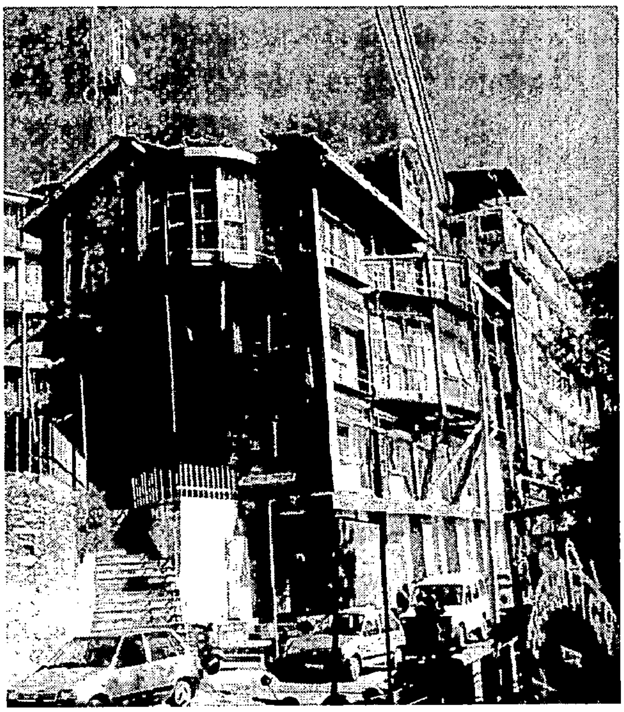


Fig 6.10: Energy efficient HIMURJA building in SDA complex

6.2.15 Landscaping

Open spaces are not treated properly. No consideration has been give for the designing of open spaces. Some wild shrubs and trees are grown on the open spaces. Only one building (SBI building) have some landscaped area developed as a series of steps. Ugly concrete retaining walls are presented as hard landscaped elements in the complex.

6.2.16 Roofscape

The complex has a interesting roofscape which is developed by combination of sloping roofs having different features. These sloping roofs presents a stepped series of red and green colours.

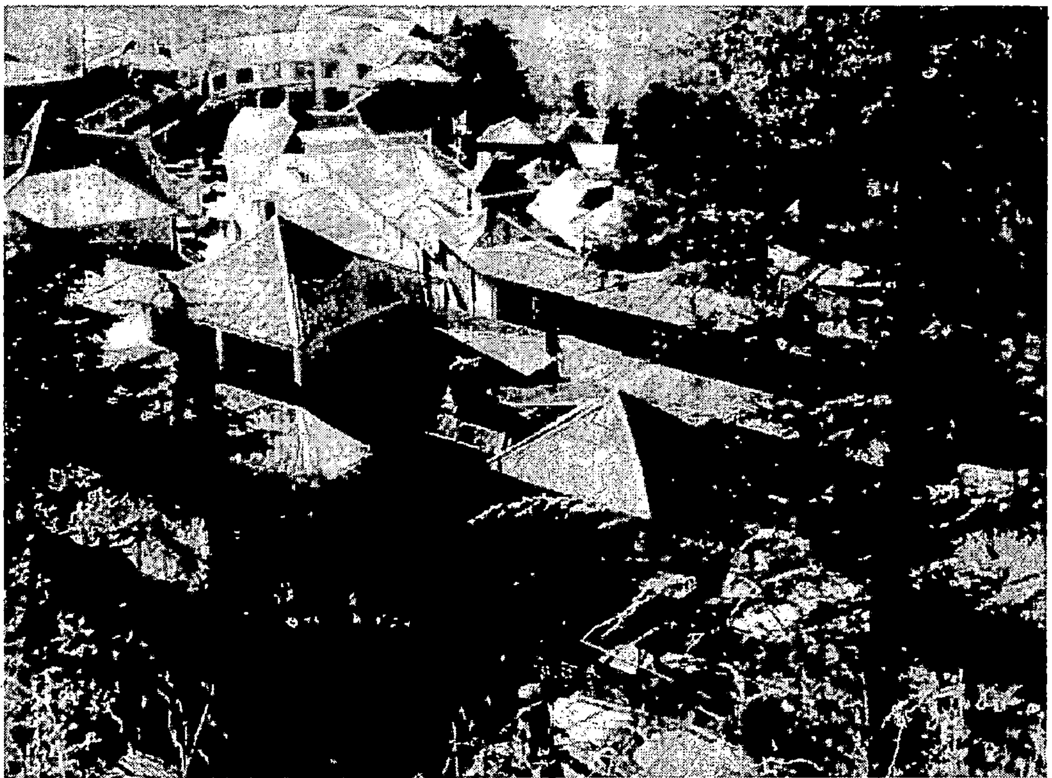


Fig 6.11 : Interesting roofscape of buildings

6.2.17 Problems in the SDA complex

The various problems related to mid rise buildings in the complex are as follows:

i) The roads provided have insufficient width and have greater slope gradients. The slope gradient of internal roads is high at different locations which are difficult to drive and vehicles parked on road makes it more tedious. This leads to frequent accidents.

ii) The condition of roads is poor, no rain water/ waste water drains are provided along the roads.

iii) Parking facilities provided are inadequate and most of the vehicles are parked on the roads in front of building blocks.

iv) Buildings are placed abutting the road, no set back is provided.

v) Most of the time roads are in shade as located towards the north of buildings and are not maintained.

vi) No provision for storm water collection and disposal.

vii) Space between the buildings is inadequate and often unutilized.

viii) No consideration for physically challenged/ differently able people

ix) Some portion of buildings remains under the shade throughout the day

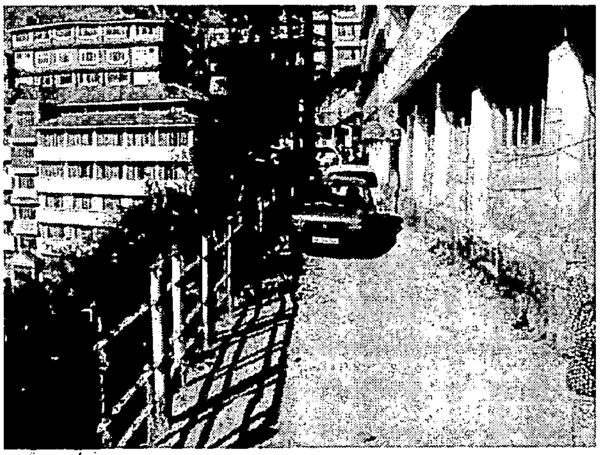


Fig 6.12: Parked vehicles hinders movement

Fig 6.13: Buildings abutting the road

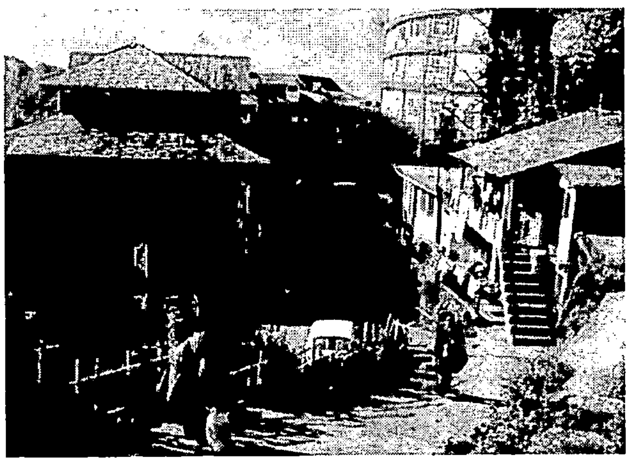


Fig 6.14: High gradient and shaded roads

Fig 6.15: Different Facades on Congested Road

Fig 6.16: Mid rise buildings in SDA Complex, Shimla

6.2.18 Inferences

The various inferences drawn from the case study of SDA complex are as follows:

i) The site selected for the complex is on southern sloping hill and is located on the mid hill area results in the maximum solar exposure and minimum exposure to cold winds.

ii) Access to the site is through 12 meter wide road. And for internal roads hierarchy of internal roads are used as 9m, 6m, 4.5m and 3m depending upon the traffic conditions though the slope gradient in roads is high at different places.

iii) Buildings are placed at different leveled terraces made after cutting the hill slope on the southern sloping hill. Due to their placement on different leveled terraces, the solar access of one building is not stopped by the other as half of the building is placed below the ground of other building. Which may not be the case in mid rise buildings at same leveled ground.

iv) The edge distance from the cut slope or edge of the hill is kept as 3m and the cut slopes are stabilized with retaining walls. Stone or RCC retaining walls are used depending upon the height of rating wall and load coming on to the wall the materials.

v) The side set back of building is kept as 1.5 meters which is usually less and is not used for any purposes. Usually buildings starts from the road itself without any setback results in congestion on roads and vehicles are parked on the road due to absence of any proper provision hinders the movement on roads.

vi) No provisions or considerations are taken in planning and design for physically disabled or challenged persons.

vii) No pedestrian pathway is provided along the roads. Pedestrian pathways are provided across the contours to connect the terraced grounds, which usually have high steps for climbing.

viii) Buildings though placed along a road have different plinth heights in accordance to the slope of road to minimize the cutting and filling.

ix) Due to sloping topography different entrances to a block are easily made.

x) The parking facilities provided are very less, results in parking of vehicles on roads which leads to traffic jams and hindrance in movement of vehicles and pedestrians.

xi) Building facades are simple and unattractive or aesthetically unpleasing.

xii) Sloping roofs with dormer and clear storey windows at different levels in the complex makes an interesting view/ skyline.

xiii) RCC frame structures are used in buildings.

xiv) Though mandatory as per the byelaws, no considerations for rainwater harvesting are taken in the complex.

xv) The services provided in the complex are insufficient.

xvi) No Parks or recreational areas are provided to the people working in the complex.

xvii) Only two restaurants and 3 tea shops are present in the complex which is lesser as compared to number of persons working and visitors in the area.

xviii) Energy efficient building is an integral part of the complex.

After the area level study of mid rise buildings in Shimla, there is a need to study existing mid rise buildings to understand the various issues and aspects of mid rise building design in hill regions.

CHAPTER VII

CASE STUDY: MID RISE BUILDINGS IN SHIMLA

7.1 INTRODUCTION

The chapter includes study of some mid rise buildings like, Railway board building, High court buildings, Police Headquarter building and Nirman bhawan in Shimla in order to highlight the various issues of building design such as site planning, functional efficiency, structural system, energy responsiveness, appearance and materials used. This chapter also discusses the comparative analysis of these buildings and the inferences.

7.2. CASE STUDY I: RAILWAY BOARD BUILDING, SHIMLA

The railway board building is a heritage structure built by the British in 1896-97 as public works department building. This is a unique colonial style cast iron structure, along with overwhelming use of iron pipes in its façade, is distinct in the style. Besides Railway Board Building, the famous Raffles Hotel in Singapore is only such building in South Asia. Railway board building has 7 storeys including three basements and total height of the building is 25.00 metres. On the mall road side, appears as four storied structure with height varying from 11.00 metres to 15.50 including three partial basements. Presently, it houses 8 different public offices and approximately 1500 staff members.

7.2.1 Location

The building is located along the mall road on southern slopes of the hill on which the core area of the town is located. This building is located at the western end of the mal road of Shimla.

7.2.2 Site Planning

Railway board building is located on a sloping site having steep slope. It is placed on mall road without any set back. It is a rectangular/ linear building of 80mx18m, oriented along north- south direction. The southern façade is exposed to direct sun throughout the day whereas the northern part of the building receives only diffused light. No parking is provided in the building.

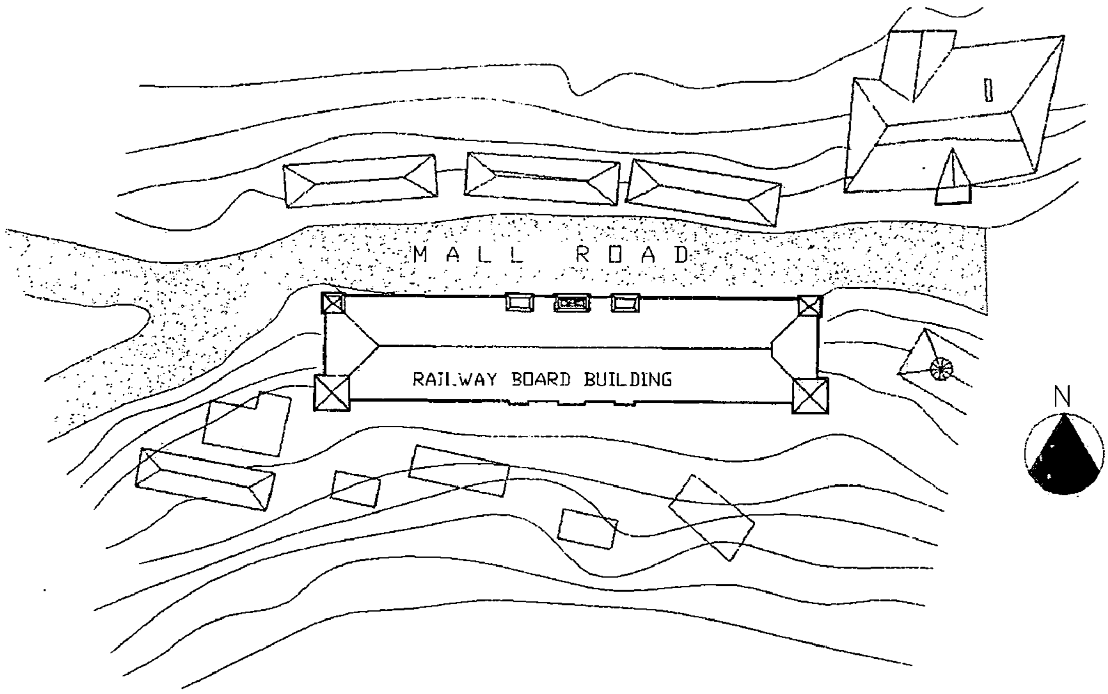


Fig 7.1: Site Plan of Railway Board Building, Shimla
Source: B.Arch 2009 batch, IITR

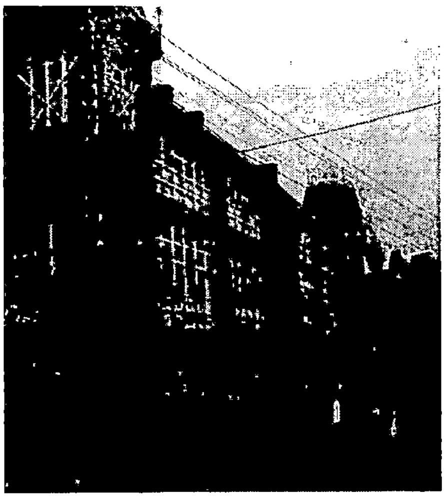


Fig 7.2: North facade of Railway board building

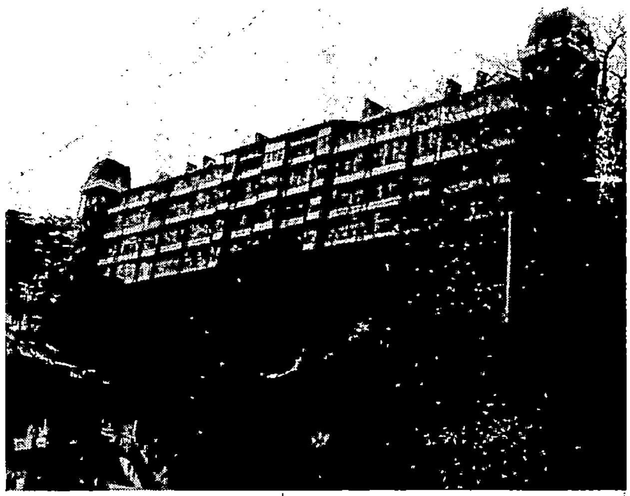


Fig 7.3: South view of the building

7.2.3 Building Design and Functions

2.4 m wide corridor is running around the building, acts as means of horizontal circulation. The work spaces/ rooms are located inside the corridor. Same distribution of spaces/ area is followed on all the floors.. The length of corridor is high as compared t its width. Cast iron staircases are provided at different locations acts as vertical means of circulation within the building. Staircases are provided in the corridor itself Service cores are provided on the south-east and south west corners of building including toilets and emergency fire exit staircase. The public aminities like toilets provided in the building are inadequate.

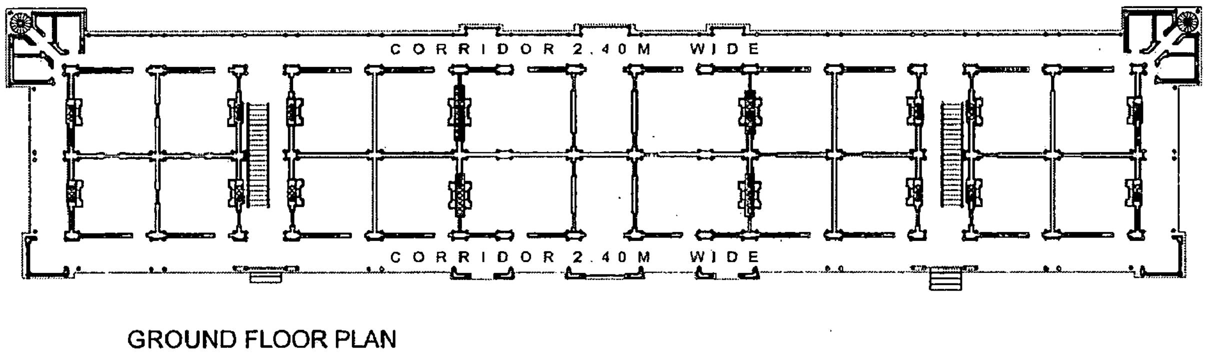


Fig: 7.4: Ground floor plan of railway board building
Source: B.Arch 2009 batch, IITR

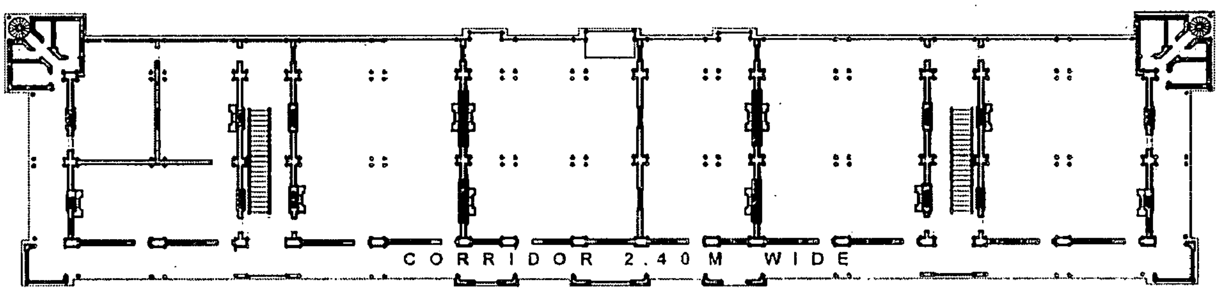


Fig: 7.5: Third floor plan of railway board building
Source: B.Arch 2009 batch, IITR

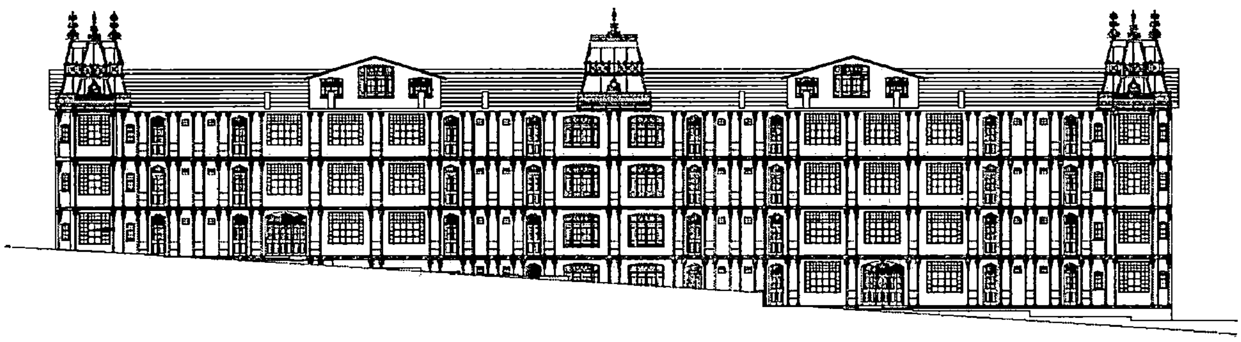


Fig: 7.6: Front elevation of railway board building
Source: B.Arch 2009 batch, IITR

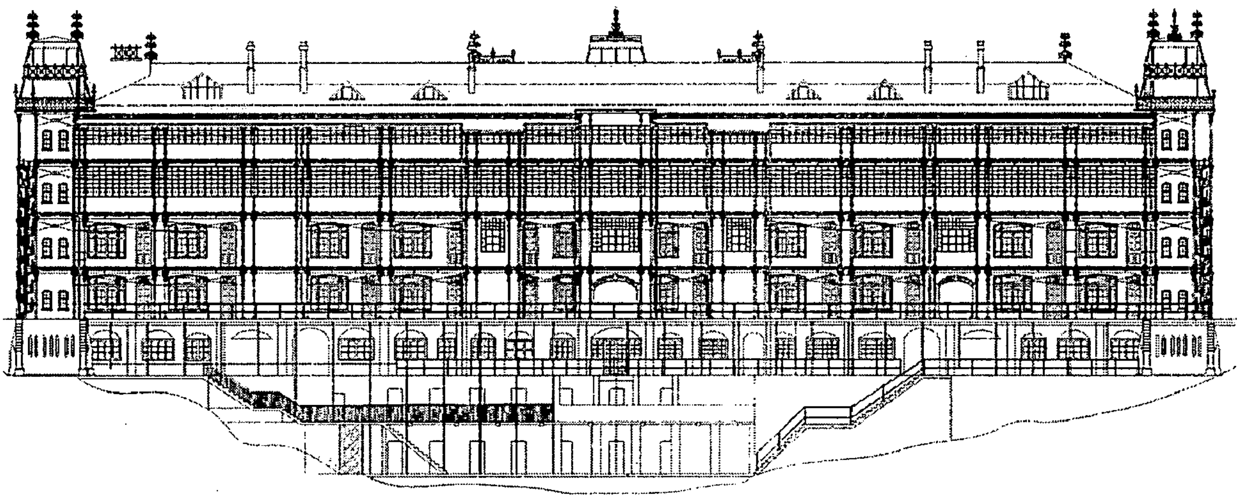


Fig. 7.7: Rear elevation of railway board building
Source: B.Arch 2009 batch, IITR

7.2.4 Structure

The railway board building has a frame structure consists of the columns and beams of cast iron. The walls are made up of brick masonry in lime mortar and timber. GI sheets are used for roofing. Four cylindrical cast iron pillars are used to form a column. Glass is extensively used on north and southern facades. The vertical load carrying members are tied with each other at various levels through iron rods. The joints between the members are flexible for thermal expansion and contraction within the members.

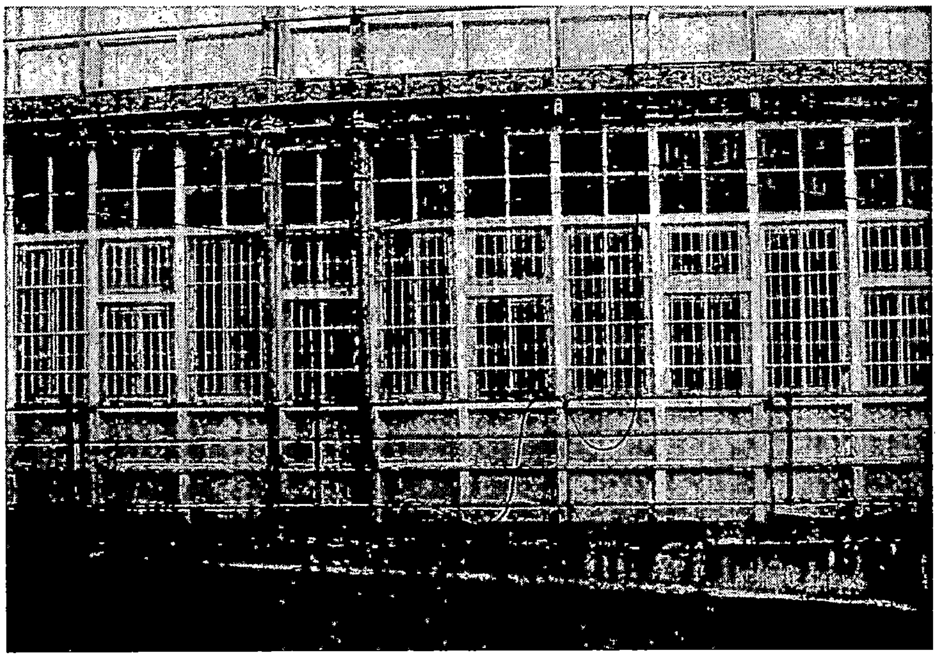


Fig 7.8: Structural members in the facade of building

7.2.5 Circulation

Corridors are the horizontal means of circulation, which runs all around the building forming a loop. Steel staircases are provided for vertical circulation in the building. No mechanical means of vertical circulation is provided. Spiral staircases are provided in the service core for emergency.

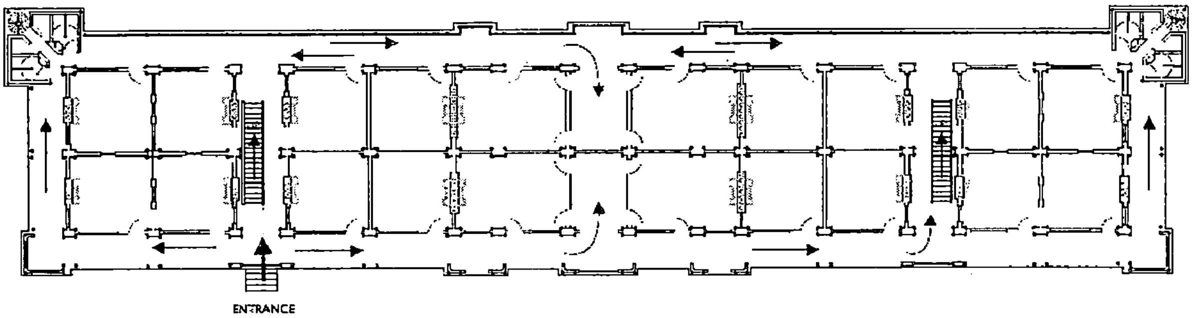


Fig 7.9: Circulation pattern in building

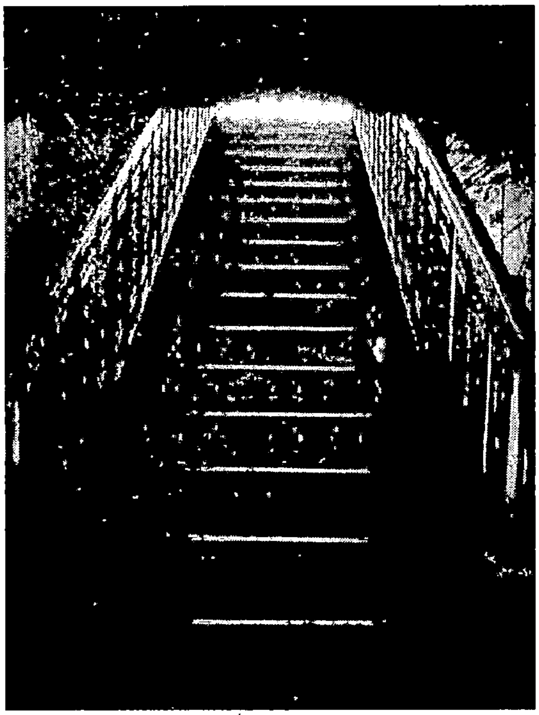


Fig 7.10: Cast iron staircase

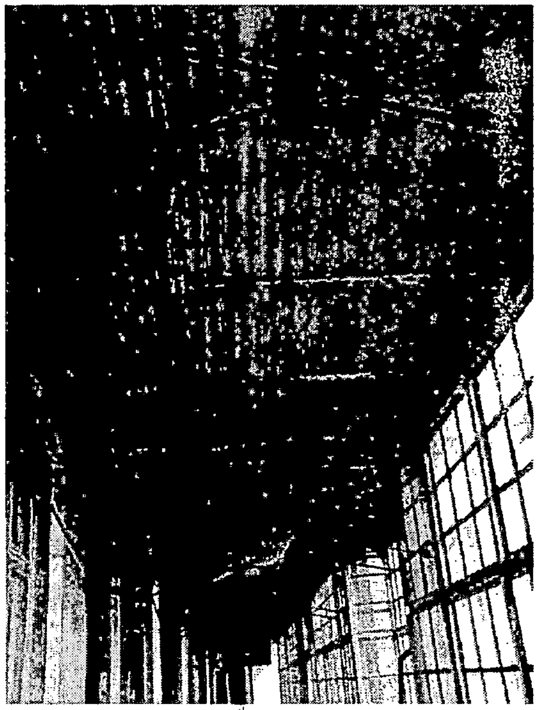


Fig 7.11: Bracings in the corridor

7.2.6 Safety Considerations

Framed structure made of cast iron columns and girders in provided. No edge distance is provided from the edge of the hill. Various load bearing members are braced to each other through iron rods. The joint between the various members is flexible. Horizontal and vertical members are tied to each other through iron pipes in the facade of the building. Retaining walls are used to hold soil in foundation.

7.2.7 Climatic Response

The building is located on the ridge of hill. It is exposed to cold winds from the north though the lower floors are protected by the buildings behind. Due to its being taller than those behind and its location on the south of the road, the road as well as the buildings on the northern side of this building do not receive sun in winters as the sun angle is lower in winters. Although the building itself is oriented with its major axis along north south direction thus the southern façade is exposed to direct sun having continuous glass windows entraps solar radiations throughout the day. The heat gain is further increased due to dark colour painted sloping roof. The north parts of the building being shaded need more energy for heating the interiors to comfort level than the southern part of the building and day light received is also inadequate for carry out daily works.

Fig 7.12: Glazed north facade

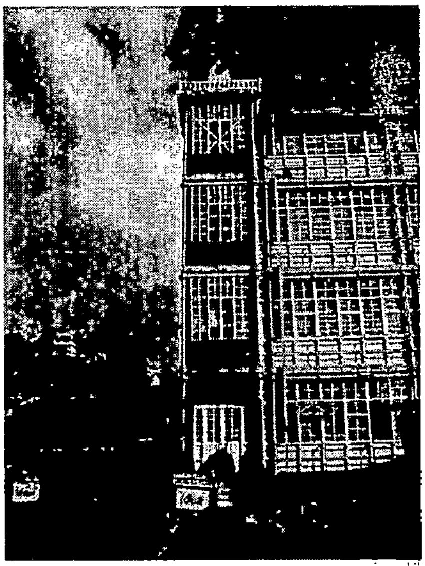


Fig 7.13: Shaded road on the north of building

7.2.8 Appearance

It is a symmetrical building and architectural masterpieces. The expressive faced is created with glass, bricks, timber and structural members. It is a symmetrical combination of solid and voids, red and white colour. The silhouette of building is improved by red coloured sloping roof, dormer windows and pyramidical roofs over corner towers. Sculptures made of cast iron are used at the ridge level of the sloping roof to make skyline of the building interesting.

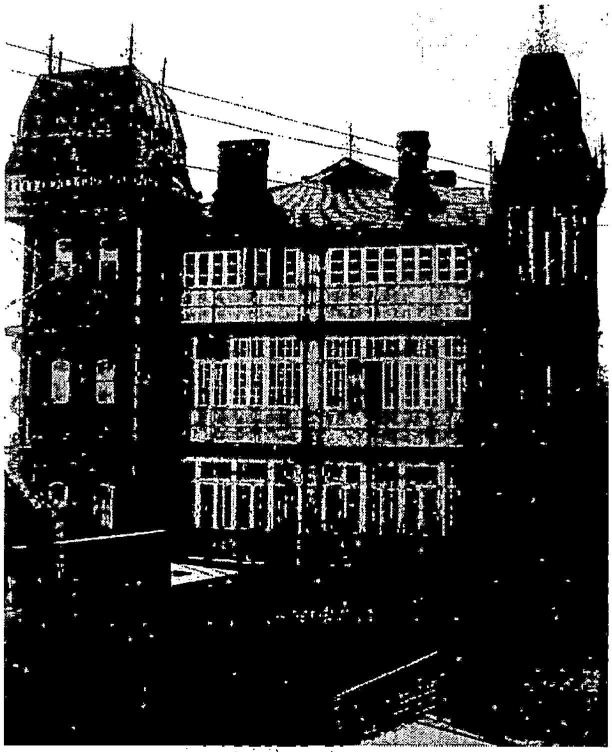


Fig 7.14: Cast Iron Spiral Staircases for Emergency Exits Fig 7.15: East Facade of the Building

7.2.9 Merits

i) Building stands in its present form from more than one century with minute renovation, one of the iconic buildings of British period in Shimla.

ii) Proper use of southern sun for lighting the corridors.

iii) Innovative / unconventional/ unique structural system use of cast iron columns and iron girders with interconnecting iron pipes at various levels

iv) For earthquake safety, framed structure is used; various members are braced to each other with flexible joints.

v) Symmetrical building, aesthetic pleasure is created through symmetrical arrangement of the entire component along two axes.

7.2.10 Demerits

i) Building is placed on the road without any set back, building opens up directly on road, no area for landscaping and road on the northern side remains in shade.

ii) No provision/ consideration for parking of vehicles results in the congestion on road due to parked people.

iii) The daylight level in the working areas is very less due to presence of corridor on the periphery; though longer side of building faces south leads in high consumption of energy.

iv) No edge distance of the building from the edge of hill.

v) Basement used for storage purposes are damp.

vi) The services provided are insufficient/ inadequate and difficult to maintain.

vii) No space for common lunch is provided.

viii) Insufficient fire safety measures in the buildings. A fire in 2000 burnt most of the records - a loss of Rs. 9 crores.

ix) Long corridors along the periphery of the building make the circulation unidirectional and inconvenient movement.

x) Staircase in between the corridor makes the circulation difficult and congested.

xi) Being on ridge upper floors experiences more cold wind, result in more consumption of energy for maintaining comfortable indoor temperature.

7.3 CASE STUDY II: HIMACHAL PRADESH HIGH COURT, SHIMLA

The high court building is one of the most prominent modern and tallest buildings in Shimla. The towering modern building also symbolises the transition from the traditional architecture to contemporary style. This building has 11 floors including 3 basements. Basement of building is used for building services and parking.

7.3.1 Location

The building is situated near the eastern end of mall road on the mid slope of southern side. As the building is presented on the independent hill top no other structure is presented close to this building

7.3.2 Site Planning

It is built on a sloping site having total level difference of 20m in site. The building is a rectangular in plan and having upper floors projected out over cantilevers. The total built up area of building is 12,750 sq m including parking facilities in 2000 sqm in basements. Building has its major axis along southwest- north east direction. The entrance to building is 6 m below the connecting which can be approached through series of steps and ramp built on the foreground/ in front of the building. A separate parking lot is provided near the high court to cater the parking needs of visitors.

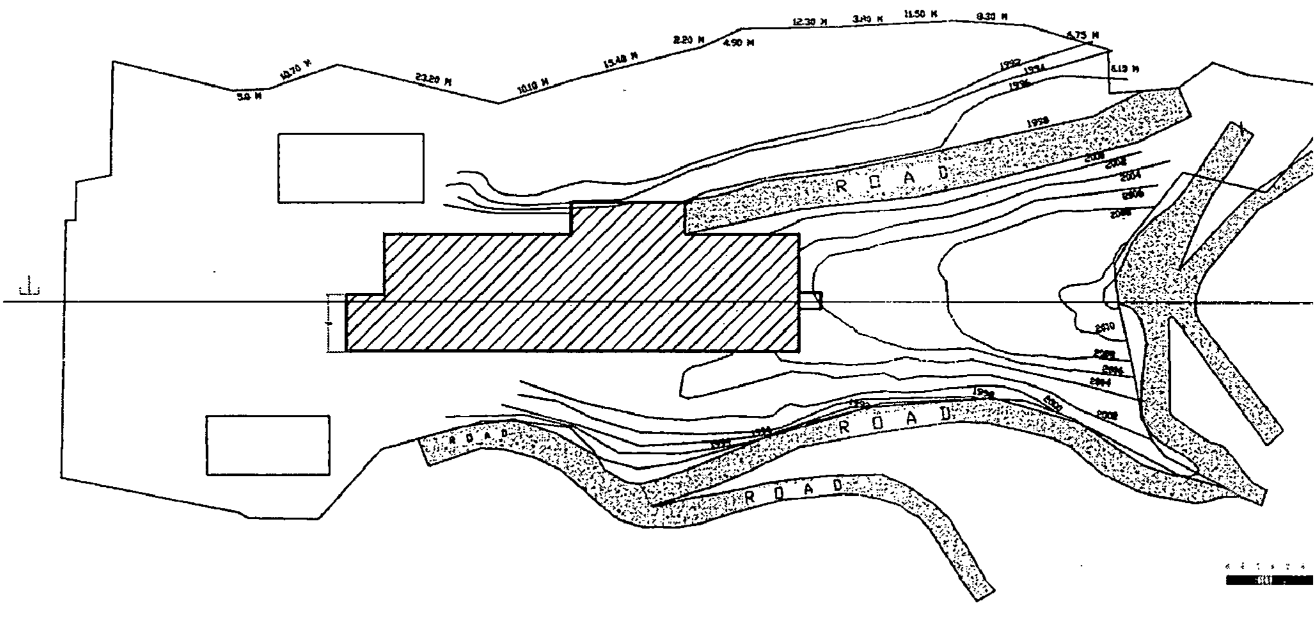


Fig 7.16: Site plan of high court complex, Shimla
Source: H.P.P.W.D Shimla

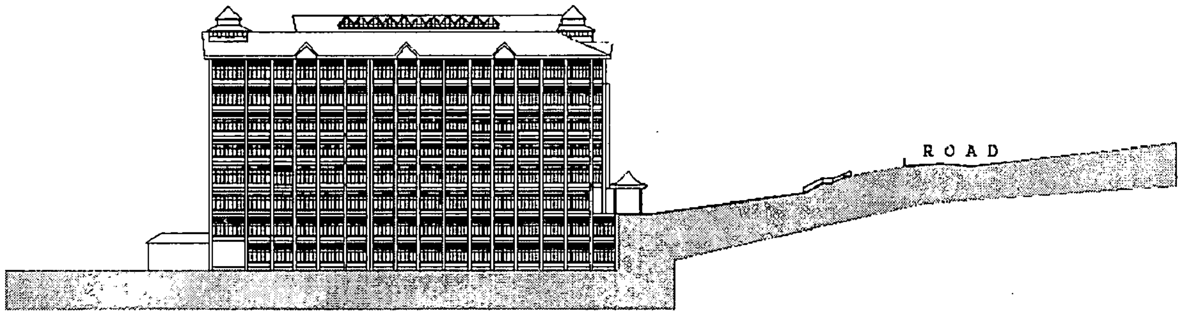


Fig 7.17: Site section of high court complex, Shimla

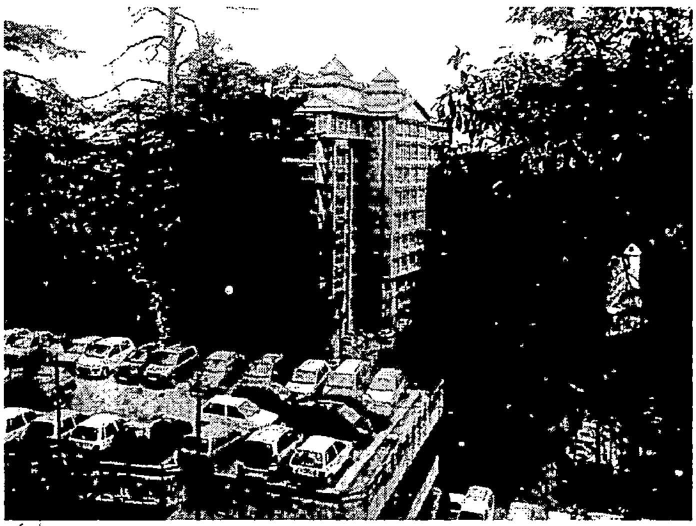


Fig 7.18: Insufficient Parking Provisions

Fig 7.19: vehicles parked along the road hinders traffic

7.3.3 Building Design and Functions

The main approach to the building is 6 meter below the road level and at second floor level to the building. Building is rectangular in plan having bar rooms, eight courts along with chambers, library and a computer centre. The access to various areas is through corridor. Staircases and lifts are provided at different locations acts as vertical means of circulation. Total height of building is 43.50 m. depending of area requirement for different activities at different floor levels, corridors are provided either at centre or at edges.

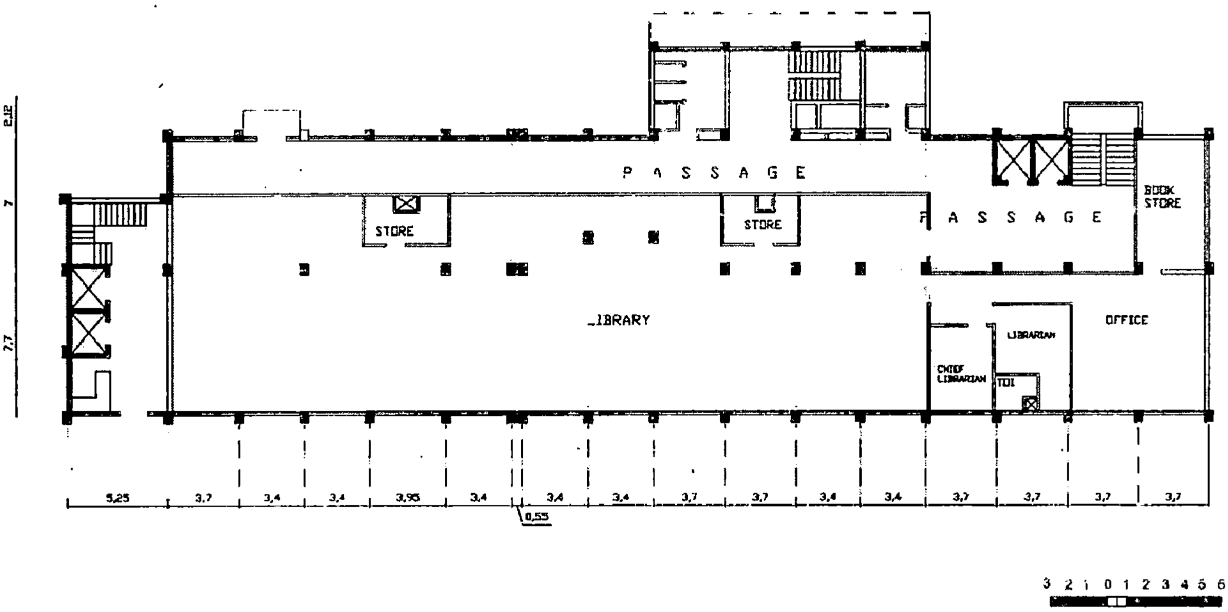


Fig 7.20: Ground floor plan of High Court Building, Shimla
Source: H.P.P.W.D Shimla

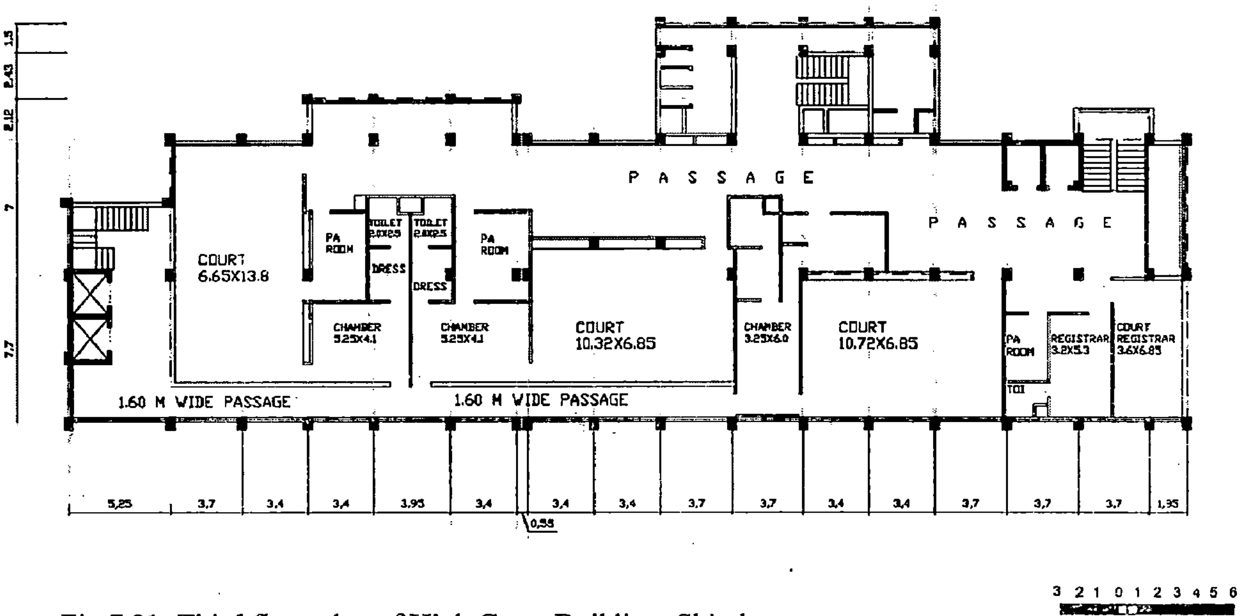


Fig 7.21: Third floor plan of High Court Building, Shimla
Source: H.P.P.W.D Shimla

7.3.4 Structure

Building is a RCC framed structure having grids as 3.6mx7.5m, 3.6x7.0m, 3.6mx4.5m, 5.5x7.5m. the column size is of 75cmx45cm. The site is properly stabilized with stone retaining walls for landslide protection. There is a shift in the location of column on different floors. 2m shift in the location of all the columns on the exterior grid at the seventh floor level.

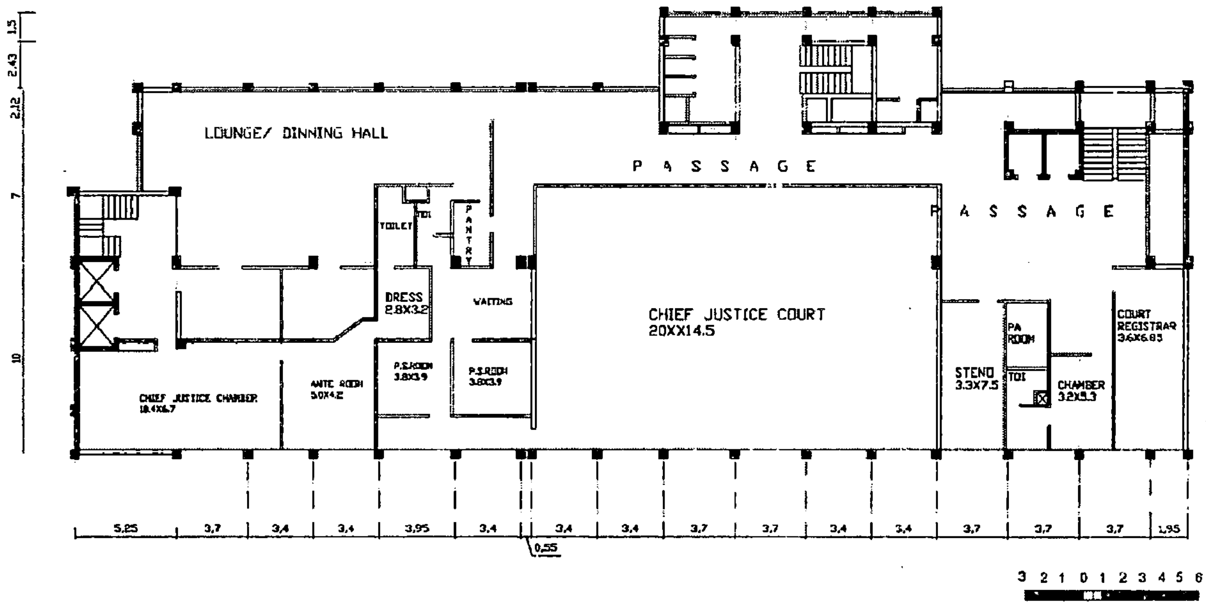


Fig 7.22: Seventh floor plan of high court Building, Shimla
Source: H.P.P.W.D Shimla

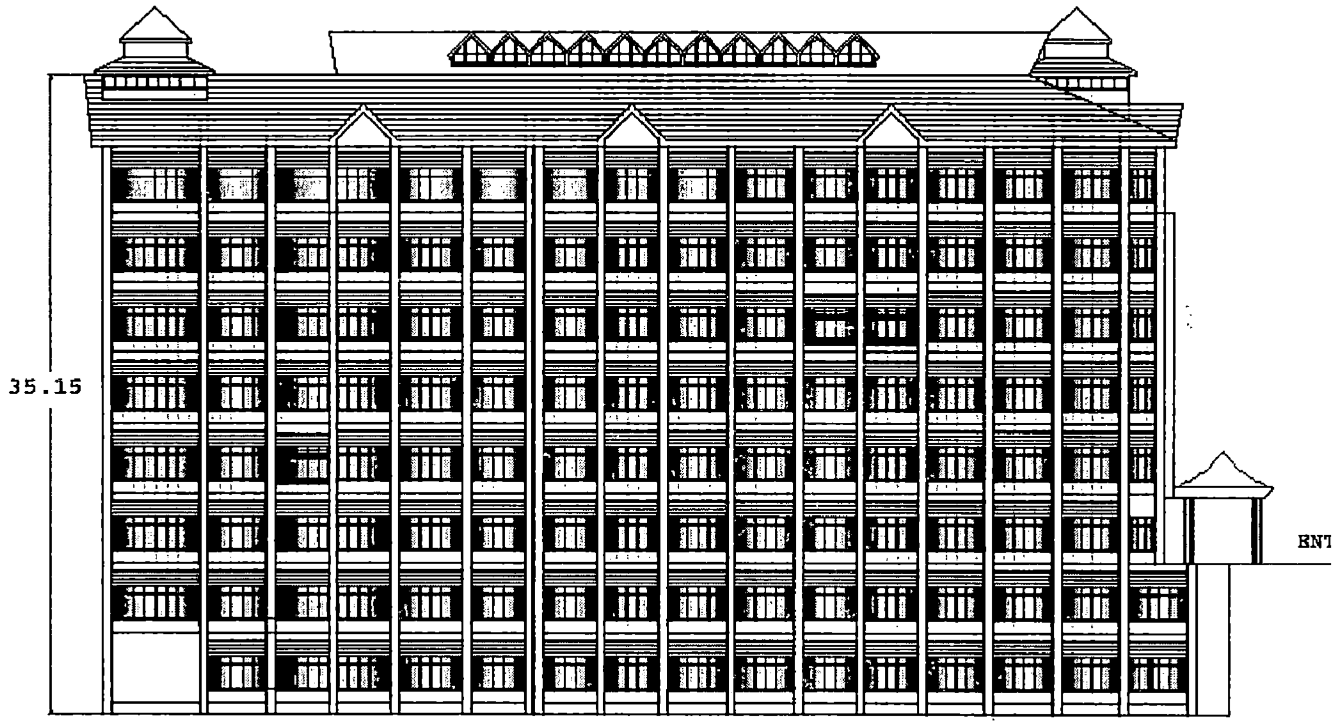


Fig 7.23: Side elevation of high court building Shimla
Source:

7.3.5 Services

Three service cores are provided, one is at the centre consisting of lift, staircase and well furnished toilets and two at corners comprises of vertical means of circulations in the building. Lifts are provided as mechanical means of vertical circulation. The public amenities are provided at every floor. Fire hydrants are provided at suitable locations at every floor. Electricity generators are located in the basement for power back up.

7.3.6 Safety against Natural Hazards

R.C.C frame structure is provided. Seismic joint is provided at suitable location. Rectangular configuration of building is chosen for better seismic response. the changing location of vertical load bearing members at different floor levels and cantilevered columns at third floor level decreases the seismic adequacy of the building. Light weight GI sheet roofing is provided.

The minimum edge distance of the building from the edge of hill is 4 meters. Concrete retaining walls are used to stabilise the soil in basements. For site development purposes stone retaining walls are used to hold the soil in place. The proper site drainage system is provided for runoff rain water. Weep holes are provided in the retaining walls.

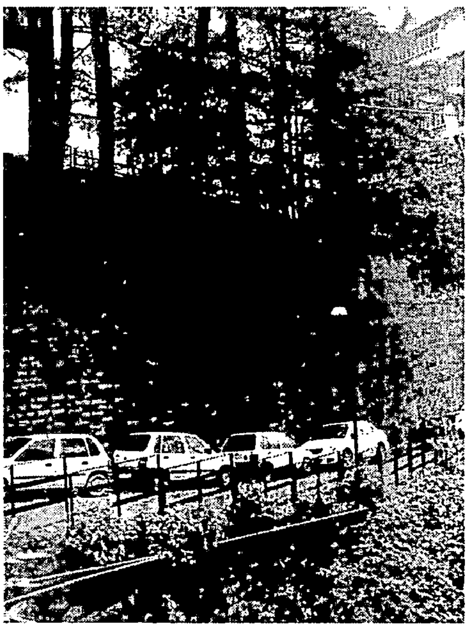


Fig 7.24: High retaining walls may leads to landslide

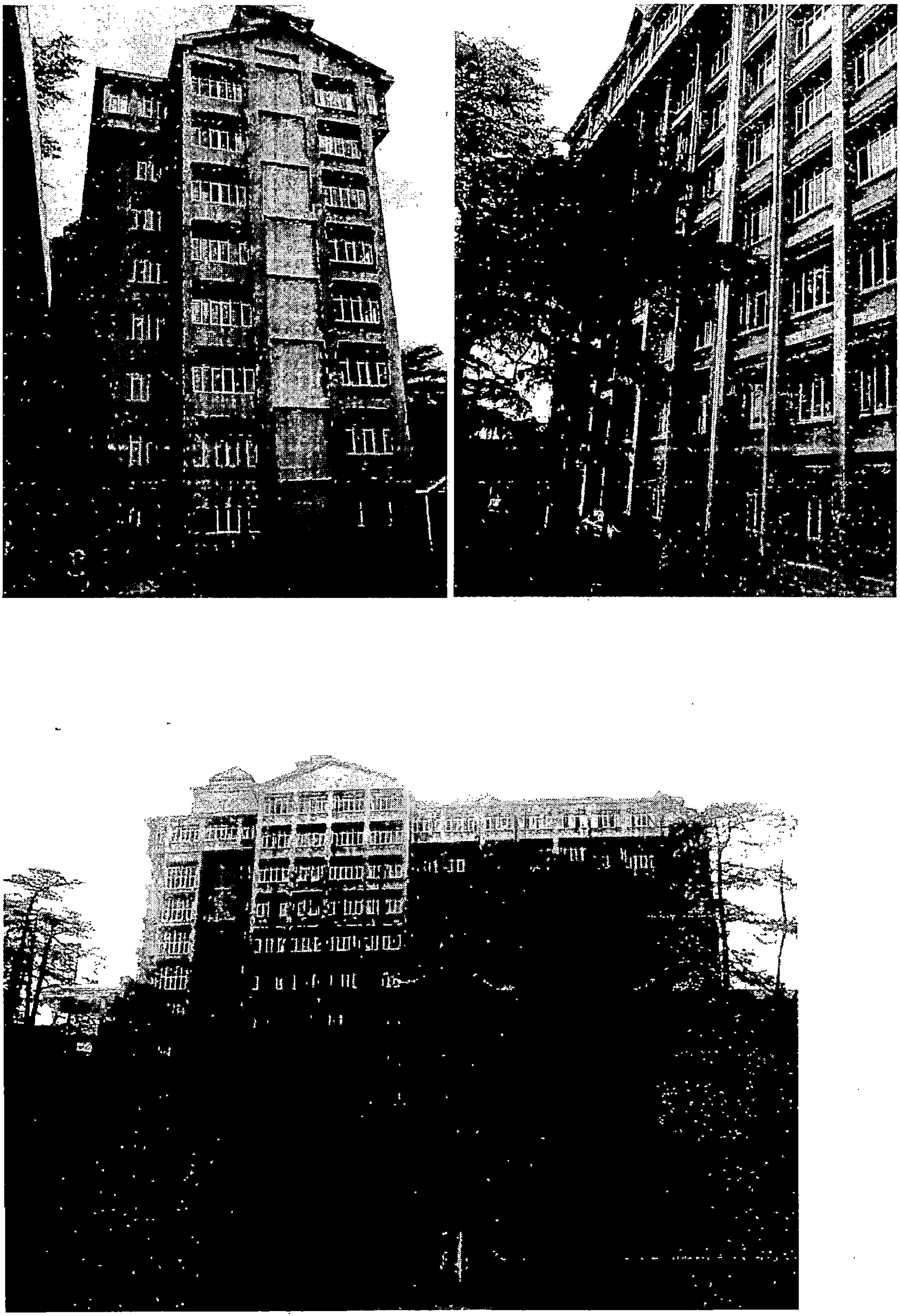


Fig 7.25: Different views of high court building, Shimla

7.3.7 Climatic Consideration

Building has its major axis along southwest- north east direction. As the building is presented on the independent hill top no other structure is presented close to this building which gets affected by the shadow of the building. Due to more height of building upper floors experiences more wind but its effect will be minimised by the trees presented on the north of the building. Windows are provided on every facade to get sufficient daylight. Wide terrace on the southern side also allows better sun penetration in the building.

7.3.8 Materials used

Reinforced cement concrete, composite stone masonry, sand stone, bricks, timber, aluminium glazing and GI sheets are the main materials used in buildings.

7.3.9 Appearance

The upper floor of the building is projected out on cantilevers resembles the building form to the form of columnar temples. The building has a faced made up of horizontal and vertical bands. Vertical continuous bands are of structural columns running throughout the building, which are braced by horizontal bands at different levels. The space in between is filled with sand stone, glazing and concrete sun shade finished with cement plaster. The silhouette of building is improved by the interesting sloping roof at levels and dormers. Hard and soft landscape is provided in front of building. Local deodar trees are planted at different locations.

7.3.10 Inferences

i) Discontinuity of the structural frame at different floors. At top floor the location of exterior column is shifted by 2m results in less strength of structure.

ii) Major cantilevered projections may results in destruction during earthquake

iii) The building being the tallest in town is in contrast to other surrounding buildings.

iv) Parking demand of building is very high; facilities provided for parking are insufficient.

v) Higher retaining walls more than 17 m high in front facade are used for creating flat terraces for landscaping.

vi) Though on midlands, upper floors experiences high wind velocity due to increased height.

vii) No measures for rain water harvesting or energy efficient measures.

viii) Linear arrangement of various areas/ spaces results in linear building block having more length to width ratio.

7.4 CASE STUDY III: POLICE HEAD QUARTER COMPLEX, SHIMLA

This complex consists of three interconnected block planned and constructed on different levels. It is located in Chotta Shimla, newly developed area outside the main town at a distance of 6 km from the core area. The buildings consist of seven floors having total built up area of 10,835 sqm each.

7.4.1 Site Planning

Site is located in mid slopes of southern sloping hill. Total level difference in site is 49 m and slope angle is 28^{o}. Complex is divided into three different blocks having east west, northeast- southwest. Road is at the higher level of site. From the road, building appears to have only three storeys. Parking is provided in the basements and on terrace of parking block adjacent to building.

Fig 7.26: Views of police headquarter complex, Shimla

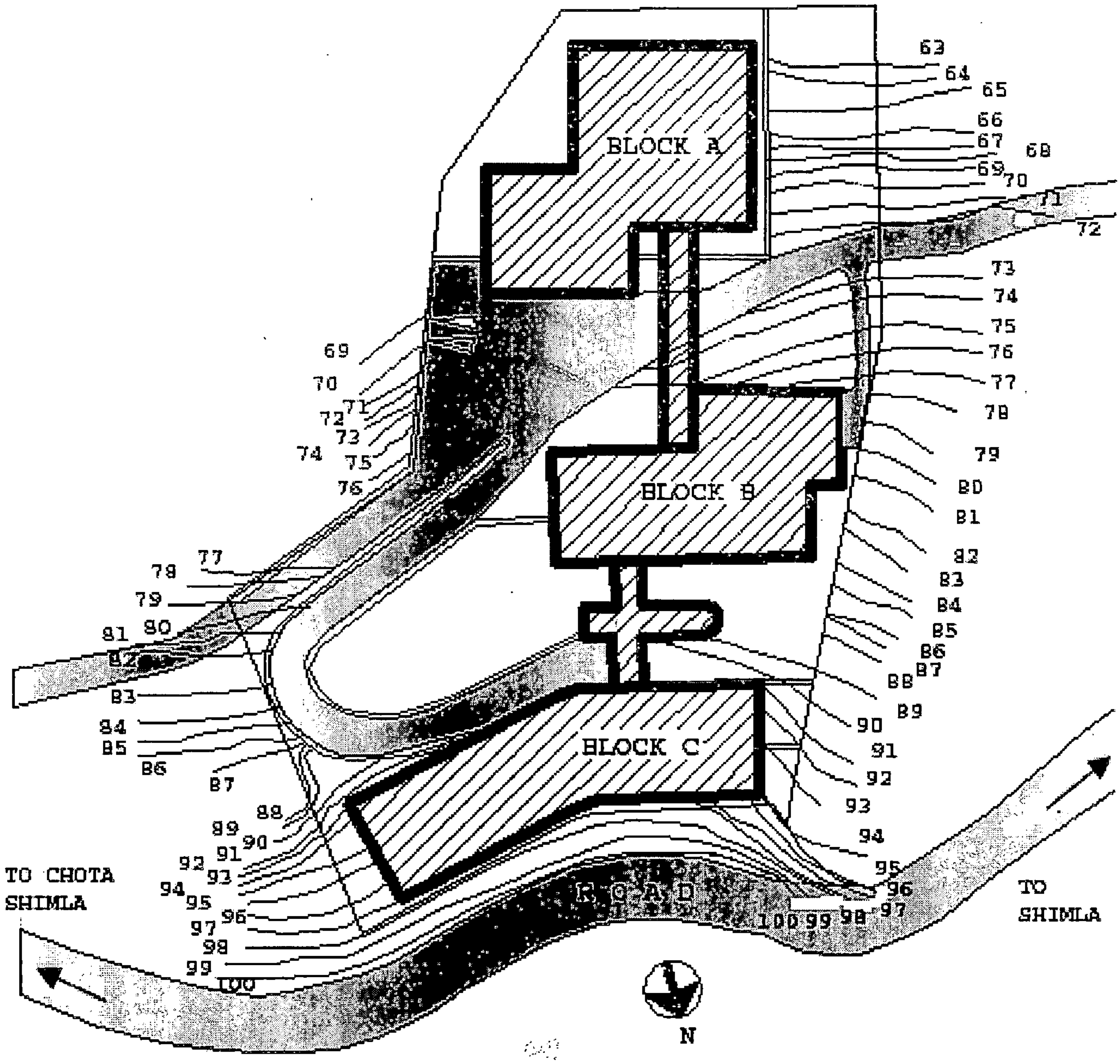


Fig. 7.27: Site plan of the police headquarter complex, Shimla
Source: H.P.P.W.D Shimla

7.4.2 Building Planning and Design

In different blocks the various rooms are placed along 1.80m wide corridor which runs throughout the length of building. These different blocks are connected with each other through the service core areas, having lifts and staircase in common areas. Fire alarms, fire hydrants and staircases of external walls are provided for fire protection. Parking facilities are provided as onsite, basement as well as terrace parking. Upper floors are projected out on cantilevers.

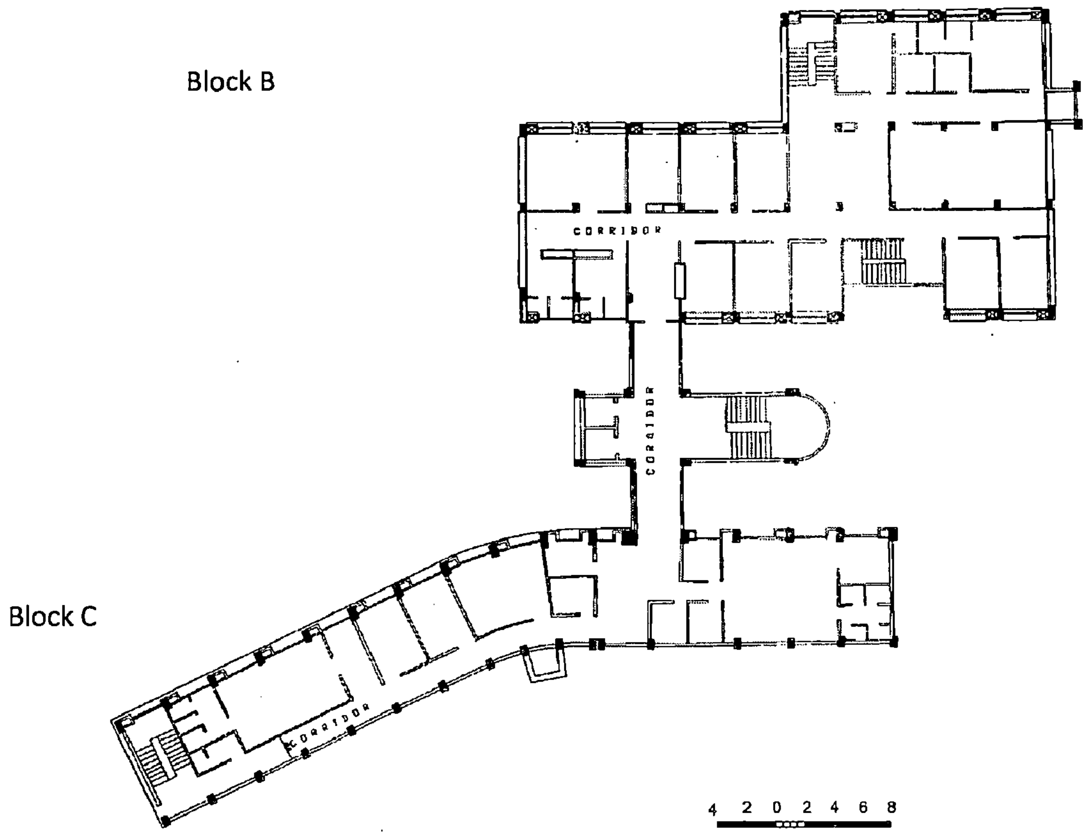


Fig 7.28: Plan of block B & C of police complex, Shimla
Source: H.P.P.W.D Shimla

7.4.3 Structure

RCC frame structure is used in building having column sizes 40x60 cm & 40x80cm. Building has grids of 3.3x6.90 m and 3.3x5.0m. Earthquake considerations are taken in structural design of building. Buildings have regular forms and sesmic joints are provided at suitable intervals. Concrete retaining walls are used to hold the earth at various levels.

7.4.4 Safety against Disasters

The site has a higher slope gradient. But the building is divided into three blocks placed at different levels to ensure better strength. R C C framed structure is provided in the building having column size of 40cm x 60cm and 40cm x 80cm . Different building blocks are separated by each other by seismic joint. Concrete retaining walls are used to hold the soil of cut slopes in basements. Retaining walls as much higher as 10 m are constructed for road construction. No special consideration is given for the drainage of runoff water.

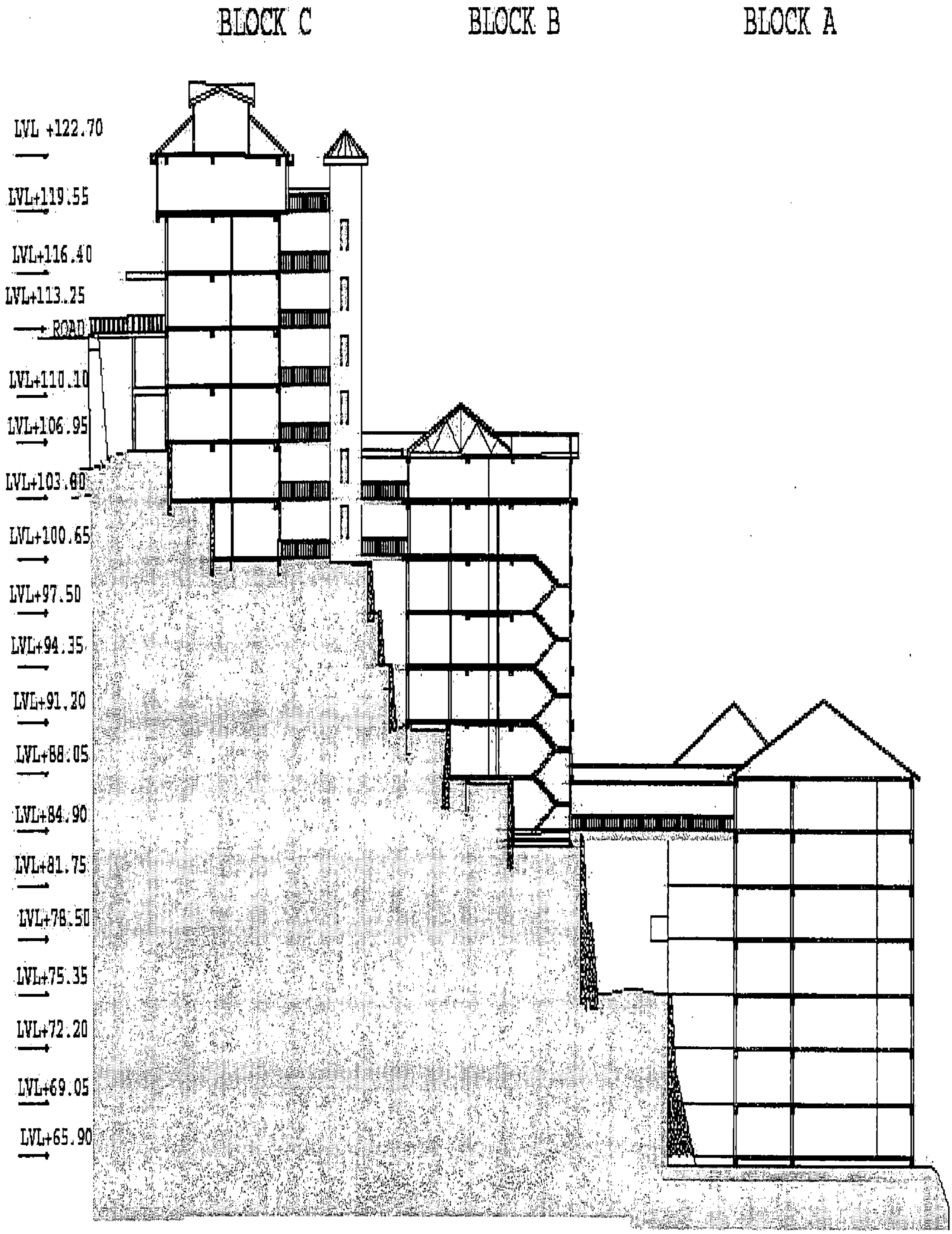


Fig 7.29: Building section at A,B

7.4.5 Materials Used

Reinforced cement concrete, sand stone, bricks and Gl sheets are the main materials used in the construction of building.

7.4.6 Service Core

Service cores are provided at the edge of each block, toilets, drinking water facility and stairs for vertical circulation. Whereas service cores shared between two blocks comprises of lifts and staircases for vertical circulation. Total 4 lifts are provided in the building complex. Fire house cabinets are provided at every floor. And all the stairs are on external face of building.

Fig 7.30: Block C of police complex

7.4.7 Climatic Response

Building is located on the mid slopes of leeward hill having protection from cold wind. Windows are provided on the southern facade to entrap sun. Due to step in type of building most parts of building gets direct sun.

7.4.8 Appearance

Upper floor is projected out on cantilevers to break the cuboidal shape of the building. Sloping roofs and connecting bridges are the main elevation features. Facade of building is combination of plastered surface, sand stone masonry, vertical and horizontal bands and glass windows. No landscaping design to external areas.

7.4.9 Inferences

i) Site having high slope gradient is used for the construction of building

ii) Built on the lower side of the road on southern slopes, appears to be three storied from the entrances.

iii) Built across the contours in different level, an example of stepback setback building, which imparts high stability and ensures proper solar access to every building block.

iv) 10 m high retaining wall is used to retain road and entrance is provided to building.

v) 3m wide space is kept between the road and building to ensure some light and ventilation in the rear ends of the basements.

vi) Upper floors are extended on the cantilevers results in decrease in structural stability of building.

vii) In different blocks, 1.80 m wide corridor is used for circulations. Rooms are placed on one side or both side of the corridor.

viii) The vertical circulation services are placed in between two blocks and are shared by users of two blocks.

ix) No provisions for rain water harvesting or rain water drainage.

7.5 CASE STUDY IV: NIRMAN BHAWAN, SHIMLA

This is newly constructed H.P.P.W.D office building at Chotta Shimla. Total built up area of this building is 6850 sq m. Building has 8 storeys including 2 basements. Total height of the building is 32.6m. Deigned with an atrium at the centre and various rooms are located around the atrium. Building consists of two blocks, one block is functional whereas second block is under construction.

7.5.1 Site Planning

Site is on the mid slopes of a southern sloping hill having total level difference of 20 metres. Site has a varying slope from 16^{o} to 30^{o}. Building block is oriented along the north- south direction. The space in front of the building is developed as landscaped area. Parking facilities are provided on site and in basements.

7.5.2 Building Design

Building is divided into two blocks, one has atrium in the centre and rooms are located around the atrium. As compared to height of building the dimensions of atrium seems to be small. Whereas the second block is linear having rooms along a corridor. The size of atrium is 10.5m x11m and height of atrium is 20m. A 1.80 m wide corridor is provided around the atrium for horizontal circulation. It is covered with transparent fibre sheets at the top to allow natural light to come into the interiors. Upper floor is cantilevered over entrance and acts as porch.

Fig 7.31: Northern view of Nirman bhawan, Shimla

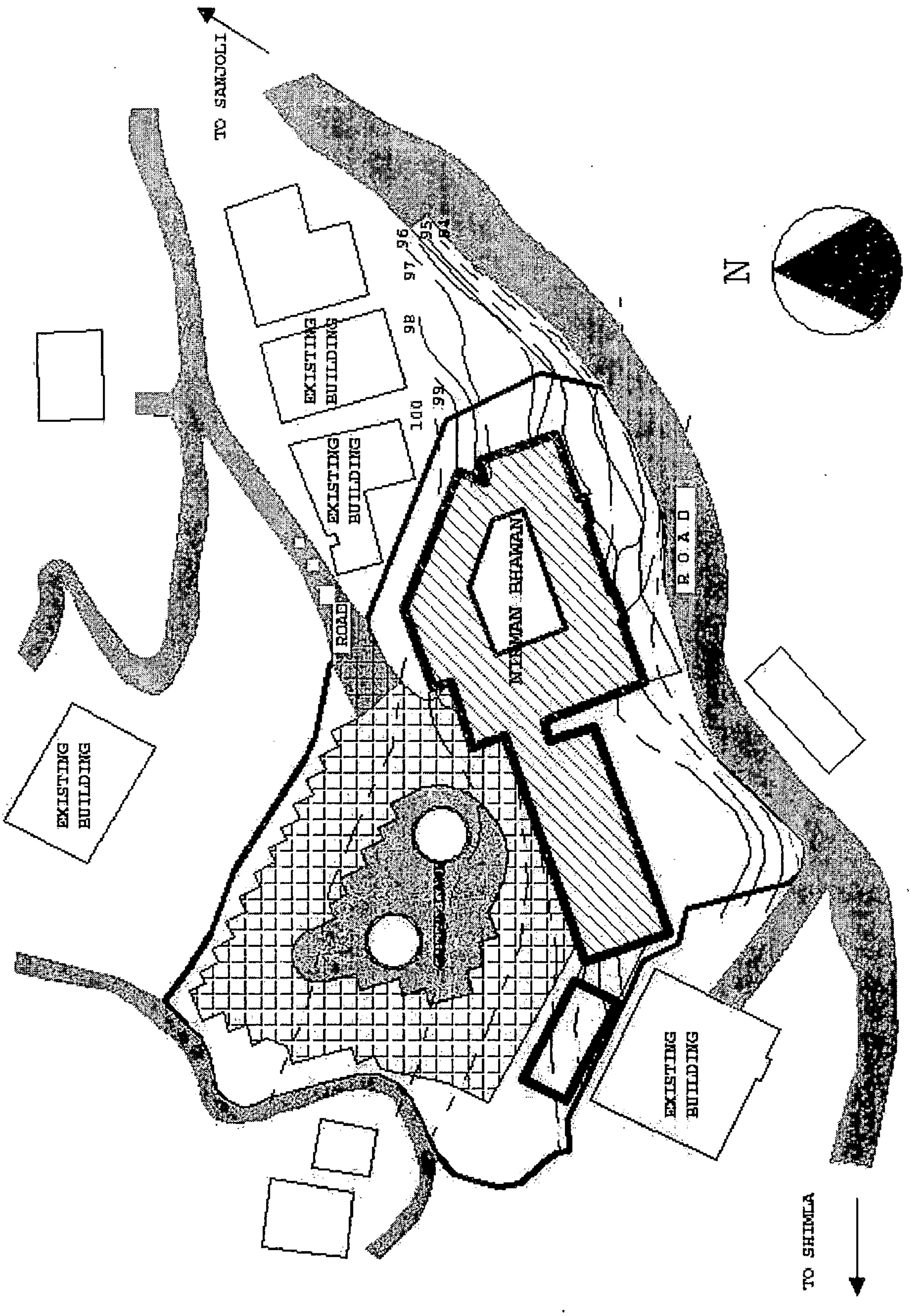


Fig 7.32: Site Plan of Nirman bhawan, Shimla
Source: H.P.P.W.D Shimla

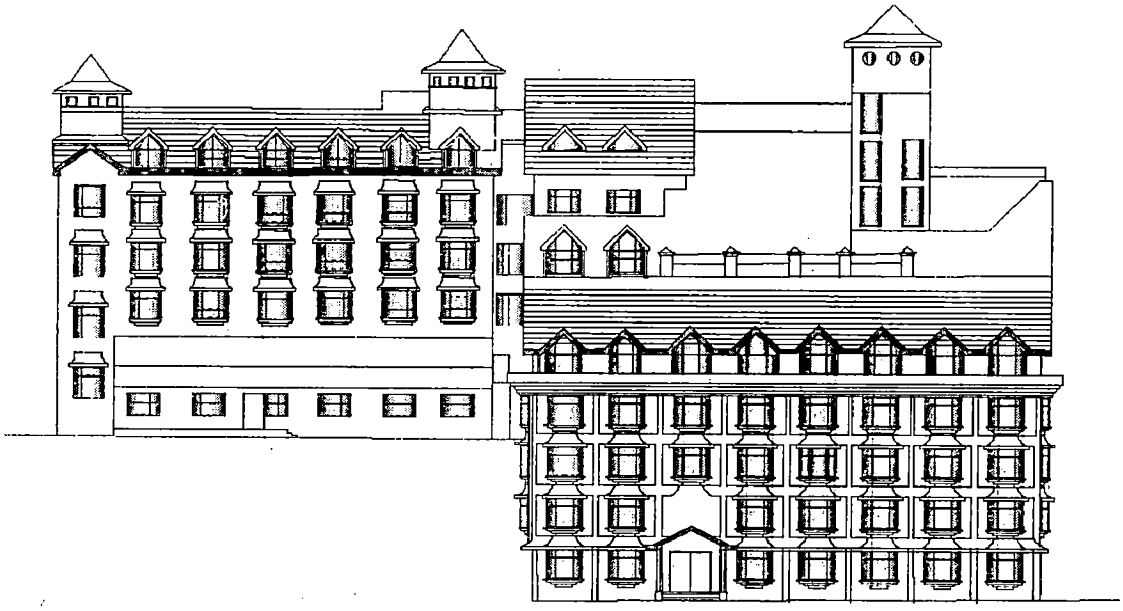


Fig 7.33: Southern elevation of building
Source: H.P.P.W.D Shimla

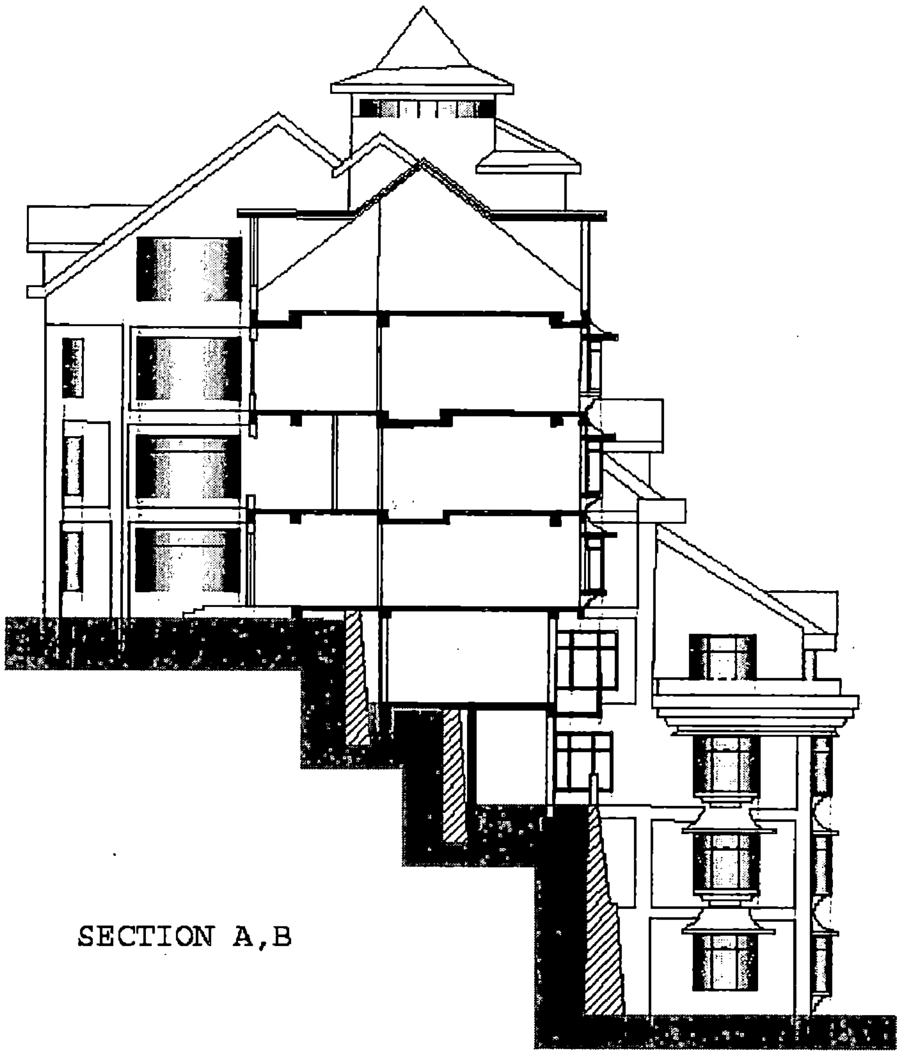


Fig 7.34: Transverse section of Nirman Bhawan, Shimla
Source: H.P.P.W.D Shimla

7.5.3 Structure

The building is designed with R.C.C frame structure having column size of 0.45mx 0.75m. Rectangular grids of 3.40 x 5.70m, 3.40x 4.50, 4.30x 5.70 and 4.30x 4.50m are used in the building. Concrete retaining walls are used in the basement of the buildings to hold the soil, whereas, stone retaining wall are used in site development for making terraced landscape and for making levelling of roads. G I sheets are used for roofing.

Fig 7.35: Entrance to nirman bhawan

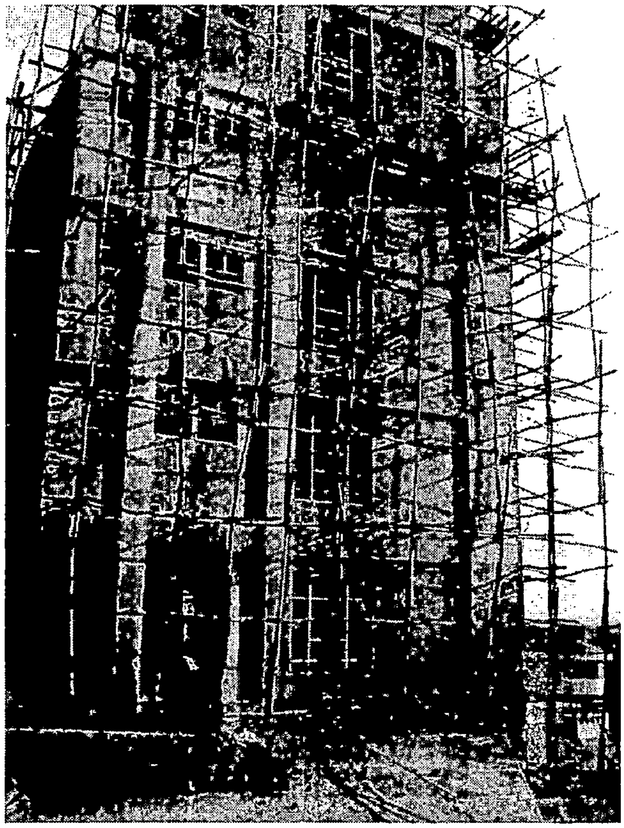


Fig 7.36 : Under construction block of nirman bhawan

7.5.4 Climatic Response

Building is oriented north south. On the south facade extended bay type glazed windows are provided to entrap more sunlight to make the interiors comfortable. Being on the mid land of a southern sloping hill, building is protected from the cold north winds prevailing in winters. The daylight and heat is also entrapped by atrium provided in the building.

Fig 7.37: Glazing on south facade of building

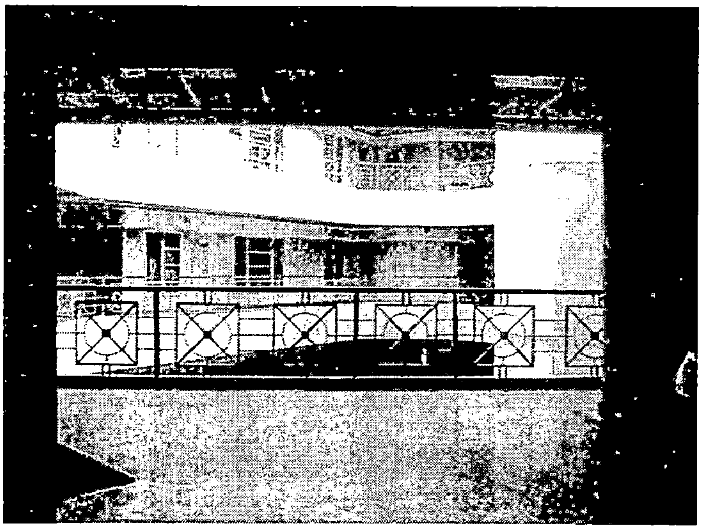


Fig 7.39: View of atrium

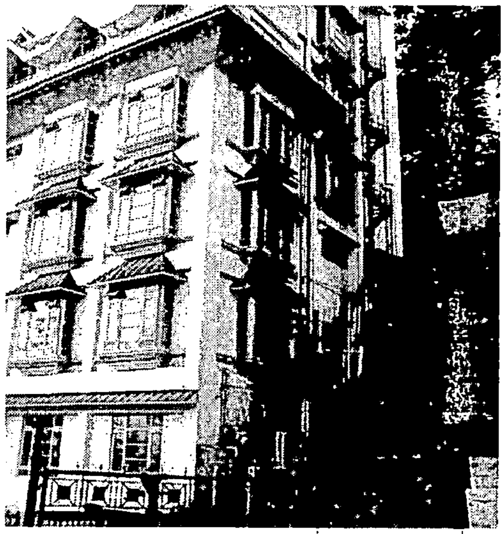


Fig 7.39: Stone retaining wall for site development

7.5.5 Safety Considerations against Natural Hazards

R.C.C frame structure is provided, but upper floors are cantilevered out of structural grid. Retaining walls are provided in basements and for site development. Channelization of upstream and site runoff water is provided for proper drainage. Building is place at minimum edge distance of 3 m which varies according to profile of site. This space is used as porch and for parking of vehicles on the southern side of building.

Fig 7.40: Entrance porch on southern side

Fig 7.41: Use of set back from road for parking

7.5.6 Service cores

Three service cores are provided which consists of staircases, toilets and drinking water facility. A single lift is provided in the atrium as the mechanical means of vertical circulation.

7.5.7 Appearance

The facade of building is a combination white painted plastered surface, vertical and horizontal bands of columns and beams, bay windows and sunshades. Sloping roofs is provided with dormers and clear storey windows. The open area in front of building is landscaped with soft and hard landscaping elements.

7.5.8 Inferences

i) Built on the upper side of a south sloping hill. The slope gradient of the site is high.

ii) Stone retaining walls are used to stabilized the cut slopes and distinguish the building ground from the road on the south side.

iii) Atrium is used as the main feature for designing of building, which has smaller dimensions as compared to height, gives the impact of tunnel. Atrim is covered with transparent sheets to allow light to enter in the building

iv) A combination of traditional doubly loaded corridor system and atrium design is adopted for design of building.

v) Multi entrances to the building one from the north and other from south.

vi) Bay windows are provided on the southern façade of the building is main elevational feature and entraps more southern sun to heat up interiors and provided excellent daylight to work.

vii) Entrance is highlighted through three storied high porch, lost the significance of entrance. On the secondary entrance porch is extended up to the site boundary.

viii) Mo space between the building and the surrounding ground may results in dampness in the building.

ix) Different levelled sloping roof with dormers and higher pyramidical roof over service cores results in interesting sky line.

x) Rain water collection and harvesting system.

xi) Landscaped area is provided in front of the built mass.

7.6 COMPARISON BETWEEN THE CASE STUDIES

The various case studies which are discussed above in this chapter are compared in terms of various aspects such as; Site Planning, Functional Efficiency, Structural System, Safety considerations against earthquakes and landslides. Mid rise buildings studied in this chapter are also compared in terms of fire safety considerations, Parking provisions, Service cores, Energy responsiveness and aesthetics.

These main aspects are further divided into sub aspects for comparing mid rise buildings studied in this chapter as follows:

i) Site planning aspect is divided into the location of site, site orientation, level difference in site, slope angle and adequacy of slope. The various slope stabilization techniques, presence of any natural drain within site and minimum distance from the cutting edge are other aspects for site planning. The width of access road, its gradient and setback provided are also considered in site planning.

ii) Functional efficiency is analyzed in terms of functions of building, placement of spaces, circulation, emergency exists provided. The provisions for disabled people and daylighting level in working areas are also considered for functional efficiency.

iii) Structural system is analysed in terms of types of structural systems and grid sizes.

iv) Safety considerations against landslides and earthquakes are analysed on the basis of measures taken for earthquakes, shape of building, structure, slope of hill and measures against landslides.

v) Fire safety is analysed on the basis of fire safety considerations and numbers of exists provided in buildings.

vi) Parking provisions are divided into number of parking provisions and its locations.

vii) Service cores are compared on the basis of numer of cores, its locations, number of lifts and staircases provided in buildings.

viii) Energy responsiveness is analysed in terms of orientation of buildings, design considerations, materials used, exposure to winds and provision of heating system.

ix) The aesthatics of buildings is compared in terms of form, façade and landscaping.

The comparison between the case study buildings is made in a tabular form as under:

Table 11: comparison between the case studies

Buildings	**Railway Board Building**	**High Court**	**Police complex**	**Nirman Bhawan**
Location	On southern slopes near western end of mall road	On southern slopes near eastern end of mall road	At chotta Shimla	Near chotta Shimla
Type of building	Rectangular configuration	Rectangular	Step back and set back	Step back and set back
Year of construction	1896	1994	2002	2002
Architect	Richardson and Cruddas, Bombay	Chief architect HPPWD Shimla	Chief Architect HPPWD Shimla	Chief Architect HPPWD Shimla
Site area		7520 sqm	5100	4650 sqm
Building area	8, 640 sq m	12,750 sq m	11,900 sqm	6,850 sq m
Ground coverage		15. 75%	33.35%	24. 67%
F.A.R		1.69	2.33	1.48
Number of floors	07 storeys including 3 basements	11 storeys including 3 basements	07, stories	08 stories including 2 basements
Height of building	25m	43.50 m	25.5 m	32.6m
Site Planning				
Location of site	On ridge	Mid slopes	Mid slopes	Mid slopes
Site orientation	north- south	southwest-north east	North south	North west – south east
Total level difference in site	12 m	20 m	49 m	22m
Slope angle	30°	10°	28°	Varying slope from 15 ° - 30 °
Adequacy of slope	Inadequate	Adequate	Inadequate	Inadequate
Slope stabilization techniques	Stone retaining walls are used	Stone, RCC retaining walls are used	R.C.C retaining walls are used	RCC retaining walls are used
Presence of any natural drain within site	No	No	No	No
Min. distance from edge of hill/ cut slope	3m	4 m,	4m	3m

Buildings	Railway Board Building	High Court	Police complex	Nirman Bhawan
Width of access road	7.5m	5.0m	9.0m	9.0m
Gradient of road	Adequate	High	Adequate	adequate
Set back from access road	No set back	42.0 m	4. 0m	3.0 m
Functional Efficiency				
Function	Office	Court, library, bar rooms	Office complex	Office complex
Placement of spaces	Rooms are placed inside the corridor running around the building	Various rooms are provided along the 1.80m wide corridors running either at centre or on the exterior of building.	Various spaces are arranged around the 1.80 m wide corridor	Atrium is provided functional spaces are place along doubly loaded corridor. Service areas are provided at the two ends of building.
Circulation	Horizontal circulation through corridors and vertical circulation through staircases.	Horizontal circulation through corridors and vertical circulation trough staircases and lifts.	Corridors for horizontal movement either doubly loaded or singly loaded and vertical circulation through lifts and staircases	Corridors for horizontal movement either doubly loaded or around atrium and vertical circulation through lifts and staircases.
Emergency exists provided	Yes	Yes	Yes	Yes
Provisions for disabled peoples	No	No	No	No
Daylight level in working areas in building	Inadequate	Adequate	Inadequate in some areas	Adequate
Structural System				
Structure system	Cast iron columns and beams every column is combination of 4 cast iron cylindrical iron posts.	RCC frame structure having column size 75x45cm	RCC frame structure having column sizes 40x60 cm & 40x80cm	RCC frame structure having column sizes 45x70

Buildings	Railway Board Building	High Court	Police complex	Nirman Bhawan
Grid	Clear span of 4.95x4.75, 4.95x4.50, 4.95x3.85 5.30x4.75 5.30x4.50	3.6mx7.5m 3.6x7.0m, 3.6mx4.5m 5.5x7.5m	3.3x6.90 m 3.3x5.0m	3.40x5.70m 3.40x 4.50m 4.30x 5.70m 4.30x 4.50m
Earthquake and Landslide Safety Measures				
measures taken against earthquake	Tying of structural members at various levels Flexible joint between the bracing members	RCC framed structure, tying of building at various levels rectangular configuration Seismic gap between parts of building	Earthquake consideration in structural design of building. Regular forms of building	Earthquake consideration in structural design. Regular forms of building
Shape of building	Rectangular	Rectangular	Setback stepback	Setback stepback
Structure	Cast iron frame structure	RCC frame structure	RCC frame structure	RCC frame structure
Slope of hill	30^o	10^o	28^o	30^o
measures taken against landslides	Retaining walls to hold the earth. In basements	Stone and RCC retaining walls, channelization of upstream water and efficient drainage of site.	Stone and RCC retaining walls, channelization of upstream water and efficient drainage of site.	Stone and RCC retaining walls, channelization of upstream water and efficient drainage of site.
Design consideration against snow	Provision of sloping roof.	Provision of sloping roof. And consideration of snow load in structural design	Provision of sloping roof. And consideration of snow load in structural design	Provision of sloping roof. And consideration of snow load in structural design
Fire safety				
Fire safety considerations	Emergency spiral staircases	Fire alarms, fire hydrants, staircases of external walls	Fire alarms, fire hydrants, staircases of external walls	Fire alarms, fire hydrants, staircases of external walls
Emergency exists provided	2	2	2	2

Buildings	Railway Board Building	High Court	Police complex	Nirman Bhawan
Parking				
No of parking	No parking provision	200	50	50
Type Location		Onsite, parking complex near the building and basement parking	Onsite, basement and terrace parking	Onsite and basement parking
Adequacy	Inadequate	Inadequate	Adequate	Adequate
Service Cores				
Number of cores	02	03	04	02
Location	At two edges	One is at centre and two at either sides.	At edges of two blocks	At two sides
No of lifts provided	No lift	04	02	01
Adequacy	Inadequate	Adequate	Adequate	Inadequate
No of staircases	03	03	05	03
Energy Responsiveness				
Climate of region	Cold climate	Cold climate	Cold climate	Cold climate
Orientation of building	North south	South west-north east		North- south
Design considerations	Glazing on the southern wall	Large windows on south west	Solar panels, windows on southern wall	Atrium is provided, bay windows on southern facade
Material used	Iron, brick, timber, glass, iron sheet roofing	Composite stone masonary, Sandstone, brick, timber glass, concrete, GI sheets	Stone, concrete block, brick, timber, aluminium, glass, GI sheets	Stone, concrete block, brick, timber, aluminium, glass, GI sheets
Exposure to cold wind	Exposed	Not exposed as built on mid slopes	Not exposed as built on mid slopes	Not exposed as built on mid slopes
Mechanical heating system	No	No	No	No

Buildings	Railway Board Building	High Court	Police complex	Nirman Bhawan
Aesthetics				
form	Cuboidal in form having gable roof in top, dormer windows and pinnacles forms an interesting skyline	Building is cuboidal in shape having upper floors projected out on cantilevers. Sloping roof having dormer windows create skyline.	Cuboidal building having upper floor projected and sloping roof. Connecting bridges at various levels	
façade	Facade of building comprises of structural members, tying horizontal members, infill timber or brick walls and glass.	Façade is combination of vertical rcc columns, stone masonary walls and glass in glazing.	Faced is combination of plastered surface stone masonary walls, rcc columns and glass windows.	Faced is combination of plastered surface stone masonary walls, rcc columns and bay windows
landscaping	No landscaping as building is abutting the road	Hard and soft landscape in front of the building.	No lanscapeded area.	Landscaped area in front of building

7.7 Inferences

The inferences after comparing the case studies can be grouped under different aspects of planning and design of mid rise buildings in hill regions are as follow:

7.7.1. Site Planning and Development

i) Preferred sites for mid rise buildings are on south sloping hills. Usually at the midlands having all the advantages of a ridge and valley.

ii) Sites are located on the leeward side of the hill having minimum exposure to cold winds coming from north.

iii) The slope gradient of access roads is high in some cases.

iv) No provision for pedestrian movement along the access road.

v) Maximum ground coverage in these cases is near to 35% and maximum F.A.R is 2.33.

vi) The slopes within slope angles of 27.5° are stable. But in most of cases sites up to slope angle 30° are used for construction.

vii) Provisions for stabilizations of slopes like retaining walls of stone, concrete and RCC are used

viii) Different levelled terraces are used for the construction of building. The height of cutting is higher than the permissible.

ix) The minimum distance from the edge of the hill or cut slope is kept as 3m.

x) Building built on the lower side of road has a distance of 3 m from the cut slope for the light and ventilation to partial basements, which are used as office space.

xi) Retaining walls are used for slope stabilisation.

xii) Parking provisions are provided as basements parking, on terrace and on site to cater the high parking demands of the occupants.

xiii) Rain water harvesting is considered in the design of new buildings.

7.7.2. Planning and Design of Buildings

i) Transition in the design of buildings from linear with singly loaded corridors as main features to atrium in new building of same function. The width of corridor provided is 1.80m.

ii) No considerations in any of the buildings for physically handicapped persons and no provisions for movement of wheel chairs.

iii) Rectangular buildings blocks with north south orientation.

iv) Upper floor is projected out of the facade of buildings on cantilevers is prominent feature of mid rise buildings constructed in Shimla.

v) RCC framed structures are used in these buildings with rectangular grids are used shorter span varies from 3.6m to 4.5m and larger span varies from 6 to 8.0 m.

vi) Multiple service cores are used for providing circulation and other services in the building. The location of cores is usually at the edges of building. Service core consists of vertical means of circulation staircase, lifts, public amenities like toilets and drinking water facility.

vii) In step type building complex a common service core having staircase and lift is shared by two building blocks results in efficient use and cost effectiveness.

viii) Water supply to all buildings is provided by municipal water scheme.

ix) Sewage collection and disposal in some building, other have septic tank.

x) Fire hydrant is provided at every floor and emergency stairs are provided.

xi) Basements are provided in buildings, which are used for parking and services.

xii) Maximum glazing/windows are provided on the southern facade.

xiii) Construction/ seismic joints are provided at desirable distances.

xiv) RCC, stone, concrete blocks are main building materials, wooden or aluminium openings are provided.

xv) Sloping roofs with dormers is provide to create interesting sky lines. The angle of roof is kept high to facilitate the removal of snow and rain.

7.7.3. Safety against Hazards

i) R.C.C frame structure is used in buildings as it provides efficient load path for lateral, seismic and wind loads.

ii) Buildings have the simpler geometry and rectangular configuration.

iii) Separation joint is provided at different locations.

iv) Shear walled service cores are distributed in the buildings.

v) Buildings are placed on different levelled terraces and the cut slopes are retained with the help of retaining walls.

vi) In case of landscaped area or for site development stone retaining walls with weeping holes are provided, whereas in basements concrete walls are used.

vii) In case of higher cut slopes retaining walls are provided in steps to minimise the size of retaining.

viii) Channelization of upstream water coming from the uphill. Site drainage is necessary for stability.

7.7.4. Energy Conservation

i) The preferred orientation is north south and maximum glazing is provided on the southern facade to entrap maximum sun.

ii) Built on lee ward side of hill, results in protection of buildings from cold wind and energy consumption for maintaining comfort conditions is less.

iii) Due to lower angle of sun, the shadow casted by buildings is large results in shading of buildings on the north as the distance between the buildings is less, leads to high consumption of energy.

iv) Energy efficient buildings are constructed in Shimla, like Himurja building, HP state cooperative bank and MLA hostel.

v) Energy efficient features like trombe wall, sunspace, double glazed windows, solar water heater and are used in other buildings also.

vi) Use of conventional construction materials in buildings which have high embodied and transportation energy materials and energy consuming construction techniques.

7.7.5. Aesthetic Consideration

i) Cuboidal form of building, which is broken by extended top floor and roofing is provided by slopping roofs having dormers.

ii) Unattractive plain facades of buildings usually unfinished and unmaintained.

iii) Facade usually comprises of structural members horizontal and vertical stone or concrete infill walls and glazing.

iv) New construction have interesting facade of bay windows, brackets and white painted plastered finish.

v) Due to buildings on different terraces interesting roofscape is formed in

vi) Landscaping is not considered as important part of building design. Though in some building front facades are beautifully landscaped with hard and soft elements.

CHAPTER VIII

CONCLUSIONS RECOMMENDATIONS AND GUIDELINES

8.1. INTRODUCTION

A attempt is made in this study to understand the various design issues of mid rise buildings in hill town, problems for designing of mid rise buildings and criteria affect mid rise buildings. This chapter discusses the issues of mid rise buildings as area level and buildings level. The criteria for the design of mid rise buildings are identified for planning and design of mid rise buildings in Shimla. Recommendations are made for functional, safe, energy efficient and visually appropriate mid rise buildings. Thereafter guidelines are suggested for designing of mid rise buildings in Shimla based on the above issues and criteria.

8.2 CONCLUSIONS

The various conclusions from the study can be grouped into two different categories as major issues identified from Area Level study of mid rise buildings and major issues identified at buildings for designing of mid rise buildings in Shimla.

8.2.1 Major Issues Identified from Area Level Study of Mid rise Buildings

The various issues identified for the designing of mid rise buildings from area level study are as follows:

i) Front and Rear Setbacks on sloping site

ii) Spacing between Buildings

iii) Access Roads

iv) Parking

v) Multiple Entries to Buildings

vi) Visibility

These identified issues from the study are studied in detail in order to indentify the implication of these issues identified.

8.2.1.1 Front and Rear Setbacks on sloping site

One of the major issues which are identified in the study is absence of front and rear setbacks of building between buildings and road and building and cut slope. The implications or feasibility of provision of setback in buildings is to be analysed. Buildings on a sloping site may be constructed either on upside or downside of hill either by cutting or filling the slopes. Consider a building which is constructed on the upside of a 6.0m wide road. The depth of building is considered as 15 m for the analysis purposes. The three different conditions are analysed in first case building is abutting both the road and cut slope on back. In second case a setback of three metre is provided from the road but rear portion is in contact with cut slope. A 3 m wide setback is provided to the building from road as well as the cut slope in third case as shown in fig 7.1. These conditions are analysed for different slope angles such as 10°, 15 °, 20 °, 25 °, 30 °, 35 °, 40 ° and 45 °. The height of cutting of slope required is tabulated as.

Table 11: Height of cut slope required for different slope gradients

Slope in site	Height of cutting of slope		
	Building without any setback	Building with 3m front setback	Building with 3m front and rear set back
10°	3.78	4.31	4.84
15°	5.71	6.51	7.32
20°	8.15	8.74	9.83
25°	9.79	11.19	12.59
30°	12.12	13.86	15.59
35°	14.7o	16.68	18.91
40°	17.62	20.14	22.91
45°	21	24	27

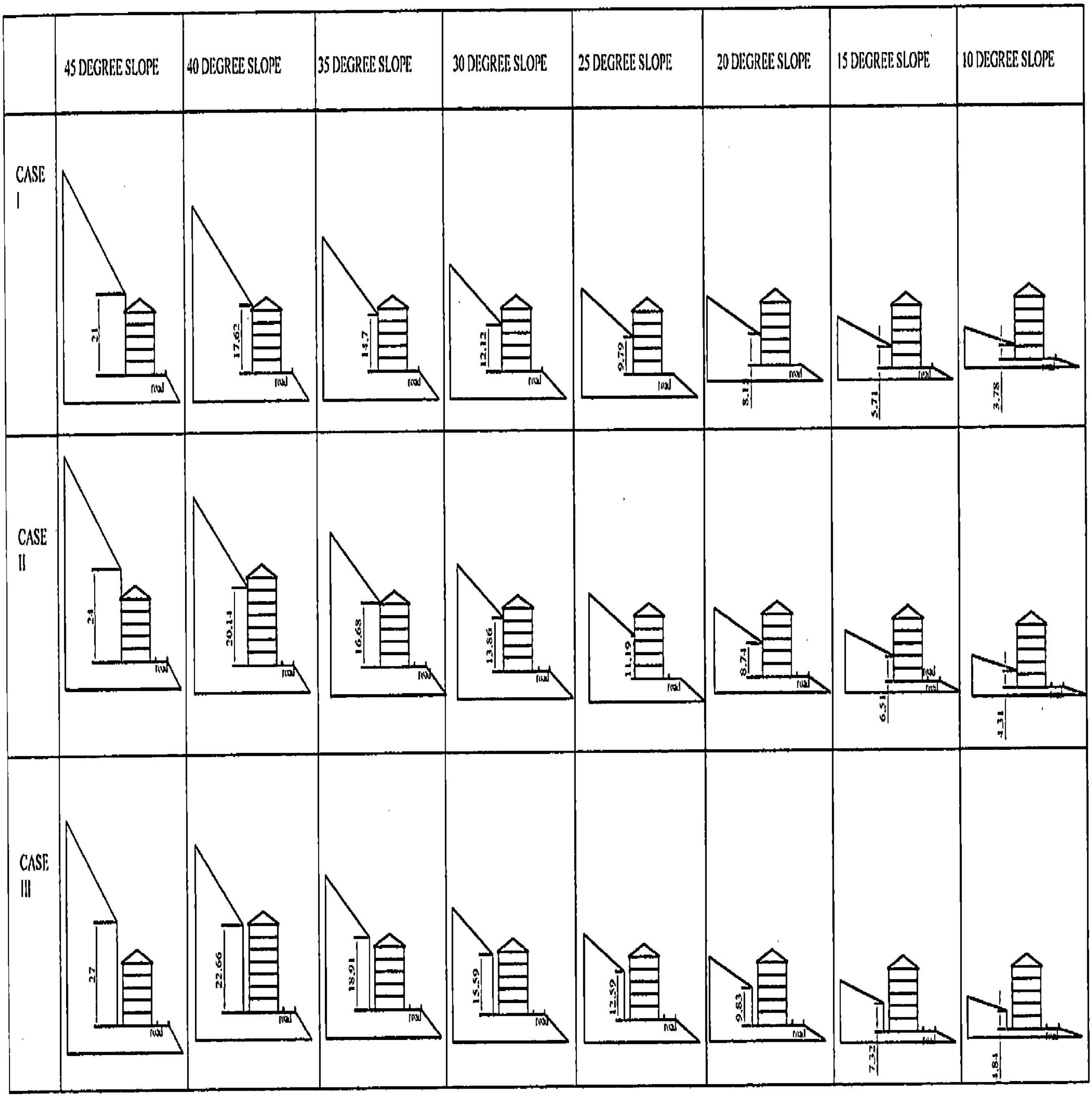


Fig. 8.1: Buildings on ground having different slope gradients

As specified by IS codes the maximum height of cut slope will be 8m therefore for slopes having slope angle less than 20°. It is easier and safe to provide both front and rear set back to the buildings. The front and rear setbacks can be provided to buildings on slope between 20° to 30 ° by designing them as step back buildings. Whereas it is difficult to construct as the height of cut slope is much higher on slopes more than 30°.

8.2.1.2 Spacing between Buildings

The spacing between the buildings is crucial to provide proper daylight to the buildings. In Shimla which is located on higher latitude the vertical solar angle is 35° at the noon on 23 December (on the smallest day).

Consider a five storied building of size 25m x 15m having sloping roof, having north south orientation. The open space required in between two buildings to have solar access is a function of slope angle, slope morphometry (direction), height of building and orientation of building. This building is analysed for 10°, 15 °, 20 ° and 25 ° slope angles in both northern as well as southern sloping grounds.

Table 12: Spacing between buildings on sites having different slope gradients on southern and northern slopes

S.no	Slope angle	Open space require between two five storied buildings on southern slopes (m)	Open space require between two five storied buildings in northern slopes (m)
1.	0 °	24.17	24.17
2.	10 °	16.14	32.31
3.	15 °	13.33	39.16
4.	20 °	10.77	50.36
5.	25 °	8.51	72.36

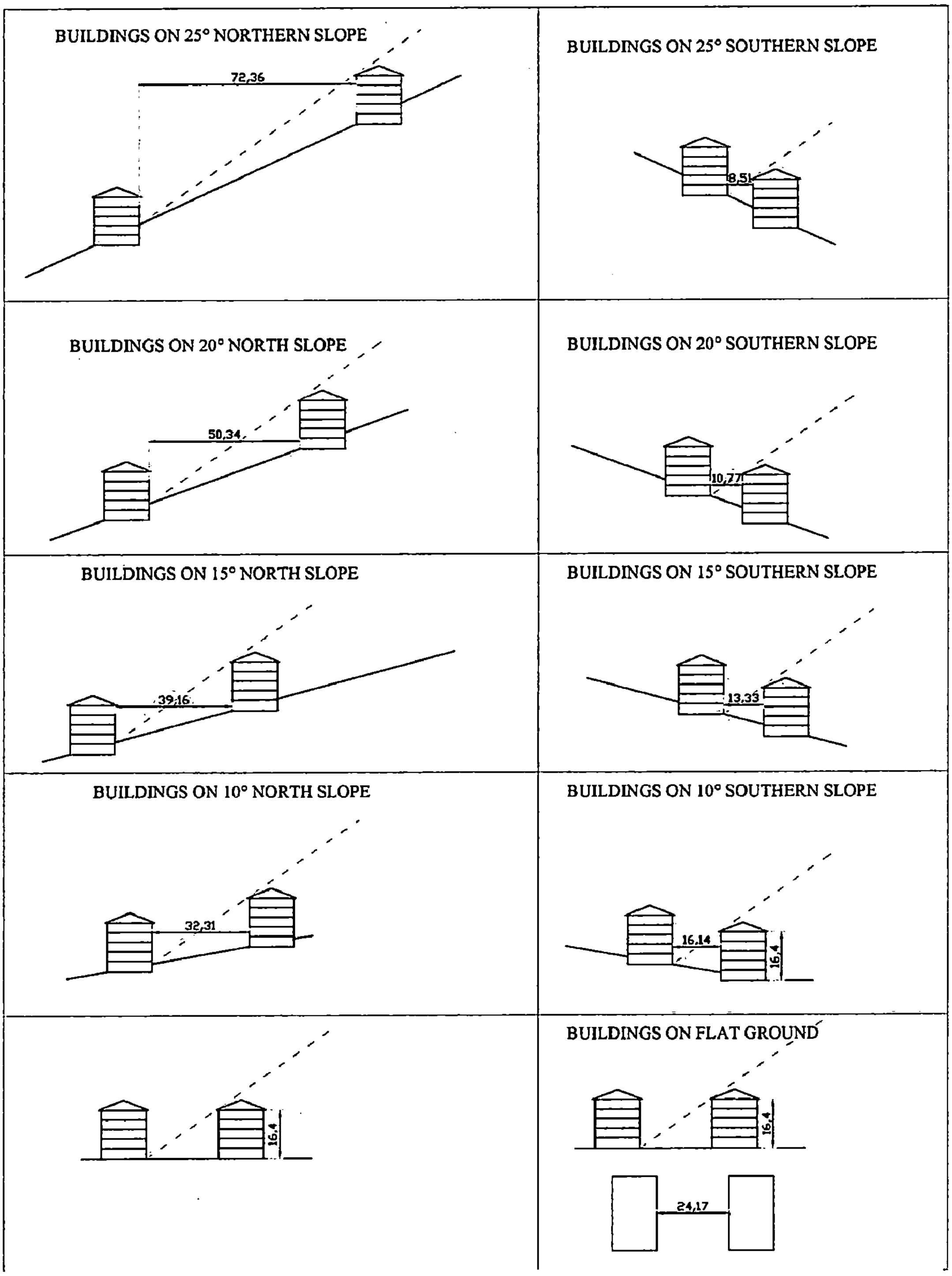


Fig 8.2: Spacing between buildings on different orientations and slope gradients

However from the table this can be interpret that, on the southern slopes with increase in the slope angle of the ground lesser space is required in between the buildings. Whereas on the north facing slopes with increase in slope angle the space required is also increased. The space required between two buildings should be different in different slope directions. It should be different for different slope gradient within a single slope also.

8.2.1.3 Access Roads

In hill regions width of access roads to buildings is less as compared to the access roads in plains. For providing wide roads amount of cutting or filling of slopes requires is high which make provision of access roads uneconomical. Due to same reason provisions for pedestrian movements are also not provided along the roads. Pedestrian stairways/ramps are provided across the slope to access different height. The slope angle of the roads is also higher than the recommended as for providing roads with lower gradient road length required is much higher which is not possible to provide in the sloping terrain as in affects the ecological balance, stability and requires more resources. On the low slope gradients wide access roads with low slope angle can be provided with ease.

8.2.1.4 Parking

Parking is one of the major problems in the areas, as vehicles are parked on the road in front of building hindering the traffic as well as pedestrian movement. The parking demand of mid rise building is high due to high occupancy. The problem of parking in mid rise buildings can be solved through proper designing. In mid rise buildings parking provisions can be made either in basements or at terrace depending upon whether the building is constructed uphill side or downhill side of the road. Flat ground is mostly unavailable which can be used for providing onsite parking provisions. Due to sloping ground the onsite parking provisions are results in more expanses and are difficult to provide. The cutting and filling required for providing onsite parking is high which results in change in ground profile and requires strengthening measures. Due to high cutting and filling the overall cost of the project is increased to a large extent. Provision for parking floor is present in the building bye laws prevailing in the area, which is exempted from F.A.R and height restrictions.

8.2.1.5 Multiple Entries to Buildings

Mid rise buildings (often mix used type) have flow of varied type of people having different nature of work in same premises. Therefore, multiple entries are required in building to regularise the traffic flow for the smooth functioning of building. In sloping regions, ground touches the same building at different levels; therefore different entries can be designed at different floor levels.

8.2.1.6 Visibility

Visibility of a building from different places depends upon its topographical location. A building built on the ridge has maximum visibility as ridge being highest point and visible from all sides. Whereas a building built in the valley has minimum visibility. As valley is the lowest portion and having view from the surrounding hills only. The aesthetic characteristics of buildings should be designed in accordance to its extent of visibility. An aesthetically unappealing structure built on the hill top or at ridge becomes eyesore.

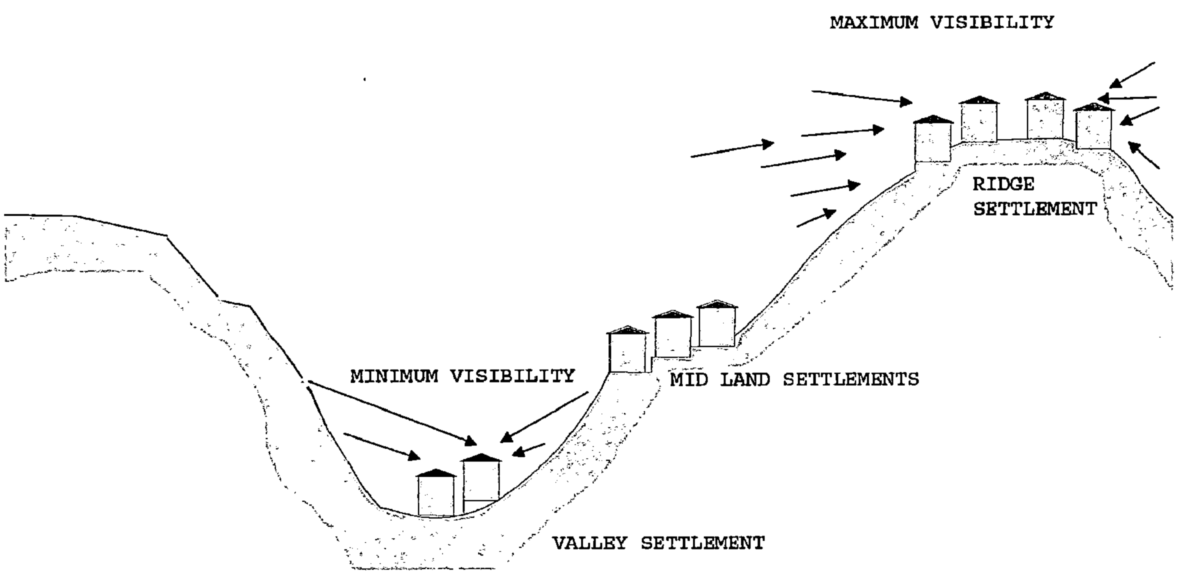


Fig 8.3: Visibility of various topographical locations in hill regions

While moving on streets of a hill town, user has experienced different serial vision. Due to curved road and sloping topography the visual cone of the user changes with every step. The visual experiences of the people can be enhanced by proper planning and design considerations and adoption of varies principles and elements of urban designs.

8.2.2 Major Issues Identified Related to Building Design

The various issues which are identified from the study at building level are related to the following:

i) Site selection

ii) Site planning and development

iii) Building design

iv) Energy efficiency

v) Visual appropriateness/ aesthetics

The various criterias identified related to these issues for designing of mid rise buildings in Shimla.

8.2.2.1 Site Selection

The various criteria for site selection and development for mid rise buildings in Shimla are as follows.

i) Topographical location

ii) Land use

iii) Safety of slopes from landslides and earthquake faults

iv) Proximity to town centre/ activity areas

v) Accessibility

vi) Infrastructural facilities

vii) Soil suitability

viii) Vegetation

ix) Visibility and visual quality

x) Land development cost

8.2.2.2 Site Planning and Development

The various criteria for site planning and development of mid rise buildings in Shimla/hill regions are as follows.

i) Functionality

ii) Site responsive/ responsive to the context

iii) Safety considerations

iv) Sustainability

v) Minimum damage to environment

vi) Minimal use of resources

vii) Cost effective

viii) Orientation and solar access to buildings

ix) Landscaping

8.2.2.3 Building Design

The various criteria for architectural design of mid rise buildings in hill region are.

i) Functionality

ii) Safety considerations

iii) Building services

iv) Climatic considerations

8.2.2.4 Energy Efficiency

The various criteria for energy efficiency in mid rise buildings are as follows.

i) Minimum use of non renewable energy

ii) Maximize use of renewable sources of energy

iii) Use of passive design features

8.2.2.5 Visual Appropriateness/ Aesthetics

The various criteria for visual appropriateness of mid rise building in hill regions are as follows

i) Building facade, features,

ii) Response to the natural topographical setting

iii) Architectural charter of the surrounding

Various guidelines related to these criteria identified are discussed later in this chapter.

8.3 RECOMENDATIONS

The various recommendations for planning and design of mid rise buildings in Shimla are as follows:

i) Site selected for mid rise buildings must be on the mid slopes of southern sloping hill. The site should not have gradient more than in the ratio of 1:2 (vertical:horizontal). The hazard potential of site must be identified and mid rise construction should be allowed in low and moderate hazard areas.

ii) The developmental controls for Shimla town should be made differently by considering the regional context. Special/ specific provisions for design of mid rise buildings should be made in the developmental controls of shimla.

iii) The set back conditions, spacing between buildings should be different for different slope gradients, orientations of the site height of building to have proper daylight and ventilation to every building.

iv) A mid rise policy for hill towns should be made by the government to cater the increased need of residential, offices, commercials and service buildings and to regulate the designing of mid rise buildings in Shimla and other hill towns.

v) Vehicular access through a recommended gradient road should be mandatory for every building. Building having no vehicular access should be designed and permitted.

vi) Mid rise buildings in Shimla should be designed as barrier free spaces with proper considerations for physically disabled peoples. Recommended provisions in national building code for disables should be made in the mid rise buildings.

vii) The structural design of the mid rise buildings should be made by civil engineer poses the masters in civil engineering (structures) having experience of designing buildings in hill regions. The structure of buildings should be designed in accordance to earthquake safety codes IS 1892, 2002; IS 4326, 1993.

viii) Before the occupancy of building, the clearance certificate from the fire department should be necessary for providing the occupancy certificate from the development/ municipal authority. This certificate should be provided for a period of 3 or 5 years and renewed thereafter.

ix) Incorporation of passive solar heating systems should be made mandatory by the authorities.

x) The energy auditing of the mid rise building should be compulsory by authorities in order to access the consumption of the energy by the building.

xi) Special concession / offer should be given by authorities, in order to promote the green building concept in Shimla.

xii) It is made mandatory to provide sloping roofs incorporating features like dormers, clearstorey windows for mid rise buildings in Shimla. This is to match the topographical profile of the region and roofs should be coloured with single colour. (as it is a regulation in present byelaws in Shimla)

xiii) It is made mandatory in building regulation to provide a parking floor in every mid rise buildings designed in Shimla.

xiv) The open area in the plot/ site should be used for landscaping.

xv) Provision of rain water collection and harvesting system should be made mandatory in mid rise buildings in Shimla.

8.4 GUIDELINES FOR DESIGN OF MID RISE BUILDINGS IN SHIMLA

The various guidelines for the designing of mid rise buildings in Shimla (hill regions) are divided into following categories

i) Guidelines related to site selection

ii) Guidelines related to site planning and development

iii) Guidelines related to functionality of buildings

iv) Guidelines related to safety considerations

v) Guidelines related to building services

vi) Guidelines related to visual appropriateness

vii) Guidelines related to energy efficiency

8.4.1 Guidelines Related to Site Selection

The various guidelines for site selection for mid rise buildings in hill towns are as follows.

i) Sites selected for mid rise buildings should be on southern slopes to have maximum solar access throughout the day.

ii) Site selected should be on the mid lands of lee ward side of hill having minimum exposure to prevailing cold winds coming from the north.

iii) The site selected should have the vertical to horizontal ratio up to 1:2 or slope gradient up to 28°.

iv) Site selected should have the same land use. The surrounding land uses should have the same typology. So that development can be done in accordance to land use plan to above any ambiguity.

v) The site selected should not have proneness to landslides and rock fall.

vi) The landslide hazard zonation map should be prepared at town level in accordance to IS code 14496 part II (Preparation of Landslide Hazard Zonation Maps in mountainous Terrains –Guidelines) and mid rise construction should be allowded in low and moderate hazard areas.

vii) Site selected for mid rise buildings should be away from earthquake fault line.

viii) Site selected should have well compacted soil or rock, having good bearing capacity. Sites containing loose/ buried soil should not be selected for mid rise buildings.

ix) Site selected for mid rise buildings should have vehicular access, if not exist, then it should be provided with proper slope gradient and width.

x) Site selected for mid rise buildings should have proximity to the major activity areas of the town.

xi) The site selected for mid rise buildings should have sparsh to moderate vegetation cover. Sites having dense and very dense vegetation cover should not be selected for mid rise buildings.

xii) As far as possible any tree present on site should be preserved.

xiii) Infrastructural facilities like road, water supply, electricity, sewage disposal, and telecommunication should be present on/ near the site.

xiv) Site selected for mid rise buildings should have easy access to emergency services.

xv) Depending upon the importance of the building the visibility of selected site should be considered. Mid rise buildings public/ commercial use should have maximum visibility. Whereas, residential buildings should have lesser visibility.

xvi) The site selected for mid rise buildings should have minimum site development cost.

8.4.2 Site Planning and Development

The various guidelines for design of mid rise buildings in Shimla are as below.

i) The minimum space between two buildings should be in accordance to slope of site and orientation of site and height of building to have proper daylight and ventilation to every building but should not be less than 8m.

ii) The space between the road and building and building and cut slope should depends upon the width of road slope of site, orientation and height of building.

iii) The site development for mid rise buildings in hill regions should be done in accordance to IS code 14243 part II (Selection and Development of Site for Building in Hill Areas- Guidelines)

iv) The maximum height of cut/ fill of slopes should be less than 6m. In order to have more height cutting / filling should be made in different levelled terraces for the construction of building.

v) The cut slopes should be stabilised/ protected with retaining walls

vi) The minimum distance from the edge of the hill or cut slope should be kept as 3m.

vii) Retaining walls of stone or concrete should be used for slope stabilisation for site development works.

viii) To the extent possible, street location and design shall conform to existing topographic characteristics. Cutting and filling shall be minimized in the construction of streets. Flat as possible grades shall be utilized proximate to intersections

ix) Buildings on site shall be oriented to get maximum exposure to sun and minimum toward cold winds.

x) The impact of cold winds should be reduced through the use of landscaping elements.

xi) Provision for safe and convenient movement of physically disabled and elderly should be made in site planning.

xii) Mid-rise buildings should be oriented to maximize the privacy of the occupants of adjacent buildings.

xiii) Privacy of the users should be enhanced by the use natural topographical features and landscaping elements

xiv) The natural topographic and landscape features of the site shall be incorporated into the plan and the development whenever practicable.

xv) The regional context/ site character should be reflected in the site planning.

xvi) Open spaces should be linked together.

xvii) Required number of parking lots for different uses of mid rise buildings in hill towns shall be calculated according to National Building code 2005- III.

xviii) Required parking spaces for mid rise buildings should be provided with in the site area. If open area is insufficient to provide required parking space, a combination of open and basement or open and terrace parking shall be used depending upon the topography of the site.

xix) Rain water harvesting measures should be employed in the buildings.

xx) Rain water collection system should be made in accordance to IS code 14961, 2001 (Guidelines for Rain Water Harvesting in Hilly Areas by Roof Water Collection System)

xxi) Soft Landscaping should be done in open areas for percolation of maximum rainwater in soil. For hard landscaping porous materials should be used which allows the water to percolate to ground.

xxii) The existing trees within the site should be retained.

xxiii) Native trees shall be used as an integral part of the landscaping scheme.

xxiv) Deciduous frees shall be used which shed their leaves in winters.

xxv) A close relationship with the existing natural and cultural environment through the appropriate use of locally available materials should be used for site development.

xxvi) Channelization of upstream water coming from the uphill should be channelized before entering into the site.

xxvii) Natural drainage pattern should nqt be disturbed. No building should be constructed on the way of natural drains.

xxviii) To the extent possible, the storm water runoff plan should be integrated with the landscaping plan. Extra runoff water shall be collected and reused for gardening / ground water recharge purposes

xxix) Siting of mid rise buildings should be done to have minimum disturbance to noise from the adjoin street/ buildings.

8.4.3 Guidelines Related to Functionality of Mid rise Buildings

The various guidelines for design of mid rise buildings in hill towns are as follows.

i) Mid rise buildings in hill regions should be designed as barrier free spaces with proper considerations for physically disabled peoples. Ramps with adequate slope and width, wheel chair lift, toilets for disabled peoples should be provided in buildings

ii) The circulation area should be minimum. In case of buildings having singly loaded corridors the width of corridor should be 1.80m and doubly loaded corridor is 2.40m.

iii) Minimum size of different spaces/ rooms of a building shall be in accordance to National Building code 2005.

iv) Building built on the lower side of road should have a minimum distance of 3 m from the cut slope for the light and ventilation to partial basements.

v) Distributed service core system shall be used for providing circulation and other services in the building.

vi) Service core should be easily accessible from all parts of buildings.

vii) Public amenities should be provided in the buildings for both workers and visitors.

viii) Multiple entries should be provided to segregate the traffic flow in buildings. Separate entrances should be provided for staff and visitors.

ix) The provision of flexible indoor spaces should be made in the buildings.

x) Buildings on sloping site having slope angle more than 15° should be of step back or step back and set back type.

xi) In building design in order to achieve standardisation, modular layout or dimensions should be used/ repeated.

xii) Proper illumination level should be maintained in the working areas.

xiii) Indoor air quality should be maintained in the buildings.

xiv) Staircases of suitable widths are provided in the mid rise buildings. The numbers of staircases and distances between them is in accordance to National building code 2005.

xv) Finishes used should be maintenance free or requires minimum maintenance.

xvi) Aluminium doors and windows are used in place of wooden doors and windows as aluminium has lesser embodied energy as compared to steel.

xvii) Proper signage should be used within the buildings to guide the visitors.

xviii) The total cost of the project should be less.

xix) Locally available materials which has good climatic response, easily available and have lesser embodied energy should be used.

8.4.4 Guidelines Related to Safety Considerations

The various guidelines related to safety against natural disasters (like landslides, earthquakes and cloudburst) and fire protection are enlisted below:

i) Mid rise building should be designed with RCC frame structure with continuous rectangular grids.

ii) As far as possible the omission of any structural members at different floors or change/ shift in the position of structural members should be avoided

iii) The height of various floors should be regular. There should not be any shift in storey height of different floors.

iv) The structural design of the buildings should be in accordance to earthquake safety codes IS: 1893,2002; IS: 4326: 1993 etc

v) Buildings geometry should be simple for structural design purposes. Complex building forms should be broken / converted into simplified forms for structural design of buildings.

vi) If building is to be constructed adjacent to hill slope, then the building should be so designed that heavier part of the building should be located on the uphill side to provide better stability.

vii) The foundation across the slope for columns in one row should be continuous strip type instead of isolated type. The combined/ continuous type of footing will distribute the load uniformly and the pressure intensity on the slope will be less and avoid slope failure.

viii) The foundation system of the structure should be taken deeper into the slope thereby the local failure of slope is avoided as the deeper foundation system gives a lateral support to the soil and avoids any landslides or slope failures.

ix) The plinth beam system should be as heavy as possible. The heavy plinth beam system will help in reducing the cracks and failure of the structure in case some local failure of slope takes place at some point under the building foundation.

x) The irregular building blocks shall be separated from each other with seismic joint to avoid torsion.

xi) Shear walled service cores should be symmetrically distributed in the buildings.

xii) The foundation deeper into the slope on the upstream side increases the stability of the slope.

xiii) Stability analysis of slope suggested that the buildings on flat ground adjacent to hill slope should have setback type configuration and buildings on sloping ground should have step back type configurations to achieve better stability.

xiv) Good quality building materials should be used.

xv) Base isolation techniques may be used for very important or lifetime buildings where cost of building is not an important criterion.

xvi) Fire resistant measures as per National building code Part IV shall be considered and fire resistant materials shall be used.

xvii) The site selected for mid rise buildings should have low to moderate landslide hazard in accordance with IS code 14243 Part I (Selection and Development of Site for Building in Hill Areas –Guidelines)

xviii) The drainage system should be very good; in addition a pucca apron must be constructed around the whole building area to avoid any water seepage into the soil system under the building area.

xix) Retaining walls shall be used for the stability of cut slopes. Depending upon the amount of loads coming on the retaining walls the sections and materials of retaining walls should be selected.

xx) Site selected for mid rise buildings should not be prone to cloudbursts.

8.4.5 Guidelines Related to Building Services

The various guidelines related to building services in mid rise buildings are as follows:

i) Service core should consist of vertical means of circulation staircase, lifts, public amenities like toilets and drinking water facility.

ii) In step type building complex a service core should be shared between two building blocks for efficient use and cost effectiveness.

iii) Service core should contain provisions for physically disabled persons.

iv) Water efficient fixtures should be used to minimise the use of water in building.

v) Water supply should be provided to buildings from municipal water scheme. It should be stored in water tank placed on site or on roof top.

vi) Water should be supplied in the building through gravitational pressure.

8.4.6 Guidelines Related to Visual Appropriateness

The various guidelines related to appearance of mid rise buildings in Shimla are as follows:

i) Depending upon the importance of building the extent of visibility of site selected and building shall be considered.

ii) Uppermost floor should be projected over the lower floors to maintain the existing character followed in the most of the mid rise buildings of Shimla.

iii) The visual character of an area should be maintained in the design of new buildings.

iv) Facades of the mid rise buildings shall be properly designed and maintained.

v) Sloping roofs with dormers should be provided to create interesting sky lines and to matches the topography of the region.

vi) Roofscape should made attractive and to maintain same character or should be painted in one colour.

vii) Buildings should follow the natural profile of the ground and shall be designed to merge with the surrounding hillscape.

viii) Depending upon the importance, location and character of building mid rise buildings should be designed as landmarks in hill regions.

ix) All the facades of buildings shall be well designed and maintained. As visual angle changes with every step due to curved roads. The visitor/ viewer should have a good visual experience of built environments.

x) The space between the buildings should be landscaped with different landscaping elements.

xi) Natural topographical profile as far as possible should not be disturbed. If so, attempt to reform it should be made.

xii) On site vegetation presents should be maintained and enhanced with new plantation.

8.4.7 Guidelines Related to Energy Efficiency

The guidelines for energy efficiency of mid rise buildings in Shimla are as follows.

i) North South orientations for buildings should be preferred.

ii) Compact building forms having minimum surface-to-volume ratio should be used. Sloping roofs shall be provided for increasing heat gain.

iii) Solar access to all buildings should be ensured. No entrance or circulation of cold wind in interiors.

iv) Landscape elements should be used to minimise the impact of climate. Buffers and wind screens should be provided as protection from cold winds. Hard landscape materials to absorb heat should be used.

v) Maximum windows/ glazing shall be provided on southern walls and minimum on north walls of the buildings. Depth of buildings should be decided with due consideration to natural daylight.

vi) Use of day lighting for generalised lighting in buildings. skylights, light shelves should be used for effective daylight distribution

vii) Use of low embodied and transportation energy construction materials and energy efficient construction techniques.

viii) The volume of building for heating shall be minimised by providing false ceiling.

ix) Solar passive techniques for heating in building design should be used.

x) All external surfaces should be well insulated and double-glazed windows, Sun-porch, trombe wall for heat entrapment from solar radiation.

xi) Energy-efficient lighting, heating systems and electric equipments should be used.

Mid rise buildings are built in response to the increased pressure for development on the already limited land available and competing demands (for residential, work places, recreational, commercial and educational buildings) for both the permanent and the floating population in popular hill towns. These mid rise buildings in hills face problems related to the instability, functionality energy efficiency and visual appropriateness which are caused due to poor planning/ design, inappropriateness of site selection/ location, layout, and materials adopted.

These problems can be taken up as challenges which requiring a sensitive approach. With proper consideration focusing on site selection, site planning and development, building design, safety against natural hazards, energy efficiency and visual appropriateness in the planning and design of mid rise buildings in hill regions results in for contextually appropriate and sustainable mid rise buildings in Shimla. Mid rise buildings in hill regions also provide an opportunity for innovative solutions using latest technology and create energy efficient and sustainable buildings for meeting the societal needs (of residential, work places, commercial and buildings) and become trend setter for future development in hill towns.

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