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Review of building regulations for safety against hazards in Indian hill towns☆

Ashwani Kumar

Department of Architecture and Planning, Malaviya National Institute of Technology Jaipur, India

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ABSTRACT

The picturesque hill towns of India are vulnerable to different types of natural hazards, which may cause enormous destruction during their occurrence leading to substantial loss of precious human life and resources. Hill towns are presenting undergoing tremendous developmental activity having densely constructed multi-storied buildings causing severe concerns related to their suitability in the hill towns. Different building regulations are formulated and enforced to the protection of human life and buildings in hill towns. But, in spite of the enforced building regulations, most of the buildings existing in hill towns have no/minimal measures to withstand the adverse impacts of disasters.

Therefore, this paper highlights the general issues and problems related to the development and building regulations of hill towns. A comparative study of existing building regulations for safety against natural hazards of various Himalayan hill towns is made to have the in-depth understanding of issues related to building regulations for safety against hazards in hill towns.

1. Introduction

Hilly regions are the most difficult yet most exciting 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 the country. Any area having altitude more than 600 m from mean sea level or any area with an average slope of 30° is classified as hilly in India (BIS, 2005). In India, 21% of the total land area is hilly or mountainous, which includes the northern mountains of the Himalayas, the Central Highlands, the Deccan Plateau, the north-eastern hill ranges.

Most of the hill towns of Himalayas are located in the seismically most vulnerable zones of the country and classified as zone V and IV of seismic vulnerability atlas (NDMD, 2007). These regions are susceptible to high magnitude earthquake and may lead to enormous destruction during the occurrence of an earthquake. Hill regions are in general prone to landslides and every year during rains massive loss of human life and resources occurs due to landslides. Along with landslides and earthquakes, hill regions are also prone to the various disasters like the cloudburst, floods, fire, wildfire, avalanche, etc. (BIS, 2000). In spite of high proneness of hill areas to different disasters, various hill stations are established and subsequently developed as major urban centers in hill regions, thus have high population density. Shimla, Mussoorie, Manali, Dalhousie, Nainital, Srinagar, Shillong, and Itanagar are some such important tourist centers and fast-growing hill towns, which are experiencing a lot of pressure for development in present context. Hill towns are mostly located in ecologically sensitive zones (Menon, Kapoor, & Kohli, 2009). The ecological balance of towns is affected due to high-density development having multi-storied buildings and lower carrying capacities of hill towns (Fig. 1). Also,

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E-mail address: ashwani.patiyal@gmail.com.

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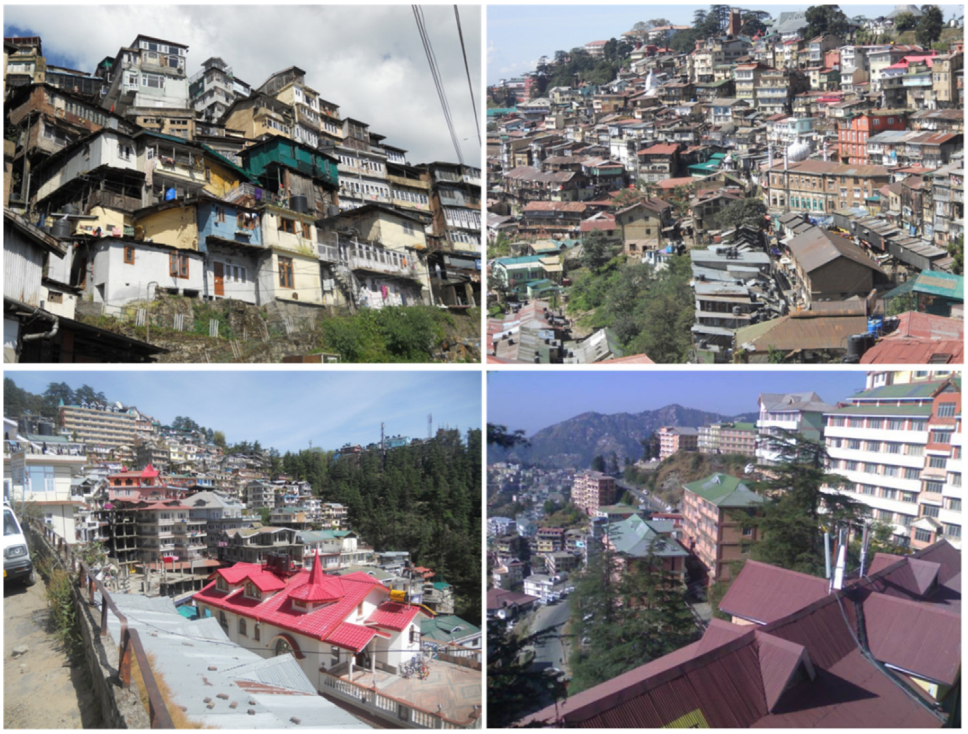

Fig. 1. Densely constructed concrete buildings in hill towns.

degradation of natural topography, vegetation and disturbance of natural drainage pattern due to massive construction has resulted in environmental degradation in the hill towns (Kumar, 2016). Construction activity on high and unstable slopes (350–600) characterized by high percentage of ground coverage is taking place and thereby limiting natural light, air and ventilation, which is likely to affect human health and well-being (ITPI, 2004).

The current scenario of development is more critical in hill towns than urban centers on flattening topography, which is characterized by steep terrain, complex geological structure, adverse climate, and fragile ecological context. The unique urbanscape present in hill towns is a result of the weaving together of topography, architecture, the arrangement of streets, urban spaces and vistas (Jutla, 2000). But, these hill towns have been experiencing enormous pressure for development from last three decades this has changed the urban scenario of hill towns considerably (Meshram, 2008; Kumar, Pushplata, 2013a) (Fig. 2). As growth in a city is regulated and guided by different building regulations that are enforced in that urban area are strong and rigid (Sridhar, 2010), but are poorly implemented and lead to most of the problems of the built environment in hill towns (Kumar and Pushplata, 2015b).

Likewise, to mitigate the impact of above mentioned natural hazards/disasters and safety of buildings and protection of human life during any catastrophe, various structural and non-structural measures for disaster mitigation are employed in the hill towns. Building regulations, being the most valuable tool to regulate and guide development, and most important non-structural measure for disaster mitigation are enforced in different hill towns (Kumar and Pushplata, 2015c). Various building regulations related to safety against landslides, earthquake, slope stability, fire, and floods have been incorporated in building regulations of different Indian hill towns (Kumar and Pushplata, 2013b).

Various problems related to the safety of buildings stock in hill towns still prevails and further intensified due to massive development on the steep and dangerous slope, improper or insufficient site development and stabilization, irregular drainage pattern, dilapidated housing stock (Pushplata and Kumar, 2012) (TCPO, 2011). Moreover, due to extensive use of wood as construction material, most of the hill towns are also prone to fire, and many instances of fire have already been taken place in hill towns, which has resulted in significant loss of human life and precious heritage available in the form of traditional buildings. Also, due to poor compliance and enforcement of different building regulation, most of the buildings that are constructed or being constructed without adhering to safety provisions against natural hazards and are susceptible to substantial damage from any natural catastrophe (Kumar and Pushplata, 2015a) (Fig. 3). Moreover, the land holdings or plots follow natural topographical profile and are irregular in shape. Residents purchase irregular shaped land (without requisite essential services and infrastructure) from landlords to construct buildings (Kumar and Pushplata, 2017). An unprecedented haphazard and unauthorized development on irregularly shaped plots due to lack of serviced land has become a significant concern for safety against disasters.

Therefore, it becomes most evident to study and understand different building regulations enforced in hill towns for safety against disasters, to highlight issues of existing building regulations.

A comparative study of existing building regulations for safety against natural hazards of various Himalayan hill towns is made to have an in-depth understanding of issues related to building regulations. Prevailing building regulations of major hill towns in

Fig. 2. Enormous development in the peripheral regions of hill towns.

Fig. 3. Occurrence of landslides in hill towns.

Himalayan regions such as Shimla, Nainital, Mussoorie, Dalhousie, Manali, Srinagar, and Shillong are studied.

2. Existing building regulations for safety against disasters in hill towns

Existing building regulations for safety against disasters enforced in major Himalayan hill towns of India are studied to identify different issues related to their formulation and enforcement. Building regulations considered for review are taken from latest development plans and building bye-laws available with local governing authorities/bodies. Different documents/master plan/development plan/building regulations used for this study of existing building regulations of Indian hill towns are as follows:

i) Draft Development Plan for Shimla Planning Area 2021 (TCPO, 2011)
ii) Development Plan for Manali Planning Area 2021 (TCPO, 2005)
iii) Development Plan for Dalhousie Planning Area 2021 Town & Country Planning office Shimla, 2004.
iv) Meghalaya Building-Bye Laws 2011 (MUDA, 2011)
v) Building Regulations and Bye-Laws (Kashmir Division) 2010 (CA 2010) (Chief Architect J&K, 2010)

Table 1
Safety regulations against different hazards in hill towns.

Safety for	Shi-mla	Dalh-ousie	Man-ali	Muss-oorie	Nain-ital	Srin-agar	Shill-ong	No of towns having regulations
Landslide	**O**	O	O	O	*	O	*	**02**
Earthquake		O	O	*	*	*	*	**05**
Slope stability	**O**	O	O	O	*	*	*	**03**
Drainage of site	*	*	*	*	*	*	*	**07**
Cutting of slopes	*	*	*	*	*	*	*	**07**
Maintenance of drainage pattern	*	*	*	*	*	*	*	**07**
Preservation of natural features	O	O	*	*	*	O	O	**03**
Fire safety		O	O	*	*	O	*	**04**
Construction safety	O	O	O	O	O	*	*	**02**
Quality of Materials	O	O	O	O	*	*	*	**03**

* regulations specified O regulations not specified.

vi) Mussoorie Dehradun Development Authority Building Construction and Development Byelaws (Amendment) 2003 (MDDA, 2003)

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The status of safety regulations related to various hazards (i.e., whether provisions are specified in regulations or not) in different hill towns is shown in Table 1 and Fig. 4. Key findings related to safety regulations in hill towns are as follows

i) The majority of hill towns like Shimla, Mussourie, Srinagar, Manali do not have any provision related to landslide and slope stability considerations, in spite of having numerous occurrences of landslides or slope failures every year during rain that results in significant loss of human life and resources. There are various protective measures related to safety against landslides mentioned in various Indian standard (IS) codes. But, the adoption of these protective measures will lead to significant increase in construction and site development cost. As a consequence, the owner having weak economic conditions often neglected the various crucial provisions that are necessary for providing protective measures against landslides in hilly regions.
ii) Due to the high seismic vulnerability of hill towns, earthquake safety regulations are included in most of the hill towns except Dalhousie and Manali. But, provisions and considerations discussed in existing building regulations of Indian hill towns have a lot of variations and disparities, which results in noncompliance or ineffective enforcement of these mandatory laws. In most of the building regulations, it is specified that the structure of the proposed buildings should be by the norms laid by the various IS codes. There is no mechanism to check and ensure the adoption of prescribed earthquake safety provisions specified in Indian Standard (IS) codes. Private professionals involved in building designing and construction process, as well as, professionals working with local authorities for granting approval process do not have the necessary competence to design and construct the earthquake-resistance buildings and to check and ensure the compliance of various provisions related to earthquake-resistant design in existing building regulations of hill towns. Moreover, a structural safety certificate is required from the architect or structural designer indicating the compliance of prescribed safety measures, but the adaptation of various safety measures while construction is not ensured or monitored by the development permitting authority.
iii) Regulations related to the cutting of slopes are present in all hill towns, and the maximum height of cutting of hill slopes varies from 3.5 m to 6.6 m. But in practice, hills are cut much more than the permissible value, which leads to the change in slope stability and natural drainage pattern, increasing instances of instability or landslides, which adversely affect human life, resources, and the environment. The maximum limit of slope cutting is prescribed irrespective of slope gradient and type of soil or rock in the town. There is no mechanism in place to check and ensure the compliance of maximum limit of slope cutting.

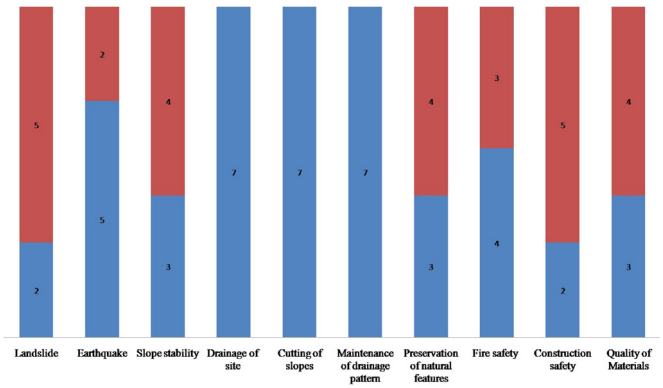

Fig. 4. Safety regulations against different hazards in Hill Towns.

iv) Some hill towns like Mussoorie, Nainital, and Manali have regulations related to preservation of natural water sources, but natural water sources like streams, waterfalls, rivers, lakes, etc. present in or around hill towns are facing severe problems related to encroachment, pollution, and siltation. Buildings developed illegally on the natural drainage course and on or near water bodies are most prone to various types of disasters.
v) Every hill town studied has regulations related to maintenance of upstream drainage pattern, and site drainage, which reflect the importance of maintaining drainage pattern. But, in spite of these rules natural drainage pattern has changed in hill towns due to human interventions like encroachments, buildings built across drainage course and development of large terraces and cutting and filling of slopes, which results in increased vulnerability to various disasters (Kumar 2017).
vi) Hill towns like Manali, Dalhousie, and Srinagar, do not have any regulations about fire safety. In others, fire safety regulations are mentioned as fire safety guidelines but, do not have any regulatory measure or setup to ensure efficient adoption of such crucial laws. No Objection Certificate (NOC) from the fire department is also mandatory for getting approval in few hill towns, whereas, this is not required in other hill towns. Also, there is no provision or mechanism to check and inspect various fire safety rules adopted in different buildings.
vii) Cities like Srinagar and Shillong also mention some regulations related to safety considerations during the construction phase whereas; other towns do not have any provisions pertaining to the safety during the construction phase.
viii) Rules related to the quality of materials used and their workmanship are also present in the building regulations of few hill towns of India.

Along with these enforced building regulations, there are other notable recommendations/provisions suggested in various IS codes which are crucial for development in hill towns and safety against disasters.

As per NBC 2005 (Annexure G part III), settlement planning in the hill areas has enormous implications on the environment. For planning new settlements or working out strategies for growth of existing settlements, it is necessary to conduct detailed environmental inventory/impact assessment, which include geological investigations, slope analysis, soil, flora and fauna analysis, climatic inventories and vulnerability assessment to natural disasters, along with aesthetic factors, cultural, architectural and historical heritage, scenic /landscape value. It further recommends that necessary steps shall be taken in designing and construction in hilly regions to achieve disaster resistance against earthquakes, avalanches, flash floods, landslides, etc. (NBC 2005)

As per National Disaster Management Division, for environmentally sound development of hill towns, integrated development plan should be prepared which include ecologically sensitive areas, hazard-prone areas, drainage channels, steep slopes and fertile land. Where cutting of hill slope causes ecological damage and slope instability in adjacent areas, such cuttings shall not be undertaken without appropriate preventive measures. No construction should be ordinarily taken in areas having slope above 30° or regions which fall in landslide hazard zones or areas falling on the spring lines and first order streams identified by the State Government from available scientific evidence (NDMD, 2007).

As per IS 14804 (2000) Siting, Design and Section of Materials for Residential Buildings in Hilly Areas- Guidelines, safety, developable topography and closeness to the place of work are the primary objectives which should govern the selection of the site for settlement in hilly regions. Varying geological situations, ongoing development activities, climatic variation and different hydrogeological conditions result in various types of hazards like earthquakes, landslides, avalanches, mudflows, flash floods occurring in hill areas (BIS, 2000).

As per IS code 14243 Part 2 (1995) Guidelines For Selection And Development of Hill Sites, Field survey and stability analysis of hill slopes should be carried out for cuttings and buildings should be located on stable hill 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. Moreover, cuttings and excavations on stable hill slopes are made to locate buildings. Such, cuttings often require protection works which add to the site development cost. Hence, it is essential to ensure the stability of such cuttings to have the adequate safety of the buildings. Hillsides with less than 30° slope, in general, are noted to be stable as the gradient corresponds to the safe angle of the repose of slope forming material. Building sites should, in general, be located on hillside with not more than 30° slope. Non-residential temporary buildings may be constructed on steeper slopes up to 45°. Site development in hilly regions consumes about 30 to 40 percent of total cost of building complex. The height of cutting, clearance around buildings, blasting and proper drainage are some essential points which shall be kept in mind during the development of terrace for a buildable site (BIS, 1995)

To develop the understanding of various concerns related to safety in existing buildings, a study is conducted in selected localities in Shimla- the famous hill station and largest hilltop city of north India.

3. Study of selected localities in Shimla

Shimla- the present capital of Himachal Pradesh and the former summer capital of India during the British period is the largest hill town of north India. Shimla, is known for its scenic beauty and picturesque setting. The topography consisting of the ridge and adjacent hill slopes on which Shimla is located and the surrounding hills and dense vegetation on the slopes form an interesting landscape. It is the largest hilltop city of its own type in the North Indian Himalayan region. The city is located in the seismic zone V having higher vulnerability to the earthquake. It is also prone to natural hazards like landslides, slope failure, flash floods, cloudburst along with various anthropogenic disasters like urban fire, building collapse, road accidents, etc. Two localities (SDA complex and New Shimla Township) have higher population densities and are developed in last two decades are considered as the case for understanding of various issues concerning development especially safety against disasters.

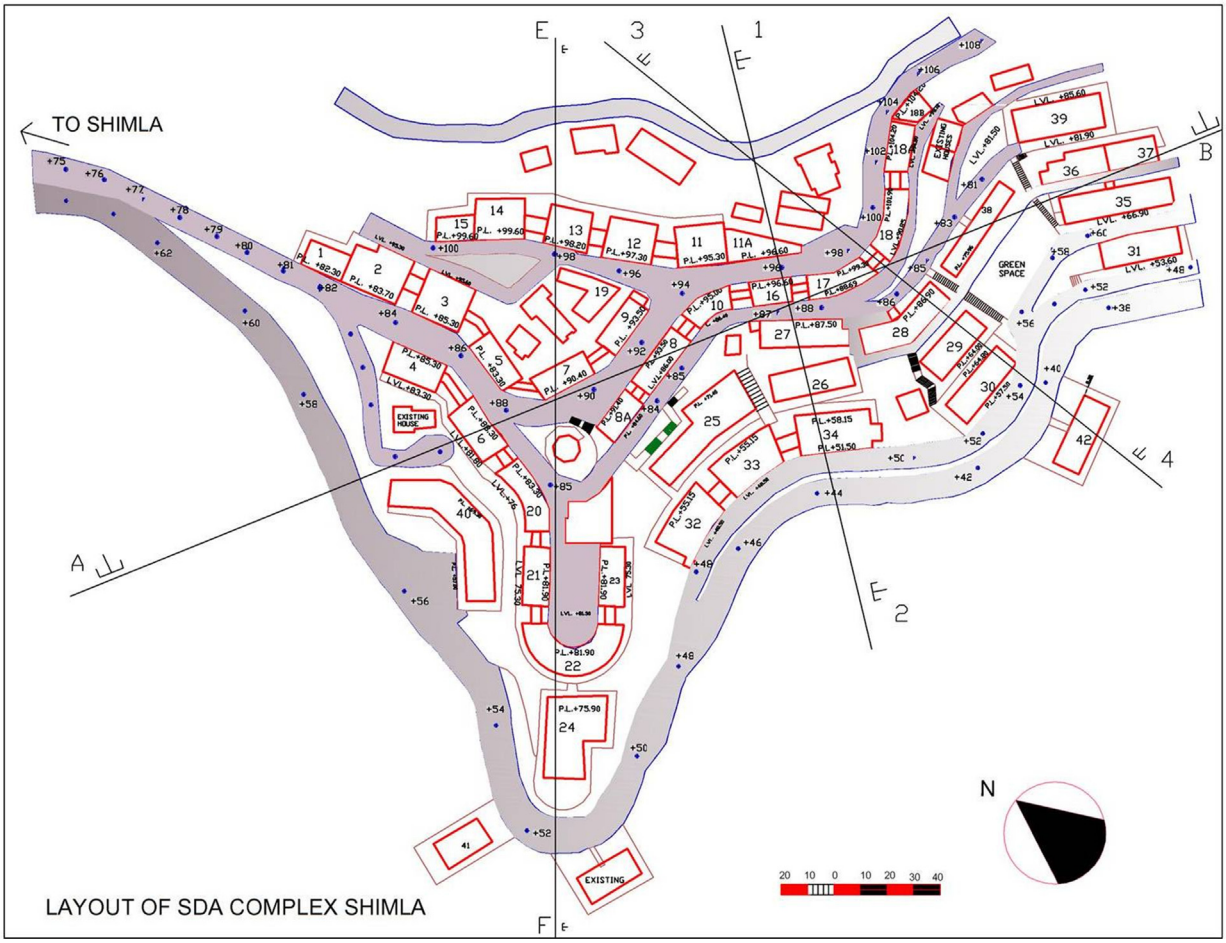

Fig. 5. Layout of SDA Complex, Shimla. Source: HIMUDA, Shimla.

3.1. SDA complex

SDA complex is a commercial, shopping cum office complex developed by HIMUDA (Himachal Pradesh Housing and Urban Development Authority) to decentralize the core city area and to increase the employment opportunities by providing commercial and workspaces. SDA complex is located at Kasumpti, at the periphery of Shimla town, which is approximately 7 km away from the core area of Shimla town. This complex has total 42 buildings designed to house more than 200 shops and offices developed on a site measuring 46190 sq m. Access to the site is through 12 m wide road and internal roads of 9 m, 6 m, 4.5 m and 3 m width are provided in different parts depending upon the traffic conditions. SDA complex is developed on a site having 46190 sq m area with a level difference of 70 m. The slopes in different parts of site varies from 15° to 35° and spreads over mid slopes of two spurs of south sloping hill which has south and south-west orientation(Figs. 5 and 6). Height of buildings in this complex varies from 12 m to 25 m. In this complex one building has 3 storey high, 7 buildings have 4 storeys, 23 buildings have 5 storeys, 10 buildings have 6 storeys and 2 buildings have 7 storey, which indicated that most of the buildings in this complex are mid-rise (having more than 04 storey) as shown in Fig. 7 and Fig. 8. The floor to floor height is taken as 3.20 m. Area covered under different buildings in this complex is 15253 sq m, which is 33.03% of total site area. Different roads in complex have an area of 11901sqm which is 25.77% of total site area. Remaining 41.2% area on site is kept uncovered and undeveloped. The open areas on the site have high slope gradient, which makes them unsafe for any development purposes. Total built-up area under different buildings in SDA complex is 77152 sqm, which accounts for consumption of 1.67 floor area ratio (F.A.R) in the complex. The various problems related to development and building regulations are as follows:

i) Total built-up area under different buildings in SDA complex is 77152 sq m, which accounts for consumption of 1.67 F.A.R in the complex, which is usually higher than building regulations enforced in town.
ii) Buildings are designed on different leveled terraces, the slope of the site is more than the desirable for building development works, building blocks are designed in linear/rectangular shapes
iii) The site has high steep slopes which usually more than 20° and multistoried (04 to 07 storied) buildings are constructed on these

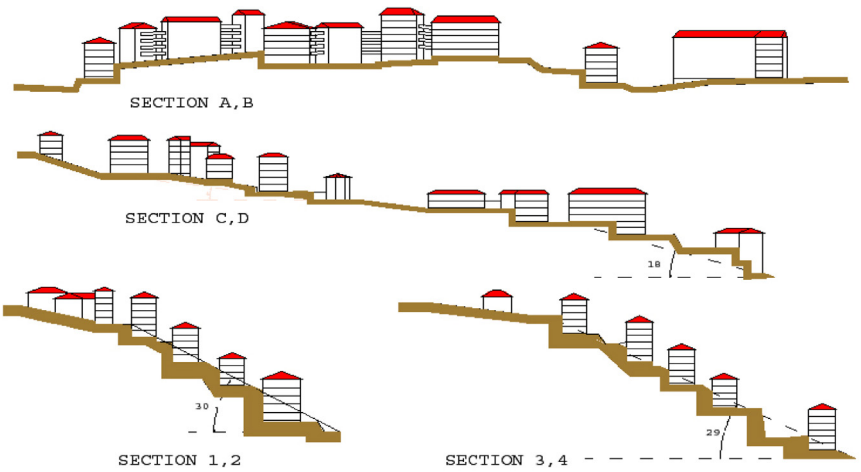

Fig. 6. Schematic Sections of SDA Complex, Shimla.

Fig. 7. Multi-storied Buildings on Different Terraces in SDA Complex, Shimla.

steep slopes as shown in Fig. 10 and Fig. 8, which is in violation to existing building regulation, as existing building regulations specify maximum permissible number of habitable storey as 04 and most of the buildings in this complex are developed without adhering to this provision of existing building regulations.

iv) Most of the buildings in the complex are linear in shape, which are usually placed along the contours to reduce the site development work. Most of the buildings have one of their longer sides facing south to have maximum solar exposure. But other/north side which is mostly adjacent to cut slope receive minimum solar exposure. Thus, damp and unhealthy living conditions generally prevail on lower storey of buildings towards cut hillside surface.

v) The roads provided in the complex have insufficient width and have greater slope gradients to cater increased number of vehicles, which often results in traffic jams and accidents in the complex. The slope gradient of internal roads is very high at different locations which make it difficult to drive and vehicles parked on road make it more tedious. The condition of roads is poor, no rainwater/ wastewater drains are provided along the roads.

vi) Most of the buildings developed in this complex are government office buildings, which have adequate safety measures against earthquake, but the provisions to minimize the impacts of flash floods and urban fire are majorly not present in the complex.

3.2. New Shimla township

New Shimla is a residential township which is planned and developed by Himachal Urban Development Authority (HIMUDA) on the outskirts of Shimla town on southern slopes, to lessen the pressure of town core area and to provide residential facilities for increasing population (Fig. 9). This township has 04 sectors and is developed in two phases. Sector 3, which is developed in phase II, is considered for this study as the issues of building regulations and their impacts are pronounced in New Shimla. This township has 781 residential units in the form of individual plotted and apartment (group housing) development, which accounts for 36.39% of proposed landuse (calculated on the basis of layout plan provided by HIMUDA). Individual plots of area, 90 sq m, 120 sq m, 200 sq m, 250 sq m and apartments or flats of area, 35 sq m, 48.5 sq m. 77 sq m, 133 sq m, 165 sq m are provided for residential accommodation in this township as shown in Table 2.

The setbacks imposed on development in this township are 3.0 m front, 2.5 m or 3.0 m side and 3.0 m rear setback. The side

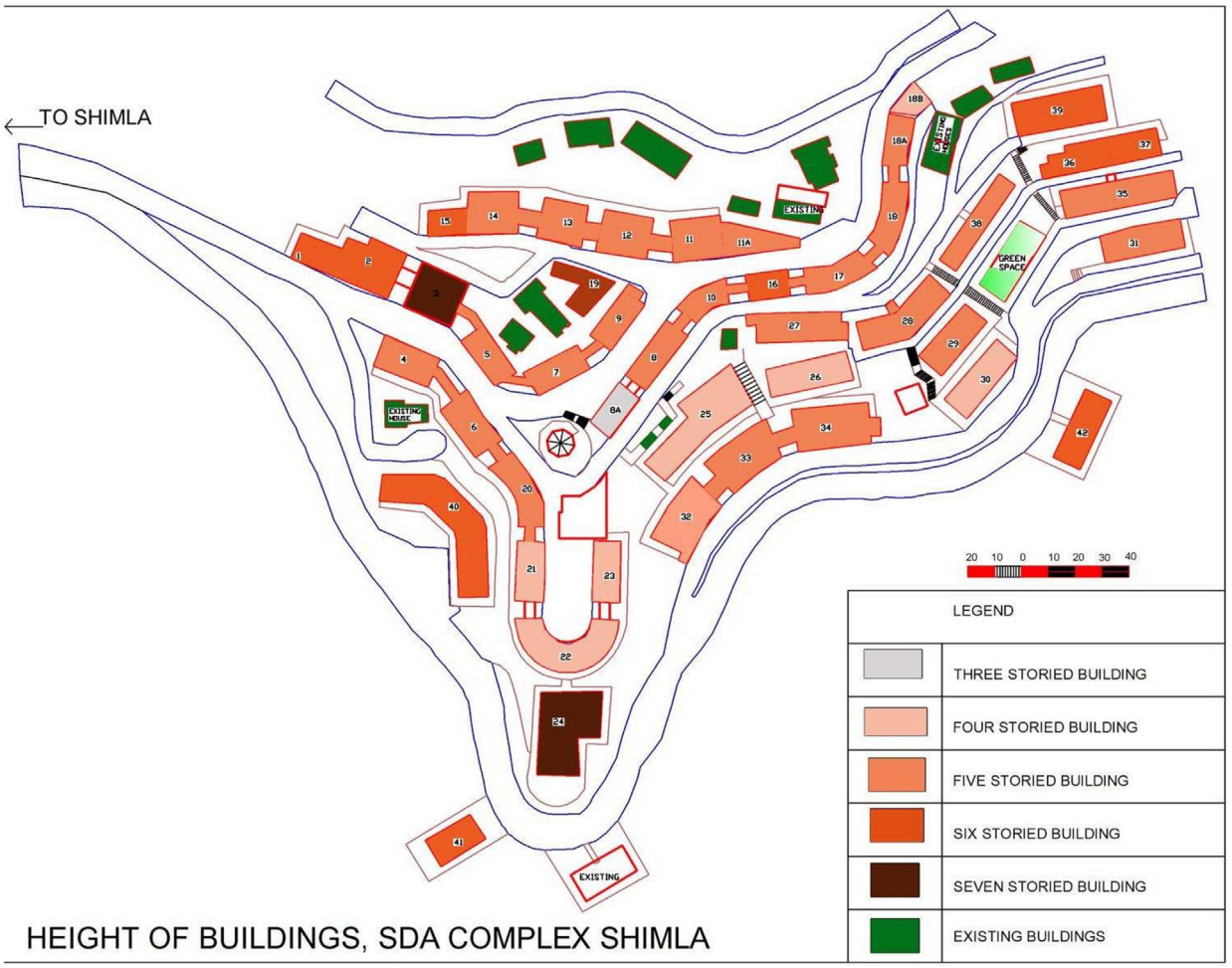

Fig. 8. Height of Buildings in SDA Complex, Shimla.

Fig. 9. View of New Shimla Township, Shimla.

setback depends upon the size of plot and type of development. The maximum number of storey allowed for plotted development is 03, including basement and habitable attic. The proposed development in sector III is shown in Figs. 10 and 11.

But in contrast to the proposed development having 03 storey buildings, the existing development pattern which is developed over time in this township is different. The existing development in the study area comprises of buildings having variation in number of storey as shown in Fig. 11. The actual ground coverage as well as F.A.R used in this township is much higher than the proposed ground coverage and F.A.R. in the town. Various observations related to the condition of existing development and performance /adoption of building regulation and their impacts are as follows:

Table 2
Proposed residential development in New Shimla Township, Shimla. Source: HIMUDA, Shimla.

S.no	Type of development	Plot area (m^2)	Plinth area (m^2)	Ground coverage
1	Flats	48.50	25	51.54
2		77.40	47	60.72
3		133.32	73	54.75
4		165.77	83	50.06
5	Independent plots	90	48	53.33
6		120	68	56.67
7		200	90	45
8		250	119	47.6

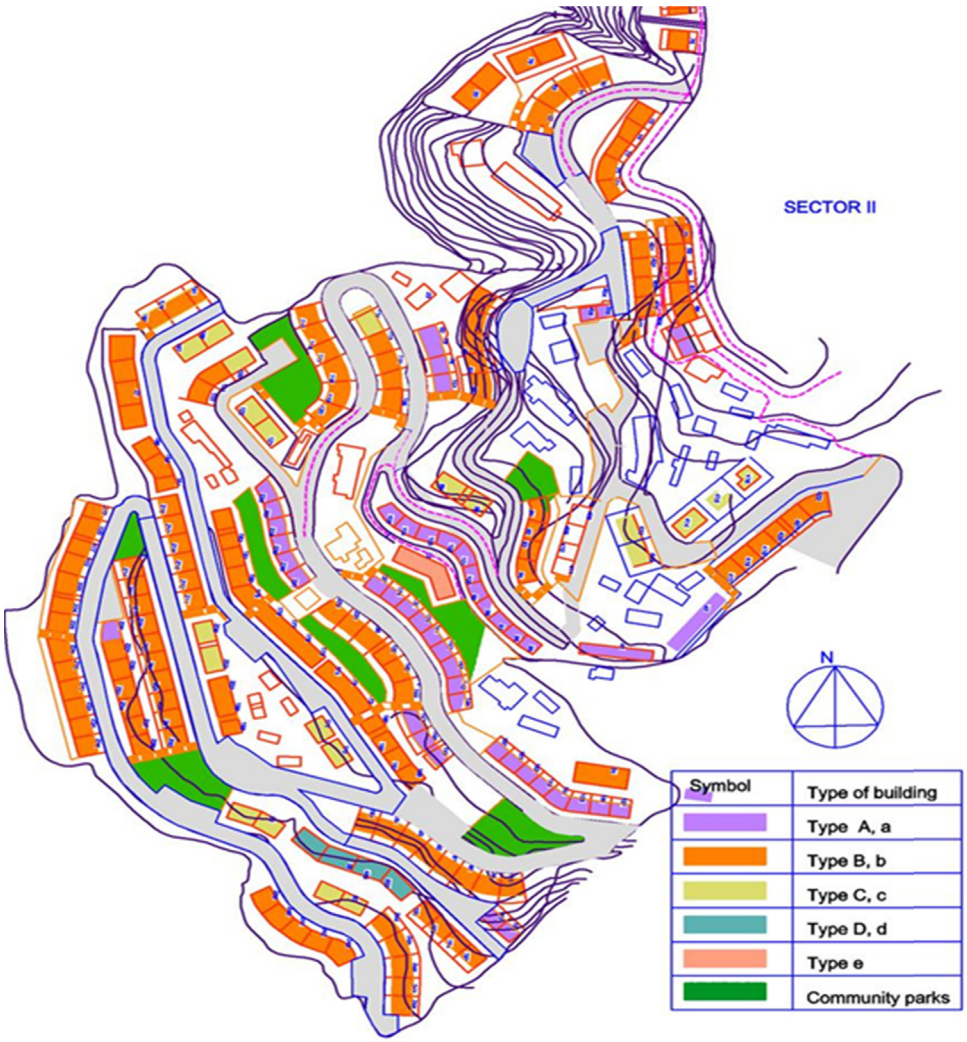

Fig. 10. Proposed Development in Sector III, New Shimla Township.

i) In this township the proposed ground coverage after fulfilling setback conditions varies in between 45% and 60%. It is observed from the study of New Shimla locality and also mentioned in Shimla Development Plan 2021 that the actual ground coverage is around 70%, which is more than the proposed ground coverage and results in high building footprint and less space between buildings for getting sufficient solar exposure.

ii) It is found from the study that most of the buildings (except ten buildings) in sector III, have 4 and more number of stories, as against 3 number of stories proposed by development authority. As a result, there is a violation of F.A.R in the study area and as analyzed by Town and country planning Department Shimla the used F.A.R in the area is 2.5 and more, whereas the enforced F.A.R is 1.75. (TCPO, 2011). Moreover, in the down hillside mostly two stories are generally constructed as partial basement

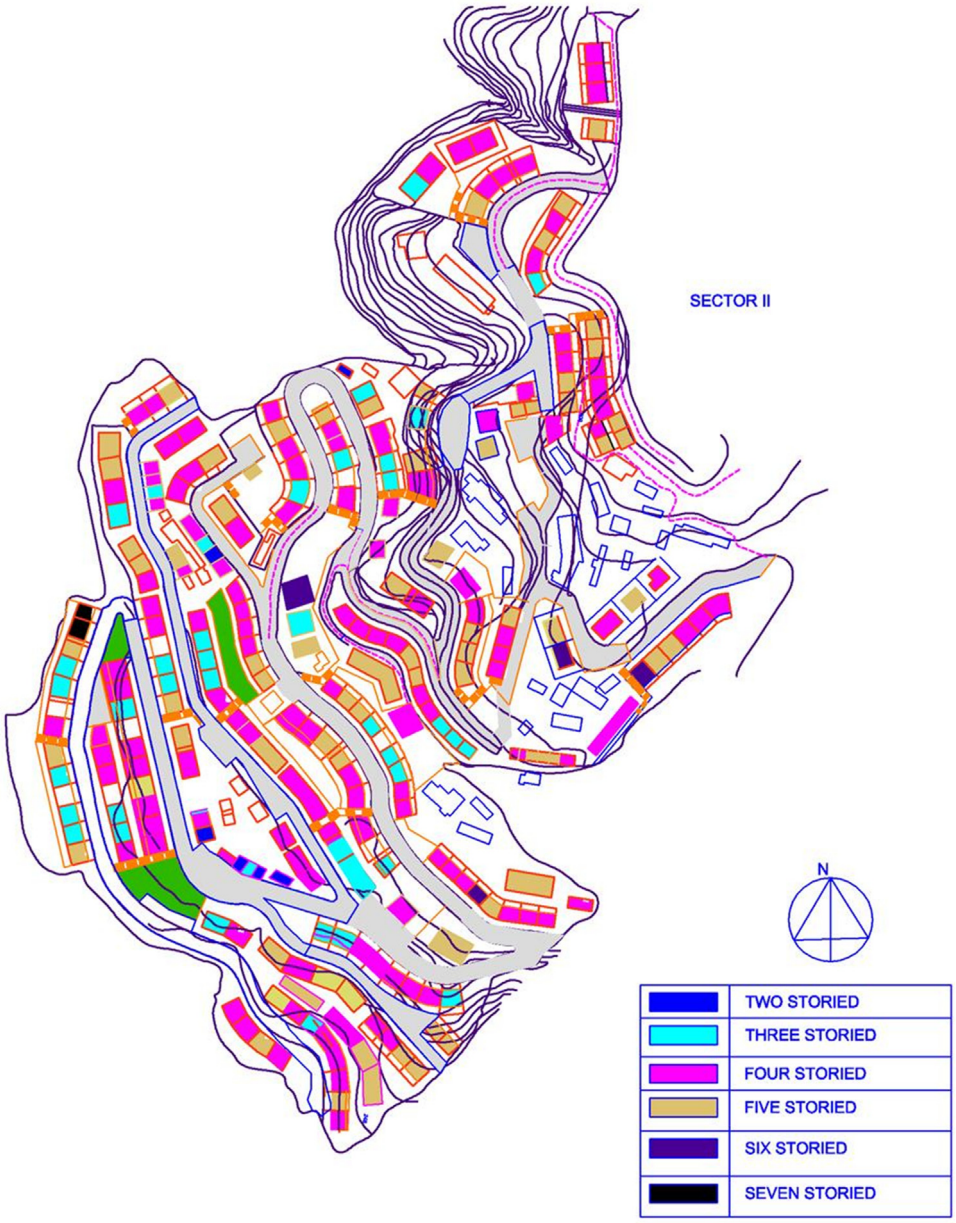

Fig. 11. Existing development in sector III, New Shimla Township.

below the existing road level (Fig. 12), which is often not included in the number of stories.

iii) There is a variation in community facilities which are proposed by planning and development authority and existing in the township. Moreover, the space allocated for these community facilities are also encroached upon by surrounding plot owners and utilized for different purposes like parking and storage.

iv) Road width in the township varies from 9 m to 4 m which are insufficient to cater the traffic. Moreover, high boundary or retaining walls are constructed all along the road making it more difficult to increase its width. These roads are having high slope gradient and sharp turns, which make them more prone to accidents due to steep slope gradient (Fig. 13).

v) Front and rear setbacks are present in all buildings, but as observed in many cases these are usually less than the specified setback conditions in the proposal. This space is utilized for different purposes like providing access to the building through ramp or stairs, for keeping water tanks or use as storage space (Fig. 14), this result in the reduction in solar access to different stories. Various projections like balconies, roof overhangs are provided in the setbacks which further reduce the effectiveness of setbacks for providing daylight to the building. This front setback has the worse impact on the development on the downhill side of the road, as this open space is crucial for having adequate daylight in spaces/areas of building towards the retained slope.

Fig. 12. Multistoried buildings with partial basements in Sector III, New Shimla Township.

Fig. 13. Multi-storied buildings along steep road in New Shimla Township.

Fig. 14. Insufficient setbacks around multistoried buildings in New Shimla Township.

vi) To achieve flat surface on uphill side of the road for the commencement of development work retaining walls up to 6–8 m height are provided. As a result, buildings are developed on a higher level than abutting road level, which results in high site development cost. Presently, due to high pressure for development, many owners have added extra stories below their buildings by excavating the retained earth/slope below building up to the road level, as shown in Fig. 15. This addition of more stories at the base of the building is done illegally without any permission of local developmental authorities and has no/inadequate safety

Fig. 15. Addition of extra storey after demolition of retaining walls in New Shimla.

measures against hazards.

vii) Though buildings are developed along the street without any side setbacks, no two buildings have similar façades, facade elements and elevation features which are creating aesthetically unappealing streetscape. Moreover, these new building facades are designed and developed without considering the rich heritage of Shimla and do not have any relevance to the existing architectural character of the town.

viii) Insufficient parking provisions (for 25–30 cars) are provided in the township, which is very less as compared to the number of vehicles available to residents. Owners are forced to keep/park their cars on/along the road which further reduces the road width and causes the traffic jam.

ix) This township is developed on green forest area, and numerous trees are cut for development, but no/very few trees are planted by the owners in their plots.

x) Regulations related to rainwater harvesting, maintenance of natural drainage pattern, channelization of upstream are present in existing building regulations of town but are not followed in existing development in the township.

It is established from the study that the regulations applicable in hill towns related to safety against natural hazards are inadequate and are poorly enforced. People are violating enforced building regulations and increasing the risks of substantial destruction during disasters.

4. Discussions related to formulation of regulations for hill towns

To improve the condition of development and formulation of appropriate building regulations, different institutions/ organizations/ authors have suggested different criteria or factors which can become basis for formulation of building regulations for specific context of hill towns.

Importance of local conditions both physical and environmental for formulating various norms and standards for urban development plans in hill areas are highlighted in Model Building Byelaws (2004) Chapter III. Local conditions and physical context must provide the threshold for formulation of standards and codes. Regulations should be place-based, emphasize details, and be buttressed by common approval. When a model code is adopted by a higher authority, the local jurisdiction must review and amend it to its unique circumstances. Codes and standards must be drafted in clear and simple terms. (Joseph, 2005).

New development in hill towns is based on a piecemeal approach and lack in proper planning and design. Development is considered as a visual blight and inappropriate in terms of scale, material and style having no apparent design guidelines; and unfair development approval process. Mountain slopes are exploited for multi-storey concrete buildings, which appeared to be haphazard, uncoordinated and lacking appropriate scale. There is a dilemma amongst planners and designers as some strongly believe in preserving the townscape character of the city, while others support its growth as per present social, economic and political forces. (Jutla, 2000)

Basic building regulations and controls prescribed through zoning regulations, such as setbacks, height, F.A.R. and ground coverage ought to be re-formulated with due consideration to topography, sun light and, wind direction. There is a need for providing measures for mitigating natural disasters (like landslides and earthquakes) Urban development with the involvement of governments, corporate sectors, builders and local community; encourage multi-nodal not single node settlements development pattern and formulate policies, which encourage development of small townships around Shimla (ITPI, 2004)

According to Moser (1991), various constraints present for hillside development include varying degrees of slope, other on-site topographic features, access, views, utilities availability, storm hydrology, soils/geology, sanitary sewage disposal, vegetation, other environmental constraints, noise, and surrounding development.

Table 3
Density reduction with increase in Slope Gradient in hillside regulations. Source: Pasadena Planning Code.

Average Slope	Density Reduction Factor
0% to 15%	1.0
15% to 20%	0.9
20% to 25%	0.8
25% to 30%	0.7
30% to 35%	0.6
35% to 40%	0.5
40% to 50%	0.4

According to Olshansky (1998), criteria which need to be consider prior to implementing of planning and building regulation for hilly areas are topography, slope stability, drainage and erosion, infrastructure, access, aesthetics, natural qualities, fire hazard, recreational values, and open space. Also, statements of purpose of various hillside building regulations in United States were organized into the following seven categories as health, safety, and general welfare; avoiding geologic hazards; fire protection; natural resource protection (water supply, open space); natural phenomena protection (river corridors, vegetation, habitats, soils); aesthetics; and access

Site development regulations for hillside development include regulations related to grading, storm water and urban runoff control regulations, landscaping, exterior lighting, fire safety, trash receptacles, large vehicle restrictions, sewer connections regulations. In Pasadena city regulations related to hillside development, to control density of hill side development, Density Reduction Factor is applied based on the average slope. There is no decrease/reduction in density for sites/plots having average slope upto 15%, sites having average slope more than 15% and upto 20% has a Density Reduction Factor of 0.90, sites having average slope more than 40% and upto 50% have Density Reduction Factor of 0.40. It implies that, a site/plot having average slope in between 40% to 50% shall have 60% less density than flat site (average slope 0–15%) for same plot area (Planning Department City of Pasadena CA,) (Table 3).

5. Conclusions

Safety against disasters is the most critical concern of new development in Indian hill towns and existing building regulations are not appropriate to provide safer buildings having sufficient resistance to disasters as the provisions and enforcement mechanism present in building regulations are ineffective and incomplete. The safety of new development against hazards can be improved by revisiting the basis of different safety regulations and formulation new building regulations for providing safety against disasters to new and existing buildings in hill towns.

Different Interventions needed for formulation and implementation of safety regulations against disasters can be divided into different categories as interventions for formulation of safety regulations for new buildings, formulation of safety regulations for existing buildings, ensuring effective enforcement and compliance, and upgradation of technical expertise of professionals and authorities. Also, there is a need to have continuous monitoring and condition assessment of retrofitted structures to ensure the efficient functioning and performance of retrofitted components.

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