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Research Article

Techno-Legal Provisions for Safer High-rise Apartment Construction in Nepal

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I N F O

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A B S T R A C T

The paper aims to review the techno-legal provisions for safer high rise appartment construction in Nepal. The review of existing acts, rules, directives, guidelines, byelaws, codes and other unpublished documents were done for the research using content analysis followed by expert consultation as it needs to be viewed in different technical aspects which need expertise of different fields.

The major provisions of the building code for seismic safety of apartment buildings are defined in Nepal National Building Code (NBC) 105:1994 and international codes are also used fulfilling the minimum requirements of the Nepal National Building Code as per NBC 000:1994. The architectural design parameters, fire fighting provisions, provisions of fire safety requirements are conformed as per the relevant NBC. At least eight government authorities are directly involved in the process of approval and building permit process. There is the provision of third party monitoring system also. Similarly the use approval to the earthquake damaged apartment is provided after repair, restore and retrofitting work according to the damage category and severity of the damages in structural and nonstructural members. For the effective compliance of the NBC and byelaws in apartments seismic safety of high rise buildings should be increased in NBC 105:1994 updating the seismic design parameters, building byelaws provisions should be updated for higher value of green open spaces, setbacks and access road. Effective coordination between all stakeholders and independent third party supervision and monitoring process should be done. For minimizing the issues raised by the neighbours after Gorkha Earthquake 2015, proper zoning for apartment construction, seismic vulnerability assessment of the existing apartments and Insurance of Neighbours of the apartments should be done. It is a review research to signify the role of NBC and bylaws for development of Nepal.

Keywords: Design parameters, Acts, Supervision, Monitoring, Seismic safety

Introduction

The Building Code is the only techno-legal document to assure safer construction in Nepal through provisions for the regulation of design and construction of the buildings that is resistant to earthquake, fire and other natural calamities for certain extent with optimum utilization of locally available construction materials and suitable geologically and climatically (MoPPW, 1999).

The growing population can be managed by vertical development like High –rise construction. The high-rise apartment building construction is being regulated by the Government authority in Nepal after Ownership of Joint Housing Act, 1997 on April 15, 2003. The government authority, Department of Urban Development and Building Construction (DUDBC) Division Office Kathmandu (DOK), have approved 71 high-rise apartment buildings in Kathmandu Valley up to 2073 BS. Out of the 71 approved apartments, 51 apartments are completed and already inhabited with or without completion certificate from DUDBC, seven apartments are under construction, five apartments are being used for other occupancies, six apartments have not started the construction and two of them have cancelled their approval till date August, 2016. The inhabited 51 apartments are accommodating more than 4,000 families in Kathmandu valley (Joshi, 2016).

During the earthquake of 1934, 1988 and 2011 and devastating Gorkha Earthquake 2015 are the recently known ones in Nepal the loss could not be expressed.

During the Gorkha Earthquake 2015 people were very afraid to live in high-rise apartment buildings, they were hesitating to enter those apartments even after two months. They were afraid to live in the apartments having damage. On the other side the Neighboring community of those high rise apartments was also very afraid to live in their own house feeling risk of the falling down of the apartment building to them. They were demanding to dismantle those high rise apartments, to government of Nepal.

On the other side during the rapid visual damage assessment the two apartments got red postage, 30 apartments got yellow postage and seven apartments got Green postage, out of 39 high-rise apartments that were occupied (Joshi, 2016). The Red postage means it is unsafe to enter the building, yellow means restricted use or only short entry is allowed to certain portion of building and the Green means it is safe for normal occupancy at time of rapid visual damage assessment.

Let's convert this fear into a great opportunity to rethink about the new technology of design and construction of those apartments to the designers, developers and investors. The fact that none of the people died due to falling of the apartment buildings can be highlighted.

The scope of paper is to review the byelaws and codes regarding high-rise apartments, review the building permit system as well as monitoring mechanism and also come up with the issues relating. In this context, the study provides distinct information about building byelaws and codes regarding high-rise apartments, building permit and approval process of apartments and issues regarding the building byelaws and code implementation/compliance in high-rise apartment building and recommendations for overcoming those challenges.

Therefore, this study will be a valuable document for designers, developers, users, policy makers and other concerned authorities or individuals to know the existing gaps in the policies, acts, byelaws, codes and guidelines for effective construction of the high-rise apartments. This study also helps to upcoming similar academic research for the researcher and upcoming high-rise apartment projects in Nepal valley to know there potential challenges.

This study focused on designer's perceptions on compliance and implementation of byelaws and codes in high-rise apartment building. Therefore, this study will be a valuable document for concerned organizations and individuals to understand their perceptions towards the building byelaws and codes for high-rise apartment buildings.

Objectives

The Research aims to review the major provisions of building byelaws and building codes along with building permit/ approval, supervision & monitoring mechanism/ process for regulating the safer construction of High-rise apartment buildings.

Literature Review

Apartment

Let's define, "apartment" means any unit of a joint housing building, which contains one or more than one room, along with such common areas and facilities as may be enjoyed freely in such a building (MoUD, 2014).

The definition of high-rise buildings for understanding i.e. buildings more than 25 m height or more than 9 stories, is considered as high-rise building as operational definition of high-rise apartment buildings in Kathmandu valley.

Nepal National Building Code (NBC)

Historical Development of National Building Code in Nepal

Nepal being at the 11th position in seismic-prone has been suffered from big earthquakes since the time immemorial. The Earthquakes in 1199, 1352, 1625, 1754, 1777, 1810 and 1834 have been found in manuscripts. After the hundred years of 1834 earthquake, the "Mahabhukampa" i.e. Bihar-Nepal Earthquake on January 15, 1934 was the

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devastating earthquake of 8.4 magnitude that has been talked the most. In this earthquake, 8519 people were died out of which 4296 (about 50%) casualty was in only the Kathmandu valley.[9] Most of the buildings, temples, towers, patis and palaces of Kathmandu valley were destroyed in this earthquake. Besides this, Nepal has been badly suffered from the earthquakes of 1988, 2011 and the most recent devastating earthquake in 2015 with 7.6 ML magnitude and epicenter at Barpak, Gorkha.

After the earthquake on August 21, 1988 of 6.7 ML magnitude and epicenter at Murkucche of Udayapur district in which casualty of 721 and destruction of more than 6500 buildings, the need of Nepal's own building code felt for the earthquake safe building construction. And thus a project was launched under Ministry for Preparation of National Building Code in 2051 BS with the financial support of UNDP/UNCHS (Habitat). The international consultants BecaWorly International Consultants Ltd, New Zealand, Golder Associates Ltd, Canada/ Urban Regional Research, USA and the National Consultants SILT Consult P. Ltd./ TAEC Consult (P) Ltd. and the Engineers, Architects, seismologist, geotechnical engineers, geologist from Government of Nepal were involved. The draft National Building code (NBC) was completed by the project on 1998. The enforcement of that NBC was guided by the Building Act 1998. However, the National Building Code 1998 was finalized in 2003 in 23 volumes after incorporating the suggestions from expert and enactment of Building Regulations 2003.[9]

National Building Code (NBC) of Nepal

The national building code of Nepal is the only techno-legal document to make necessary provisions for the regulation of design and construction of the building's resistant to earthquake, fire and other natural calamities for certain extent, with optimum utilization of locally available construction materials and suitable geologically and climatically (MoPPW, 1999). National building code (NBC), which deals with the design methods, construction technology and materials for safer building construction, plays a vital role in disaster preparedness stage which is very important for disaster risk reduction.

The National Building code of Nepal consist of the following 23 volumes which has been categorized in four categories for implementation in different levels of buildings as per Building Act 1998.

- NBC 000: 1994: Requirements For State of the art Design: An Introduction
- NBC 101: 1994: Materials Specifications
- NBC 102: 1994: Unit Weight of Materials
- NBC 103: 1994: Occupancy Load (Imposed Load)
- NBC 104: 1994: Wind Load
- NBC 105: 1994: Seismic Design of Buildings in Nepal
- NBC 106: 1994: Snow Load
- NBC 107: 1994: Provisional Recommendation On Fire Safety
- NBC 108: 1994: Site Considerations For Seismic Hazards
- NBC 109: 1994: Masonry: Unreinforced
- NBC 110: 1994: Plain and Reinforced Concrete
- NBC 111: 1994: Steel
- NBC 112: 1994: Timber
- NBC 113: 1994: Aluminum
- NBC 114: 1994: Construction Safety
- NBC 201: 1994: Mandatory Rules of Thumb: Reinforced Concrete Buildings with Masonry Infill
- NBC 202: 2016: Mandatory Rules of Thumb: Load Bearing Masonry
- NBC 203: 2016: Guidelines For Earthquake Resistant Buildings Construction: Low Strength Masonry
- NBC 204: 2016: Guidelines For Earthquake Resistant Building Construction: Earthen Building (EB)
- NBC 205: 1994: Mandatory Rules of Thumb: Reinforced Concrete Buildings Without Masonry Infill
- NBC 206: 2003: Architectural Design Requirements
- NBC 207: 2003: Electrical Design Requirements for (Public Buildings)
- NBC 208: 2003: Sanitary and Plumbing Design Requirements

The four categories of the buildings and the respective NBC to be applied is shown in Table 1.

The high-rise apartment buildings have mostly plinth area more than 1000 square feet and also taller than three storey and structural span more than 4.5 m, so that high-rise apartment buildings mostly lies on the category "B", professionally engineered buildings. Thus, all volumes of the NBC for "Professionally engineered Buildings" shall be applied for high-rise apartment buildings. Besides the national building code, the international codes such as IS Code, New Zealand codes, British codes can also be applied as per "NBC 000", but the minimum requirement of NBC shall be fulfilled.

NBC 105: 1994 Seismic Design of Buildings in Nepal

Any buildings in Nepal shall meet the minimum design requirements of the Nepal National Building Code (NBC 105: 1994), Seismic Design of Building in Nepal. Thus the seismic safety of the buildings are assured as per the NBC 105 -1994: Seismic Design of Buildings in Nepal. According to the NBC 105:1994, the following parameter are used for designing the buildings for seismic safety.

Design Load Combinations

The following load combinations shall be used for the greatest effect:

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Table 1.Type of NNBC and respective building category

S. No.	Type of Building Code				Building Category
1.	(International State of Art) NBC 000				Category "A": Modern building to be built, based on the international state-of-the-art, also in pursuance of the building codes to be followed in developed countries
2.	(For Professionally Engineered Buildings)				Category "B": Buildings with plinth area of more than 1000 square feet, with more than 3 floors including the ground floor or with structural span of more than 4.5 meters
	NBC 101	NBC 106	NBC 111	NBC 207	
	NBC 102	NBC 107	NBC 112	NBC 208	
	NBC 103	NBC 108	NBC 113		
	NBC 104	NBC 109	NBC 114		
	NBC 105	NBC 110	NBC 206		
3.	(Mandatory Rules of Thumb) NBC 201, NBC 202, NBC 205				Category "C": Buildings with plinth area of up to 1000 square feet, with up to 3 floors including the ground floor or with structural span of up to 4.5 meters
4.	Guidelines for Remote Rural Buildings (Low Strength Masonry / Earthen Buildings): NBC 203, NBC 204				Category "D": Small houses, sheds made of baked or unbaked brick, stone, clay, bamboo, grass, except those set forth in clauses (a), (b) and (c)

MoPPW, 1999

- 1.5(DL+LL)
- DL + 1.3 LL + 1.25 EQ
- DL + 1.3 LL - 1.25 EQ
- 0.9 DL + 1.25 EQ
- 0.9 DL - 1.25 EQ
- DL + 1.3 SL + 1.25 EQ
- DL + 1.3 SL - 1.25 EQ

Where, DL: Dead load, LL: Live load, SL: Snow load and EQ: Earthquake load.

Seismic Weight

The seismic weight, W_i, shall be taken as the sum of the dead loads and the seismic live loads between the mid-heights of adjacent storeys. The seismic live load shall be taken as a percentage of the design live load as 25% if design live load is up to 3 KPa and 50% if greater than 3 KPa and for roof no live load is taken.

Periods of Vibration

The periods of vibration, T_i, for framed structures with no rigid elements limiting the deflection i.e. apartment buildings shall be calculated by:

$T_i = 0.06 * H^{¾}$ for concrete frames

Where, T_i = fundamental periods of vibration and H = total height of the structure.

Selection of Method of Analysis

For structures of up to 40 m in height the Seismic Coefficient Method may be used. For all other structures the Modal Response Spectrum Method shall be used.

The Modal Spectrum Method should be used for:

- Buildings with irregular configurations
- Buildings with abrupt changes in lateral resistance
- Buildings with abrupt changes in lateral stiffness with height
- Buildings with unusual shape, size or importance.

Design Spectrum for the Modal Response Spectrum Method

The design spectrum, $C_d(T_i)$, shall be taken as:

$C_d(T_i) = C(T_i)$ ZIK

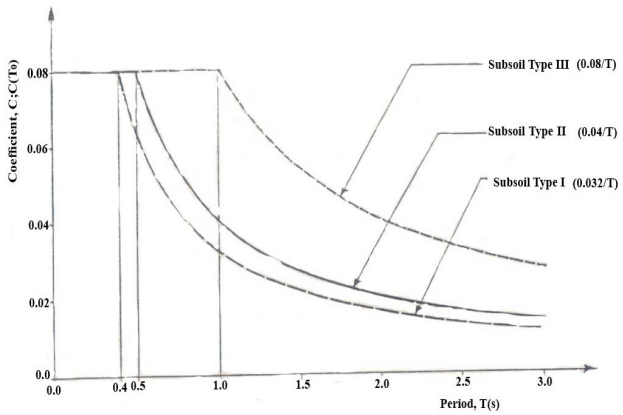

Figure 1.Base shear coefficient for natural time period
(MoUD, 1994)

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Where $C(T_i)$ = ordinate of the basic response spectrum for translational Period, I = Importance factor for Apartment building, Z = Seismic Zoning Factor for Kathmandu valley and K = Structural performance factor for Ductile moment-Resisting frame.

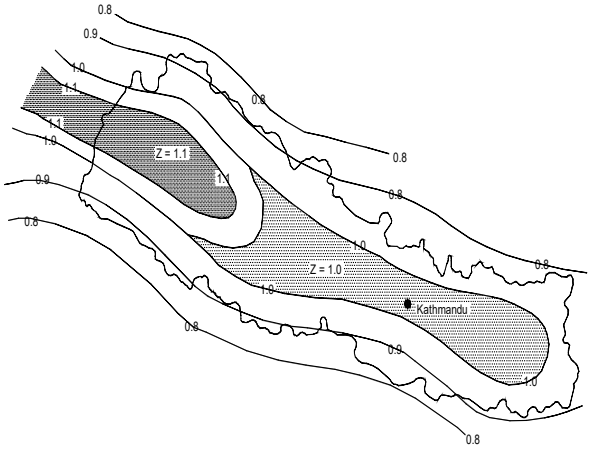

Figure 2.Seismic zoning map of Nepal (Mishra AK & Thing R, 2019; Mishra AK, 2019)

Horizontal Seismic Forces

The horizontal seismic force at each level of floor i shall be taken as:

$F_i = V W_i h_i / \Sigma W_i h_i$

Where, F_i = Horizontal seismic force at floor I; V = Seismic Base shear = $C_d(T_i)$ W; W = Total Seismic Weight of the building;

W_i = Seismic weight of the floor level I and h_i= height of floor i measured from base.

Provided that:

- Where the height to width ratio of the horizontal load resisting system is equal to or greater than 3, then 0.1 V shall be considered as concentrated at the top storey and the remaining 0.9 V shall be distributed in accordance with the equation above
- For chimneys and smoke-stacks resting on the ground, 0.2 V shall be considered as concentrated at the top and the remaining 0.8 V shall be distributed in accordance with the equation above
- For elevated tanks, the force F_i is equal to V and acts through the centre of gravity of the total weight of the structure and contents

Derivation of Design Lateral Deformations

The design lateral deformations shall be taken as the deformations resulting from the application of the forces or design spectrum, multiplied by the factor 5/K.

Building Separations

- To Boundaries

Above ground level, each building of greater than three storeys shall have a separation from the boundary, except adjacent to a designed street or public way, of not less than the design lateral deflection or 0.002 h_i or 25 mm whichever is the greater.

- Within Site

Parts of buildings or buildings on the same site which are not designed to act as an integral unit shall be separated from each other by a distance of not less than the sum of the design lateral deflections or 0.004 h_i or 50 mm whichever is the greater.

- Separation Space Width

Separation spaces shall be detailed and constructed to remain clear of debris and other obstructions. The width of such spaces shall allow for all constructional tolerances.

Inter-Storey Deflections

The ratio of the inter-storey deflection to the corresponding storey height shall not exceed 0.010 nor shall the inter-storey deflection exceed 60 mm.

Modal Response Spectrum Method of Seismic Analysis

The relative response of each contributing mode i shall be determined by multiplying the mode response by the value of $C(T_i)$. A sufficient number of modes shall be considered to ensure that at least 90% of the mass is participating in the direction under consideration.

The combination method shall take into account the effect of closely spaced modes. Modes shall be considered to be closely spaced if their frequencies are within 15 %.

NBC 206:2003 Architectural Design Requirements

The architects and engineers shall meet the minimum standards and requirements, as per Nepal National Building Code (NBC 206:2003), Architectural Design Requirements while designing a building. The principal focus of the code is on the safety of the occupants although it is also intended to maintain the minimum acceptable level of comfort & accessibility in a building. According to the NBC 206:2003, following minimum standards and requirements shall be met in apartment building.

Staircase

Every stair having two or more risers shall conform to the following conditions.

The minimum clear width (unobstructed by projections or handrails) of staircase shall be as follows:

Apartments	Shared	1000 mm
(Within each multilevel unit)	Internal	800 mm

- The minimum tread shall be 250 mm excluding nosing

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and the maximum riser will be 175 mm for all buildings except for internal staircases of Apartments, which can be permitted up to 190 mm
- Handrails shall not be lower than 900 mm above the center of the tread
- The maximum number of risers shall be limited to 15 per flight
- The minimum headroom under a staircase shall not be less than 2000 mm measured vertically from the nosing of the tread to the soffit plane above

Exits

Exits shall be defined as a continuous and unobstructed means of egress to a public way and shall include intervening doors, passages, lobbies, ramps, staircases, courts and balconies. An exit may also include a horizontal exit into another building at the approximately the same level. Mishra AK, Shrestha A analyzed exit requirements for fire safety.[11]

General Exit Requirements

Except in case of apartments, exits shall be arranged so that it shall not pass through another occupied area.

The maximum travel distance on the floor to exits shall not exceed 30 m for all types of buildings.

Exit capacities shall be calculated as follows:

Number of Occupants per 500mm width		
Building Type	Stairways* (occupants)	Doorways/ Passages (occupants)
Apartments	25	75

Exit Doors

No exit door, inclusive of frame, shall be less than 1000 mm in width and 2000 mm in height except in the case of toilets, which may be permitted to the width of 750 mm.

All exit doors to staircases and public passages shall open outwards. However, the doors shall not obstruct the passages and staircase landings when open.

Lighting and Ventilation

All habitable rooms shall have admission of light through external wall openings not less than 1/10th the floor area of the room. The admission of light is permitted through internal courtyards having minimum dimension of 3000 mm x 3000 mm.

No portion of the room shall be considered naturally lighted if it is more than 7.5 m from the opening assumed for lighting that portion. For natural ventilation, open able exterior openings not less than 1/20th of the floor area shall be provided.

For ventilating spaces for water closets and bathrooms, the minimum size of the ventilation shaft shall be 1 sq. m. Where natural lighting and ventilation requirements are not met, the same shall be assured through artificial lighting and mechanical ventilation.

Lifts

Appliances designed for vertical circulation of persons or goods shall meet the following requirements.

- Provision of Lifts shall be made for all buildings more than 15 m in height.
- Not more than 4 lifts shall be provided per bank.
- Shafts for lifts will have to be enclosed by walls having fire resistance of two hours
- The electric supply for the lift shall be on a separate supply line from the supply mains. In case of failure of normal electric supply, it shall automatically trip over to an alternate power source.

Parapet Heights

All accessible roof terraces and balconies shall have parapet walls and handrails that are not less than 1000 mm in height.

NBC 107:1994 Provisional Recommendation on Fire Safety

The Nepal National Building Code (NBC 107: 1994) Provisional Recommendation on Fire Safety covers the basic requirements for fire safety in the design of ordinary buildings. It deals with the minimum requirements of exits from and access to ordinary residential buildings from the fire safety point of view. However Designers are encouraged, wherever possible, to incorporate higher levels of fire safety in their designs.

General Requirements

All buildings shall be designed in such a way that they can contribute to the containment of a fire and thus reduce its spread to other buildings.

- Provision of a Proper Access

Every building should have an access as defined by Architectural Design Requirements (NBC 206) and should be wide enough to enable the fireman to easily approach to the building site.

- Provision of Wide Doors

The entry door shall be as defined by Architectural Design Requirements (NBC 206) and should be sufficiently wide and tall so that easy access in available to the fire man.

- Provision of Fire Escape Ways

All buildings should have sufficient ways as defined by Architectural Design Requirements NBC 206:2003 so as to allow the rapid evacuation of all occupants in the event of fire, if any. In addition to the main entrance, the side

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and/or rear entrance shall be incorporated in the design.

The set back and/or open space shall conform to the planning and building by-laws adopted by the concerned and authorized territorial authority.

- Provision of Open Space

The front entrance should have enough open space as defined by Architectural Design Requirements NBC 206:2003 so that a number of people can gather and contribute in extinguishing the fire, if any.

Exit Requirements

- General Requirements

An exit normally shall consist of either a doorway, corridor or passageway to an internal staircase, to an external staircase, to a verandah leading to the street, to the roof of a building, or to the street. The exit may also lead to another building in the neighbourhood. The exit should:

i. Be able to allow the evacuation of all the occupants in a relatively short time;
ii. Meet the minimum requirements as to size;
iii. Be free of any obstructions and shall not provide any resistance to movement;
iv. Be clearly visible, preferably with proper signs;
v. Be continuous and shall not intrude into private space.

Number of Exits

- Stairs

The number of stairs in any building, especially when it exceeds 500 square metres in plinth area, shall be a minimum of two, one internal and the other an external fire escape. Additional stairs shall be provided in proportion to any increase in the plinth area.

In the case of residential buildings, the minimum width of the stairs shall be 90 cm. For other buildings, the minimum width shall be1.5 m. The distance from any point in a passageway to a staircase in a building shall not exceed 20 metres.

- Fire Escapes

Every building more than five storeys high shall have a separate fire escape having a minimum width of 75 cm. The fire escape shall have a minimum tread width of 20 cm and each riser shall be not more than 19 cm high. The number of risers per flight shall not be more than 15. Such a fire escape shall carry users towards an open space.

- Exit Doors

Exit doors shall open to a passageway or to a corridor. They should open outwards, but without restricting the movement of people passing outside the door. The maximum distance of such an exit doorway from any point in a passage shall be 20 m. The exit doorway shall neither be smaller than 90 cm in width, nor 180 cm in height.

Access to a Building

It shall comply with all applicable zoning requirements and by-laws of the local planning and building authority.

The access leading to a building should preferably be by a road at least four metres wide, and no such road should lead to a dead end. The road should not have such sharp or restricted turns that the passage of a fire engine is made difficult in the event of fire.

Lightning Arresters/Conductors

There have been many incidents in Nepal when lightning strikes have resulted in fire in buildings and a consequential loss of life and property. The need to install lightning arresters/conductors is therefore important.

A lightning arrester shall be located in the highest part of every building and it shall be connected by a conductor to an earth rod buried in the earth. The lightning arrester shall be so located that as much as possible of the building lies inside the surface of an imaginary cone having a vertex angle of 45 degrees and its apex at the top of the arrester.

NBC 208: 2003 Sanitary and Plumbing Design Requirements

Nepal National Building code (NBC 208: 2003) Sanitary and Plumbing Design Requirements contains general guidelines for water supply installations, sewage/ waste water disposal installations and rainwater disposal installations in buildings. The objectives are to make adequate water supply available (without any interruption) for the purpose of drinking, bathing, flushing toilets and any domestic use including firefighting; to provide a system of self-cleansing conditions for conveyance of foul waste water and for the removal of such waste water/sewage to a sewer or outer outlet without risk of nuisance and hazard to health and to dispose rainwater in buildings.

Water Supply Requirements for Buildings

The water supply requirement for Apartment buildings (excluding firefighting need) should be based on Minimum requirement of 100 liter per head per day.

- Water Storage

In case water is not available in the city mains at sufficient pressure and quantity throughout the day to rise up to the highest floor, storage of water within a premises is necessary,

- To tide over period of intermittent supply
- To provide for interruption of the supply from the main itself, caused by various reasons like repairs in the system, failure of power etc.

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- To meet the peak flow requirements within a building if the city mains do not meet it.
- To maintain a storage for firefighting requirement of the building.

Water storage is usually done in underground tank or tanks at the ground level or overhead tanks.

- General Water Storage Tanks

Water tanks should be strong enough to take the vertical load and the natural pressure of water when full, and also the negative pressure within the tanks when the water in drawn out.

- Underground Storage

Underground storage tanks or tanks at ground level are necessary to collect water from the city water mains during hours of supply if it does not reach the point of supply or the overhead tanks. It is then pumped to overhead tank for use within the building.

The capacity of an underground storage tank or tank on the surface should be the net difference between the peak demand and the flow during the hours of supply. Provision should be made for supply interruption due to various reasons like main repair work or power failure etc.

For normal buildings with a reliable public supply, underground storage capacity is taken at 12-24 hours of the average daily water demand.

- Overhead Storage

In areas of chronic shortage or intermittent supply, overhead storage is also required for domestic use and flushing purposes and to ensure constant supply. The average overhead storage for apartment shall be 70 lit per resident and the recommended value per dwelling units is 500 lit.

Fire Fighting Provision

Shortage of water and intermittent public water supply has led to the need to have captive water storage tanks exclusively for firefighting operation.

For water supply for wet riser system a storage tank should be available with arrangement for replenishment of water supply through public supply mains or by an alternate source of supply at the rate of about 1000 ltr/minute. Where this is not possible the capacity of the static tank will have to be increased. The storage should last for 90-120 minutes at a nominal pumping rate of 2400 ltr/minute.

Some categories of public buildings which have generally low fire loads but higher personnel hazards, require to be provided with portables appliances where the total area of the floors exceeds 1000 sq. meters so that the whole of the floor is protected. It should be insured that no part of the floor is more than 6 meters from the hose nozzle when the hose reel in fully extended. There should be constant supply of water not less than 23 liters per minute through a nozzle of not less than 6.5 mm size for half an hour when up to 3 hose reels are operated. The hose shall be of reinforced rubber lining having a bore of 12/20-mm diameter. This water supply should be independent of domestic supply connections. A pressure of at least 3 kg/cm^2 should be available at the highest hydrant outlet.

Hydrant System

- Dry Risers, so called because they contain no water in the pipes, are installed within a building with a landing valve in the staircase lobby. They terminate at the street level in the form of a fire brigade connection. The connection enables the five brigades to connect the fire brigade connection either to street fire hydrant directly or to a fire brigade pumper and charge the dry riser with water.
- Wet risers are fixed pipe installations within a building and permanently charged with water under pressure from available water source.
- Hydrant station is provided to serve an area of 926-1000 sq. m. It is advisable of place it in fire-protected areas near each fire escape staircase or lobby so that it can be located easily.
- Each hydrant station comprises:

- A first aid, hose reel with 20 mm diameter rubber hose about 30-36 m long with a 63 mm diameter landing valve.
- Two 15m x 63 mm. Reinforced rubber lined hoses with couplings and a branch pipe with a 12 mm nozzle for use by fire service personnel.

- Fire Pumps

To enable the water to reach the topmost floor, it is necessary to provide pumping sets connected to the fire tank or city public supply mains when permitted. The pump delivery is connected to the piping system of the hydrant or sprinkler system. Pumps are electrically driven and each system provided with a stand by pump. Pumps for fire hydrant systems and sprinkler system are separated and independent of each other, though common pumps having appropriate discharging capacity are used in many parts of the world.

- Standby Pumps

Where power supply in not dependable, standby pumps with diesel engine are provided to conduct firefighting operations.

The typical fire-fighting installation requirement should be as given in the Table 2.

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Table 2.Typical fire-fighting installation requirement

S. No.	Type of building occupancy	Requirement				
		Water supply			Pump capacity	
		Type of installation	Underground static tank	Terrace tank	Near under-ground tank	At the terrace level
1.	Residential building Lodging or room houses dormitories & hotels. (No provision is needed for dormitories housing less than 25 person. *up to 15 mtr. In height. * above 15 m. height but not exceeding 24 m.	Nil One wet riser cum down comer per 1000 m. sq. floor area. The riser shall be fully automatic in operation	50000 ltr. 100000 ltr.	Nil Nil	Nil 2400 lit/min at pressure not less than 0.3 N/mm. sq. (3 kg/cm. sq.) at the topmost hydrant	Nil Nil
2.	One or two family private dwelling & apartment houses (flat) Up to 15 m. height Above 15 m. height but not exceeding 24 m.	Nil One wet riser cum down comer with a provision of fire service inlet at only ground level per 1000 m. sq. Floor area	Nil 50000Ltr.	Nil Nil	2400 lit/min at pressure not less than 0.3 N/mm. sq. (3kg./cm. sq) at the topmost hydrant	Nil Nil

MoPPW, 2003.

IS 1893:2002 Criteria for Earthquake Resistant Design of Structures

Besides the NBC 105:1994, for seismic design of the buildings in Nepal other International codes as per provisions of NBC 000: 1994 can be used for design of buildings to be constructed in Nepal. However the minimum requirements of the codal provisions of NBC 105:1994 shall be satisfied while using other international codes. The IS codes are also used in Nepal for design of the buildings because of the geographical and seismic nature of northern India is almost similar to that of Nepal. The Indian standards IS 1893 (part I): 2002 Criteria for Earthquake Resistant Design of Structures (General Provisions and buildings) is used for seismic design of the building. According to the IS 1893 (part I): 2002, the following provisions are considered for seismic design of the buildings.

Design Load Combinations

The following load combinations shall be accounted for seismic design:

- 1.5 (DL + LL)
- 1.2 (DL + LL+ EL)
- 1.2 (DL + LL - EL)
- 1.5 (DL+EL)
- 1.5 (DL - EL)
- 0.9 DL+1.5EL
- 0.9 DL - 1.5EL

Where, DL = Dead Load, LL = Live Load and EL = Earthquake Load.

Fundamental Natural Period

The approximate fundamental natural period of vibration (T,), in seconds, of a moment-resisting frame building without brick infill panels may be estimated by the empirical expression:

$T_a = 0.075\ h^{0.75}$ for RC frame building; $= 0.085\ h^{0.75}$ for steel frame building

Where,

h = Height of building, in m.

The approximate fundamental natural period of vibration (T_a), in seconds, of all other buildings, including moment-resisting frame buildings with brick infill panels, may be estimated by the empirical expression:

$$Ta = \frac{0.09\ h}{\sqrt{d}}$$

Where,

h = Height of building, in m and d = Base dimension of the building at the plinth level, in m, along the considered direction of the lateral force.

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Design Spectrum

For the purpose of determining seismic forces the country India is classified into four seismic zones and for Nepal the areas of Nepal can be considered same as the fourth most severe zone.

The design horizontal seismic coefficient A_h for a structure shall be determined by the following expression:

$$Ah = \frac{Z\,I\,Sa}{2\,R\,g}$$

Provided that for any structure with Time period (T) <0.1 s, the value of A_h will not be taken less than Z/2 whatever be the value of I/R

Where,

Z = Zone factor; I = Importance factor; R = Response Reduction Factor and Sa/g = Average response acceleration coefficient for rock or soil sites and based on appropriate natural periods and damping of the structure as per following graph.

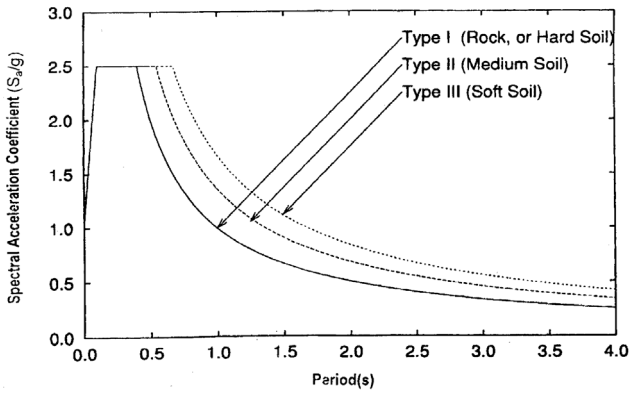

Figure 3.Response spectra for rock and soil

Seismic Weight of Floors

The seismic weight of each floor is its full dead load plus appropriate amount of imposed load 25 % for imposed load on floor up to and including 3.0 kN/m^2, and 50% for imposed load on floor above 3.0 kN/m^2.

Design Seismic Base Shear

The total design lateral force or design seismic base shear (V_B) along any principal direction shall be determined by the following expression:

$V_B = A_h W$

Where,

A_h = Design horizontal acceleration spectrum value, using the fundamental natural

Period T_a as per 7.6 in the considered direction of vibration, and

W = Total Seismic weight of the building

The design base shear (V_B) shall be distributed along the height of the building as per the following expression:

$$Qi = VB\,\frac{Wihi2}{\sum_{j=1}^{n} Wjhj2}$$

Where,

Q_i = Design lateral force at floor i,

W_i = Seismic weight of floor i,

h_i = Height of floor i measured from base, and

n = Number of storey in the building is the number of levels at which the masses are located.

Dynamic Analysis

Dynamic analysis shall be performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to the various lateral load resisting elements, for the following buildings:

- Regular buildings - Those greater than 40 m in height in Zones IV and V and those greater than 90 m in height in Zones II and III Modelling can be used.
- Irregular buildings - All framed buildings higher than 12 m in Zones IV and V and those greater than 40m in height in Zones II and III.

Dynamic analysis may be performed either by the Time History Method or by the Response Spectrum Method. However, in either method, the design base shear (V_B) shall be compared with a base shear (V'_B) calculated using a fundamental period T_a, where T_a is fundamental natural time period. Where V_B is less than V'_B, all the response quantities shall be multiplied by V'_B / V_B.

Time History Method

Time history method of analysis, when used, shall be based on an appropriate ground motion and shall be performed using accepted principles of dynamics.

Response Spectrum Method

Response spectrum method of analysis shall be performed using the design spectrum, or by a site-specific design spectrum.

Modes to be Considered

The number of modes to be used in the analysis should be such that the sum total of modal masses of all modes considered is at least 90 percent of the total seismic mass and missing mass correction beyond 33 percent.

Storey Drift Limitation

The storey drift in any storey due to the minimum specified design lateral force, with partial load factor of 1.0 shall not exceed 0.004 times the storey height or the purposes of displacement requirements only.

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Separation between Adjacent Units

Two adjacent buildings or two adjacent units of the same building with separation joint in between shall be separated by a distance equal to the amount R times the sum of the calculated storey displacements, to avoid damaging contact when the two units deflect towards each other. When floor levels of two similar adjacent units or buildings are at the same elevation levels, factor R in this requirement may be replaced by R/2.

Major Provisions of Building Byelaws 2007 for High-Rise Apartments

The following provisions shall be fulfilled for the construction of Apartment Housing/Group Housing according to building byelaws for Kathmandu valley 2007 and Ownership of joint housing Act 1998. It is expressed by Mishra, 2020 as review study.

- All Apartment Housing/ Group Housing plots shall have area not less than 2 ropani (1000 sq. m)
- The Minimum required access road width is tabulated as in Table 3

Table 3.Requirement of access road for apartments

S. No.	Number of housing units to be served	Access road width
1	4 units	4.0 m
2	10 units	4.5 m
3	50 units	6.0 m
4	More than 50 units	8.0 m
5	Cul de sac can be kept as straight road up to 100 m length	

KVTDC, 2008.

The other provisions of byelaws are tabulated as in Table 4.

Provisions of Fundamental Building Byelaws 2015 for Apartments

According to the Fundamental building byelaws 2015, for the high-rise apartment buildings the minimum access road width shall be 8 m. Similarly the height to setback ratio for any type of buildings with greater than 17 m height shall be 4:1 with minimum setback of 5 m. Also the distance between two building blocks within a plot shall be the sum of setbacks for each buildings as above. The maximum ground coverage for the plots greater than 250 sq. m. shall not be more than 60% and in case of apartment buildings same as in building byelaws for Kathmandu valley, 2007.

Building Byelaws for Apartments buildings in Indian Building Byelaws

The international building byelaws such as the Indian byelaws has been reviewed and some of the major provisions for apartment buildings have been found out.

Unified Building Byelaws of Delhi, 2016

According to the Unified building byelaws of Delhi, 2016 for high-rise buildings the access road shall be minimum 18 m. Around the building of up to 40 m height, there shall be approach road of minimum 6m width and for above 40 m height building it shall be minimum 9 m width. The minimum stair width shall be 1.35 m for apartment buildings.

For studio apartment:

Minimum plot area = 2000 sq. m.

Maximum ground coverage = 33.3 %

Maximum FAR = 200 % i.e. 2.0

For residential plot-plotted housing/apartments the setback is as shown in Table 5.

Table 4.Provisions of byelaws for apartment and group housing

S. No.	Description	Unit	Apartment in general	Apartment outside ring road
1	Ground Coverage Ratio	%	50	50
2	Floor Area Ratio (FAR)	No.	3	3.5
3	Open space in lot	%	20	20
4	Open space in overall	%	30	30
5	Front setback	m	6	8
6	Side Setback	m	4	6
7	Rear Setback	m	4	6
8	Distance between blocks	m	6	6
9	Access Road width	m	6	8

KVTDC, 2008.

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Table 5.Setbacks as per building byelaws of Delhi, 2016

S. No.	Plot Area, sq.m.	Setback, m		
		Front	Back	Side
1.	2000 to 10000	9	6	6
2.	> 10000	15	9	9

DDA, 2016.

Model Building Byelaws of India, 2016

According to the model building byelaws of India 2016, provisions of byelaws such as maximum ground coverage, maximum FAR, minimum approach road width and minimum setback for Service Apartments are listed as below:

- Maximum ground coverage = 30%
- Maximum FAR = 1.50
- In hills = 1.50
- Approach road = > 9 m
- Set back on all sides = > 6 m for up to 40 m height
- > 9 m for more than 40 m ht.

Building Byelaws of Bangalore, 2003

According to the building byelaws of Bangalore 2003 of India, Minimum setbacks for high rise buildings, Exterior open spaces/Setbacks for residential, Commercial, Public and Semi-public buildings above 9.5 m in height is as shown in Table 6.

In the case of 'high-rise buildings' the minimum set-back all-round the building shall be as in Table 6 and minimum road width facing a high-rise building shall be 12 m.

Likewise for group housing the following norms shall be adopted:

- The boundary roads if any must have a minimum width of 12 m
- The FAR should be considered with reference to the width of the public road abutting the property and the FAR should be calculated after deducting the area reserved for parks, open spaces and civic amenities
- The distance between the buildings should be a minimum of half of the height of the tallest building
- 25% of the total area be reserved for CA, parks and open spaces, subject to a minimum of 15% for parks and open space

The means of access to the building blocks in the area of group housing shall be as follows:

	Access length in m	Min. width
a)	Less than 100 m	6 m
b)	100 to 200 m	9 m
c)	More than 200 m	12 m

Table 6.Setbacks as per building byelaws of Bangalore, 2003

S. No.	Height of Building in m	Exterior open spaces/ set-backs to be left on all sides (Front, Rear and Sides) in m
1	Above 9.5 up to 12	4.5
2	Above 12 up to 15	5.0
3	Above 15 up to 18	6.0
4	Above 18 up to 21	7.0
5	Above 21 up to 24	8.0
6	Above 24 up to 27	9.0
7	Above 27 up to 30	10.0
8	Above 30 up to 35	11.0
9	Above 35 up to 40	12.0
10	Above 40 up to 45	13.0
11	Above 45 up to 50	14.0
12	Above 50	16.0

BMC, 2003.

Table 7.Building byelaws provisions for Group housing in Bangalore

Plot area	Minimum road width in m	Maximum plot coverage	Maximum FAR	Minimum set-backs in m			
				Front	Rear	Left	Right
Up to 0.40 Hectares	12	60%	2.00	5.0	4.5	4.5	5.0
Between 0.40 & 0.80 Hectares	15	60%	2.25	8.0	6.0	6.0	6.0
Above 0.80 Hectares	18	60%	2.50	9.0	8.0	8.0	8.0

BMC, 2003.

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Table 7 shows the maximum plot coverage FAR, minimum setbacks and minimum road width for Group Housing.

Note:

Group housing means more than two buildings on a plot with one or more floors and with one or more dwelling units in each floor. They are connected by an access of not less than 3.5 m. in width, if they are not approachable directly from the existing roads.

In case, the height of group housing building exceed 9.5 m, then set back to be left around the premises shall be as per Table 6 or Table 7 whichever is higher.

Building Byelaws of Jharkhand, 2015

Similarly according to the building byelaws of Jharkhand 2015 of India, Minimum setbacks for high rise buildings, the open spaces around the building unless or otherwise specified shall be as given in Table 8.

Table 8.Setbacks as per building byelaws of Jharkhand, India

S. No.	Height of the Building Up to (m)	Exterior open spaces to be left out on all sides in m	
		front setback	Side and back setback
1.	More than 15 and up to 18	6.5	4.5
2.	More than 18 and up to 21	7.5	4.5
3.	More than 21 and up to 24	8	5
4.	More than 24 and up to 27	9	6
5.	More than 27 and up to 30	10	7
6.	More than 30 and up to 35	11	7
7.	More than 35 and up to 40	12	8
8.	More than 40 and up to 45	13	8

UDHD, 2015.

Legal Framework for Seismic Safety of the High-rise Apartment Buildings

The legal framework for high-rise apartment building construction can be listed as below:

- Local Self Governance Act/ Rule, 1998
- Town Development Act, 1997
- Building Bye-laws of Kathmandu Valley, 2007
- Fundamental Building Byelaws for Settlement development, Urban planning and Building Construction, 2015
- Building Act 1998 and its amendment 2007
- Building Regulations, 2003
- Ownership of Joint Housing Act, 1998
- Ownership of Joint Housing Rule, 2003

According to the Building Act 1998 the high-rise apartment buildings lies in category B buildings and shall be built in consonance with the standards set forth in the building code of Nepal and the supervision shall be done by the designer or his/her representative, engineer or architect whose rank is at least the same as that of the designer, engineer or architect who has certified the map and design of that building. Also the concerned municipality shall not approve a design/ map as to be contrary to standards set forth in the building code.

As per Joint Ownership Housing Act 1997 the Design approval and construction and operation permit is given by DUDBC, division office after checking all the architectural/ structural/ electrical/ sanitary/ fire safety designs and drawings as per relevant building codes. The responsibility for monitoring and supervision of the apartment construction process is given to DUDBC division office. DUDBC is accountable for provision set by building act & regulation, building code, Ownership of Joint Housing Act 1998 & Ownership of Joint Housing Rules 2003 and monitoring of the provision during construction. So the seismic safety of the high-rise building is checked and monitored and supervised as per relevant Nepal building codes or IS codes from DUDBC division office.

As per the LSGA 1997, the local authorities shall give building permit after the approval from DUDBC DO and also regular monitoring and supervision shall be carried out from these local authorities also.

Apartment Building Approval and Monitoring Work procedure Guidelines

Safety of Apartment Buildings is most important, because of concerned large number of inhabitants in a single building. High rise tall buildings affects in safety of not only its inhabitants, but also in surrounding population. So assurance of safety is one of the most components in Apartment construction. Apartment Building Construction Approval and Monitoring Work Procedure, 2014 controls safety requirements. Major components of work plan are:

- Construction approval procedure
- Monitoring procedures to assure safety of the buildings
- Quality assurance procedure
- Provision of open discussion among specialist panelist

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with high level academic and professional personals on submitted design documents
- Provision Involvement of government officers and private sectors in construction monitoring
- Construction completion certificate issue procedure
- Periodic monitoring in running apartments.
- According to the apartment building approval and monitoring work procedure 2014 the following process are followed for approval of design drawing:
- The Apartment developer or the person shall submit a firm with master plan, drawings, land ownership certificate and blueprint map to Division office.
- Preliminary site investigation from division office is done
- Division office can form an Experts committee (other GoN offices, Institution, university, Campus, consultants) (if required) for checking of submitted drawing and designs for compliance of as per Building act, regulations, NBC 2003 and apartment building construction byelaws.
- The expert committee consists of ;
- Structural Engineer
- Architect
- Geotechnical Engineer
- Electrical Engineer
- Sanitary Engineer/Expert
- DUDBC division office shall work as a coordinator for coordinating with other GoN agencies also for the approval process

Similarly for Planning Permit following Process are followed as per the work procedure:

- After the preliminary Investigation from DUDBC division office required Drawings and documents are sent to Kathmandu valley Development Authority in Kathmandu and other districts as per Kathmandu valley development authority act 1988 and Town Development Act 1988.
- The KVDA and TDCs shall provide approval of the drawings with full compliance of byelaws within 30 days and sent to Division office

As per the schedule II of EPR 1998, if the apartment building need Initial Environmental Examination only the following procedure are followed;

- After Planning permit from KVDA or TDCs the Developers shall submit the IEE report to concerned Division office for proposals/ apartment buildings as per Schedule I of EPR 1998 and EPA 1997.
- The Division Office forwards the IEE report through Environment Section of DUDBC to MoUD for approval.
- And MoUD shall approve and return to Division office within 21 days.

As per the schedule II of EPR 1998, if the apartment building need Environmental Impact Assessment the following procedure are followed:

- After Planning permit from KVDA or TDCs the Developers shall submit the EIA report to concerned Division office for proposals/ apartment buildings as per Schedule II of EPR 1998 and EPA 1997
- The Division Office forwards the EIA report through Environment Section of DUDBC to MoUD and MoUD to MoSTE for approval

Besides the above approval procedure the maximum allowable height of the apartment that can be constructed and the water supply management and deep boring system for ground water use shall be approved from other two agencies i.e. Civil aviation authority and Kathmandu Upatyaka Khanepani limited or water supply management board or Nepal water supply corporation and the following procedure are applied:

- After Planning permit from KVDA or TDCs the Division office shall submit to Civil Aviation Authority for permit/ confirmation of Maximum Height of Apartment that can be constructed
- Division office shall submit to KUKL/ Water supply management board/ Nepal water supply corporation for permit about Water supply management and deep Boring system
- After permits from above all authorities the permit/ approval shall be issued within 30 days
- The Division office shall submit the approved drawings and designs to Local authorities VDCs/ Municipalities for building permit issuance
- After the clearance from these agencies, final approval and permit for building construction is given by the concerned local government (Municipalities / Village Development Committee (VDC)) as per Local Self Governance Act (LSGA) 1998

After the building permit from the local bodies, the construction work started and during the construction and up to the completion of the project the following monitoring mechanism shall work on as per the work procedure:

- The responsibility to construct the quality construction is of the developer himself
- Developer shall submit the quality assurance plan with following documents DUDBC Division office monthly.

- Quality assurance plan
- Cement test report
- Rebar test report
- Aggregate, sand test report
- Concrete cube test report
- Photos of construction activities
- Third party insurance

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- Construction work schedule (Updated)
- Designers consent for design change (if any)
- Monthly commitment letter of developers, designers and supervisors
- Implementation status of recommendations of other authorities if any
- Implementation status of recommendation of EIA/IEE report
- As built drawing if required
- Other test reports

- Developer shall submit the quality assurance test reports such as Cement, Rebar, Aggregate, sand, Concrete cube with 7th day of each month until the completion of the project to DUDBC division office
- Monthly progress report of apartment construction shall be submitted to DUDBC division office and the supervision/monitoring shall be done by division office

After the successful completion of the apartment building project and completion of all the works, the following procedure shall be followed for issuance of work completion certificate:

- Developers shall submit the application for work completion report to DUDBC Division office
- Field investigation shall be done by DUDBC division office for completion certificate and issue completion certificate within 30 days if every things are satisfied
- If the quality of construction is questioned then developers shall submit the following test reports as per requirement and the tests shall be carried out in the presence of the represent engineer from DUDBC Division office

- Schmidt hammer Test (Test for hardness and strength of the concrete)
- Rebar locator with cover detail test
- Ultrasound Pulse Velocity Test (Homogeneity and quality of concrete in terms of good, fair and poor)
- Load Test
- Core-cutter Test

Third Party Monitoring Process

After the approval for construction of the apartment building, The short listed experts and consultants shall monitor and supervise about the developer has complied the byelaws and building code, quality control and other commitments or not. The experts and the individual consultants recruited from DUDBC division office shall submit the report of supervision and monitoring to office and developer.

Also if the developer has not get the completion certificate the division office can write the letter to land revenue office not to transfer the rights of the housing units to any other individual person from developer.

Apartment Building Monitoring and Coordination Committee

A district level committee known as apartment building monitoring and coordination committee is formed of following members for monitoring and coordinating and solving the problems seen in the apartment building construction.

Division chief, Division office	Chairman
Engineer, TDC/KVDA district Officer	Member
Chief, Land revenue office	Member
Chief, Survey office	Member
Officer Representative, DAO	Member
Engineer, respective Municipality/VDC secretary	Member
Representative, NLHDA	Member
Engineer, Division office, DUDBC	Member secretary

Present Status of Apartment Construction in Kathmandu Valley

The total Apartment building construction projects that has obtained the Building permit approval from DUDBC, Division office Kathmandu are 71 numbers till date 2017. Altogether there are 6234 housing units in approved 71 apartment building projects. Apartment building construction started from 2005 and maximum number of building permits were issued in 2009 and 2010 from DUDBC, Division office Kathmandu. In year 2009 and 2010, about 50% of total building permits for apartment building construction were issued.

Present status of the apartment having apartment building approval from DUDBC, Division office Kathmandu has been summarized as following:

Scenario of Apartment Buildings after Gorkha Earthquake 2015

After the devastating earthquake on April 25, 2015, with epicenter at Barpak, Gorkha and the aftershocks 31 districts of Nepal were affected and out of them, 14 districts including three districts of Kathmandu valley were affected very badly. The Team of experts and engineers from Ministry of Urban Development, Department of Urban Development and Building Construction were mobilized immediately within a week of main shock for Rapid Visual Damage Assessment (RVDA) of government/ semi-government offices, government hospitals, courts and obviously the apartment buildings which is the concern of most people in Kathmandu valley. The main purpose of RVDA, the post disaster damage evaluation as mentioned by concerning authority was as follows (Joshi, 2016):

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Table 9.Present status of apartment building in Kathmandu Valley

S. No.	Status of apartments	Number of apartment	Housing units	Remarks
1	Inhabited and completion certificate issued	19	1747	55 apartments inside ring road and 16 apartments outside ring road
2	Inhabited but completion certificate not issued yet	32	3963	
3	Under Construction stage	7		
4	Occupancy/ Use Change	5	160	
5	Construction not started	6	224	
6	Approval Cancelled	2	140	
Total		71	6234	

DoK, 2017.

- Safe use of streets adjacent to damaged buildings
- Safe occupancy of buildings for continued use, especially emergency facilities
- Minimization of impact on commercial activity
- Minimization of displacement of people
- Assessment of the need for temporary works such as shoring, temporary supports
- saving property from unnecessary demolition
- Minimizing economic impact for the owners and communities

During RVDA the buildings that were safe for immediate occupancy were tagged with "inspected with no restrictions on use or occupancy" and labeled by Green sticker, those that were in risk and unsafe for immediate use or already collapsed were tagged as "Unsafe and prohibited entry or occupy" and labeled by Red Sticker and those that can be restrictedly entered for short period were tagged as "restricted use with brief entry allowed for access to contents only" and labeled by Yellow sticker as per Seismic Vulnerability Evaluation Guideline for Private and Public Buildings 2011. The Classification Rapid visual damage assessment Postage with type of color and its meaning is shown in Table 10:

The summary of RVDA done by DUDBC after Gorkha Earthquake 2015 is shown below:

Table 10.Classification of RVDA Postage

Posting classification	Color	Description
Inspected	Green	No apparent hazard found, although repairs may be required. Original lateral load capacity not significantly decreased. No restriction on use or occupancy
Limited Entry/ Restricted Use	Yellow	Dangerous condition believed to be present. Entry by owner permitted only for emergency purposes and only at own risk. No usage on continuous basis. Entry by public not permitted. Possible major aftershock hazard
UNSAFE	Red	Extreme hazard may collapse. Imminent danger of collapse from an aftershock. Unsafe for occupancy or entry, except by authorities

DUDBC, 2011.

Table 11.Summary of Rapid Visual Damage Assessment[7]

S. No.	Description	No	No. of Block	Postage/ Sticker					
				Green	%	Yellow	%	Red	%
1.	Government Hospitals	18	83	66	80	12	14	5	6
2.	GoN/ Semi-GoN Office, Jail buildings outside Singh durbar	188	334	237	71	72	22	24	7
3.	VVIP 5's office and residences	10	10	7	70	2	20	1	10
4.	GoN Office Buildings inside Singh durbar and Courts and Ministers' quarters	37	64	52	81	7	11	5	8
5.	Apartments Buildings	51	120	8	15	41	81	2	4
	Total =	305	611	369	63	123	30	37	7

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According to Table 11, total 120 building blocks of 51 habited apartments were assessed during Rapid Visual Damage Assessment. Out of them, four apartments were constructed before approval process as per Joint Ownership Apartment Act 1998 and not included in approved apartment list of DUDBC. Out of Assessed 51 apartments, two were tagged with Red sticker i.e. Unsafe and prohibited entry or occupy, ten were tagged with yellow sticker, sub category two i.e. restricted use with brief entry allowed for access to contents only, 31 were tagged with yellow sticker, sub category one i.e. restricted use except in defined area and eight were tagged with Green sticker i.e. inspected with no restrictions on use or occupancy.

After the RVDA of the apartment buildings Government approved working directives "Use Approval Directives of buildings damaged by Earthquake, 2016." According to the directives the owners/developers shall submit "Detail Damage Evaluation Report" with recommendations of repair or retrofit of damaged apartment buildings to DUDBC Division office Kathmandu. Also as per the Seismic Vulnerability Evaluation Guideline for Private and Public Buildings, 2011 the Damage Grade of RCC buildings are classified in five no of Grades which is shown in Table 12.

However according to "Approval Directives for use of buildings damaged by Earthquake, 2015." the Damage Grade of RCC apartment buildings shall be classified in Detail Damage Evaluation Report as masonry wall crack (Category M damage) with four subcategories M1,M2, M3 and M4, Structural Crack/Damage (Category SD damage) with six subcategories SD1, SD2, SD3, SD4, SD5, SD6 and Structural Failure (Category SF damage) with eight subcategories SF1, SF2, SF3, SF4, SF5, SF6, SF7 and SF8 (Joshi, 2016).

Table 12.Damage grade classification

S. No.	Damage grade	Damage type	Description and remedial measures
1.	Damage Grade 1	Insignificant	Damage does not significantly affect structural properties in spite of a minor loss of stiffness. Fine cracks in plaster over frame members or in walls at the base, Fine cracks in partitions and infill, Restoration measures are cosmetic unless the performance objective requires strict limits on non-structural component damage in future events
2.	Damage Grade 2	Slight	Damage has a small effect on structural properties. Cracks in columns and beams of frame and in structural walls, Cracks in partition and infill walls, fall of brittle plaster and cladding, falling mortar from joints of wall panel Relatively minor structural restoration measures are required for restoration for most components and behavior modes. Architecture repairs needed, Seismic strengthening advised
3.	Damage Grade 3	Moderate	Damage has an intermediate effect on structural properties. Cracks in column and beam at the base, spelling of concrete covers, buckling of steel bars, Large cracks in partitions and infill walls, failure of individual infill panels, Cracks in wall need grouting, architectural repairs required, Seismic strengthening advised. The scope of restoration measures depends on the component type and behavior mode. Measures may be relatively major in some cases
4.	Damage Grade 4	Heavy	Damage has a major effect on structural properties. Large cracks in structural elements with compression failure of concrete and fracture of rebar, bond failure of beam bars, tilting of columns, collapse of few columns or single upper floor, Vacate the building, demolish and construct or extensive restoration and strengthening. The scope of restoration measures is generally extensive. Replacement or enhancement of some components may be required
5.	Damage Grade 5	Extreme	Damage has reduced structural performance to unreliable levels. Collapse of ground floor or parts of the building, Clear the site and reconstruction, The scope of restoration measures generally requires replacement or enhancement of components

DUDBC, 2011.

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The detail damage evaluation report shall be verified by verification team which include government officials, professional society and private sector professionals from DUDBC. Approval procedure depends upon damage category. In case of damage category (M) only, the repair shall be permitted as approved techniques submitted by owner's consultant. In case of damage category (SD), the restoration shall be permitted as approved techniques submitted by owner's consultant In case of damage category (SF) and failure in NDT in damage category (SD) after restoration, the owner's consultant shall submit evaluation of seismic capacity and retrofitting design of the building and approval shall be given for retrofitting after review of submitted design by review consultant and after recommendation from specialist panel in DUDBC DoK (MoUD, 2016).

Up to date July 2016, out of 51 inhabited and evaluated apartments eight apartments were tagged green sticker. Among yellow stickered apartments, three got use approval after required restoration and repairs, four apartments have submitted seismic capacity and retrofitting design. Rests are in Detail Damage Evaluation verification stage or restoration/ NDT verification stage till end of December 2016 (Joshi, 2016).

Research Methodology

The published and unpublished literatures, relevant acts, rules, regulations, directives, guidelines and other related documents were reviewed to understand the provisions of building byelaws and building codes regarding the apartment construction and the issues about the implementation and compliance of those byelaws and codes in apartment building construction. Literature on national and international building byelaws and building codes related to the apartment building construction were also reviewed.

Key Informants Interview (KII)

The key informant's interview was done with the total six officials of Department of Urban Development Division Office Kathmandu (DUDBC DoK) and Kathmandu Valley Development Authority (KVDA) Kathmandu and Lalitpur offices. Two set of questions were developed for interview with the officials of DUDBC DoK and for interview with officials of KVDA. The KII was focused on approval/ permit process, monitoring and supervision process and implementation/compliance of building byelaws/codes in apartment building construction including the concerned issues. The interview was also focused on the provisions of the prevailing building code and building byelaws for apartment construction in Kathmandu valley and their concerned issues. Similarly the interview was done about the scenario of the apartment buildings after the Gorkha Earthquake 2015 and use approval process of damaged apartment buildings.

Result and Discussion

Major Provisions of Building Byelaws and Codes for High-rise Apartments

The first objective of the study was to explore the existing major provisions of building byelaws and Building codes for safer construction of High-rise apartment buildings. The result of Key informants interview with officials of concerned authorities, desk study and literature review of national and international byelaws and building codes are as follows:

Provisions of Building Byelaws for High-rise Apartments

Some of the major provisions of building byelaws for apartment housing are minimum plot area which should be 2 ropani (1000 sq. m), the minimum approach road width is 6.0 m for apartments with less than 50 units and 8.0 m for apartments more than 50 units. Likewise the maximum permissible ground coverage shall be 50% and Floor Area Ratio shall be 3.0 for apartments inside ring road and 3.50 for apartments outside ring road. The minimum front setback required is 6.0 m for apartments inside ring road and 8.0 m for apartments outside ring road. Likewise the minimum side and rear setback required are 4.0 m and 6.0 m for apartments inside and outside ring road respectively. Also the minimum distance required between two blocks is 6.0 m and the minimum open space required with greenery which allows water to percolate in to the ground is 20%. However according to "Fundamental building byelaws for settlement development, urban planning and building construction 2015" developed as model byelaws by Government of Nepal, for high-rise apartment buildings more than 17.0 m height, the minimum setback from others boundary and distance between two blocks shall be 5.0 m or the distance calculated from height : setback ratio equal to 4:1. This new provision for setback and distance between two blocks is more scientific and reasonable. This gives more distance and setback so the issues regarding the neighbors of the apartments can be addressed for some extent.

Besides, major parameters of building byelaws for apartment construction was studied comparing with the international byelaws such as the Model building byelaws of India 2016, Unified building byelaws of Delhi 2016, Bangalore building byelaws 2003 and building byelaws of Jharkhand 2015 of India and shown in Table 13.

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Table 13.Major provisions of building byelaws for apartment buildings

S. No.	Byelaws provision	Building byelaws for Kathmandu Valley, 2007	Fundamental building byelaws, 2015	Model building byelaws of India, 2016	Unified building byelaws of Delhi, 2016	Bangalore building byelaws, 2003	Building byelaws of Jharkhand, 2015
1	Maximum GCR	50 %	Same as in before	30%	33.3%	30%	30%
2	Maximum FAR	3.5	Same as in before	1.5	2.0	2.0 for up to 0.4 hectare, 2.25 for 0.4 to 0.8 hectare and 2.50 for >0.8 hectare Plot area	3.0
3	Approach road width	> 6 m > 8 m	> 6 m > 8 m	> 9 m	>18 m	> 12 m	12 m
4	Front Set back	> 6 m for inside ring road & >8 m for outside ring road	>8 m	>6 m for 40 m ht. and >9 m for more than 40 m ht.	9 m for plot area 2000 to 10000 sq. m. And 15 m for plot area >10000 sq. m.	5 m for up to 0.4 hectare, 8.0 m for 0.4 to 0.8 hectare and 9.0 m for > 0.8 hectare plot area	6.5 m for 15 to 18 m ht. to 13 m for 40 to 45 m ht. building
5	Side and rear setback	> 4m for inside ring road & >6 m for outside ring road	As per height of building with height to setback ratio 4:1 but not less than 5 m	>6 m for 40 m high and >9 m for more than 40 m high.	6 m for plot area 2000 to 10000 sq. m. and 9 m for plot area >10000 sq. m	4.5 m for up to 0.4 hectare, 6.0 m for 0.4 to 0.8 hectare and 8.0 m for > 0.8 hectare plot area	4.5 m for 15 to 18 m high, 8 m for 40 to 45 m high building

Table 13, shows that the maximum allowable GCR for apartments in Nepal is higher than in Indian bylaws where allowable maximum GCR is only 30% to 33.3%. The maximum allowable FAR for apartment in Nepal is also higher than in Indian byelaws where the allowable FAR is only 1.5 and 2.0 as per Model bye laws of India and unified building byelaws for Delhi respectively and 2.0 to 2.5 as per Byelaws of Bangalore and 3.0 as per Byelaws of Jharkhand. Similarly the minimum approach road width required in Nepal for apartment development is 6 m to 8 m where as in Indian byelaws it is greater than 9 m to 18 m. Also the minimum front setbacks in building byelaws of Nepal is 6 m to 8 m but in byelaws of Delhi it is 9 m to 15 m and 6 m to 9 m in Model byelaws of India, 5m to 9 m in byelaws of Bangalore and 6.5 m to 13 m in Byelaws of Jharkhand. Similarly the side and rear setback required for the apartment built inside ring road and outside ring road as per building byelaws for Kathmandu valley 2007 is 4 m and 6 m respectively and as per height to setback ratio of 4:1 but not less than 5 m according to fundamental building byelaws 2015 of Nepal. But the setbacks required are 6 m to 9 m as per Model byelaws of India depending upon the height of the building and 4.5 m to 8.0 m as per Bangalore byelaws and byelaws of Delhi according to Plot area. It shows that the permissible values in building byelaws of Nepal is in higher side regarding GCR and FAR and it is in lower side regarding the setbacks and access road width than in Indian building byelaws.

Similarly, from the questionnaire Survey with the architects as per appendix A following results about the major provisions of building byelaws were found:

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The Architects involved in apartment design were asked "Are you aware of provisions in building byelaws for high-rise apartment buildings?" and the result is 100% "yes". This means almost all the architects know about the provisions of the building byelaws for apartment buildings.

Likewise, the architects were asked about the major provisions regarding the building byelaws such as minimum setbacks, allowable ground coverage, minimum open spaces and sufficiency of total open spaces during emergency, minimum access road width required. The architects were asked "What shall be the governing criteria for fixing Setbacks and gaps between the blocks? And the result is as shown in Figure 4.

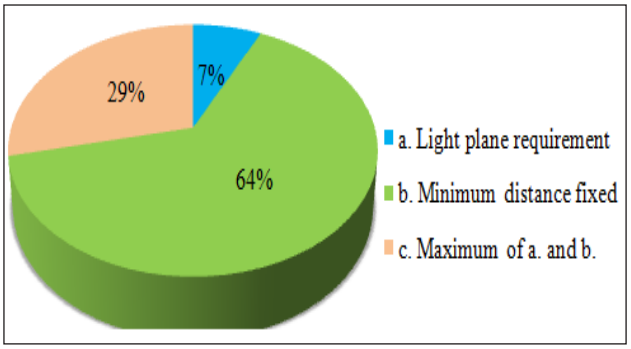

Figure 4.Governing Criteria for fixing setbacks

Minimum distance set shall be the governing criteria for fixing Setbacks from neighboring boundary and gaps between the blocks according to 64% architects, Light plane requirement shall be the governing criteria according to 7% architects and according to 29% architects the governing criteria shall be the maximum of the above two. The setbacks and the gap between two blocks has been fixed minimum distance in existing byelaws, they are practicing the same so that most of the architects prefer the same.

for Kathmandu Valley 2007 is high or reasonable or lower" and response received as allowable GCR of 50%, as per Building Byelaws 2007 was "Reasonable" according to 93% architects' opinion and "Less" according to 7% architects' opinion.

The Architects were asked about the sufficiency of open spaces, minimum access road width required and the result is summarized in Table 14.

Table 14 shows that 57.1% of architects express their views that the open spaces provided in apartments for emergency shelter during earthquake are insufficient and 42.9% of architects shows that it is partially sufficient. Likewise the 92.9% of architects' view is 20% green open spaces with surface open to ground is insufficient and 7.1% of architects' view is partially sufficient. Similarly the 78.6% of architects expressed their view as the minimum access road width of 8 m for apartments with more than 50 units as per prevailing building byelaws is sufficient, 14.3% expressed to be partially sufficient and remaining 7.1% expressed that it is insufficient. It shows that the open spaces provided as per the prevailing byelaws for apartment buildings is insufficient but the minimum access road width 8m is sufficient in the views of most of the respondents.

Likewise the Architects were asked "Are you aware of the International practices regarding the setback. Ground coverage and FAR in their building byelaws for apartment buildings?" and the result was only 14.3% of architects were aware of those international byelaws and 84.7% don't know about international byelaws. This means most of the architects were not aware of international byelaws for high-rise apartment buildings.

The architects were asked "Is there any provisions that you think to be amended in building byelaws 2064 BS and

Table 14.Sufficiency of open space and access road

S. N.	Question Asked	Architects		
		Sufficient %	Partially sufficient %	Insufficient %
1	Is the open spaces provided in high-rise apartments, sufficient during earthquake like disasters for emergency shelter?	0	42.9	57.1
2	Is the minimum 20% open spaces with open ground surface, required in the high-rise apartment construction, sufficient during earthquake like disasters for emergency shelter?	0	7.1	92.9
3	Is the minimum width of access road 8 m for apartment construction with more than 50 apartment units as per "building byelaws for Katmandu valley, 2007" sufficient?	78.6	14.3	7.1

Likewise, the architects were asked about the allowable ground coverage as "The allowable ground coverage of 50% for high-rise apartment building as per Building Byelaws

fundamental building byelaws 2072 BS?" and the result shows that 64.3% architects expressed their views for amendment of byelaws provisions in green open spaces,

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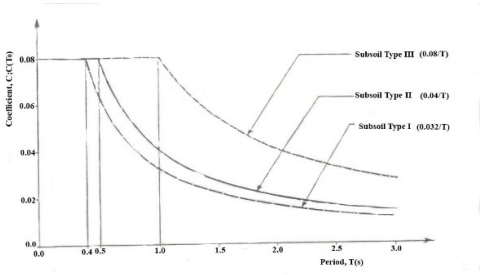
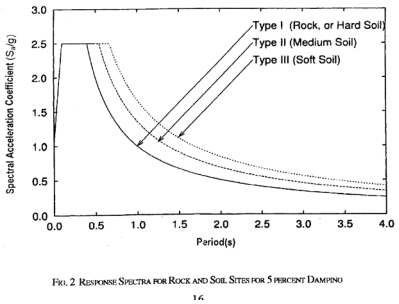
Setback and ground coverage and remaining 35.7% of architects expressed the view need not amend any provisions. This means that the green open space, setbacks in building byelaws is needed to amend.

Table 15.Seismic design parameters as per NBC and IS code

S. No.	Codal Provisions	As per NBC 105:1994	As per IS code 1893:2002
1.	Periods of Vibration	$T_1 = 0.06 * H^{¾}$ for concrete frames Where, H = Height of building,	$T_a = 0.075\ h^{0.75}$for moment-resisting RC frame building without brick infill panels and for moment-resisting frame buildings with brick infill panels Where, h = Height of building, d= Base dimension of the building
2.	Design Spectrum for the Modal Response Spectrum Method	Design spectrum, $C_d(T_i)$, $C_d(T_i) = C(T_i)$ ZIK  Where $C(T_i)$ = ordinate of the basic response spectrum for translational period, T_i I = Importance factor for Apartment building = 1 Z = Seismic Zoning Factor for Kathmandu valley = 1 K = Structural performance factor for Ductile moment-Resisting frame = 1	Design horizontal seismic coefficient A,  Fig. 2 Response Spectra for Rock and Soil Sites for 5 percent Damping Where, z = Zone factor=0.36 for zone V I = Importance factor=1 R = Response Reduction Factor=5 Sa/g = Average response acceleration coefficient
3.	Seismic Weight of Floors	Seismic weight = Dead load + % of Live Load (25 % up to 3.0 kN/m^2, and 50% above 3.0 kN/m^2)	Seismic weight = Dead load + % of Live Load (25 % up to 3.0 kN/m^2, and 50% above 3.0 kN/m^2)
4.	Design seismic base shear	The horizontal seismic shear force: $V = C_d W_t$	design seismic base shear (V_B) $V_B = A_h W$
5.	Horizontal Seismic Forces	Horizontal seismic force at each level i: $F_i = V W_i h_i / \Sigma W_i h_i$ Where, F_i = Design lateral force at floor i, W_i = Seismic weight of floor i, h_i = Height of floor i measured from base, and n = Number of storeys.	Where, Q_i = Design lateral force at floor i, W_i = Seismic weight of floor i, h_i = Height of floor i measured from base, and n = Number of storeys.
6.	Load Combination	1.5(DL+LL) DL + 1.3 LL + 1.25 EQ DL + 1.3 LL - 1.25 EQ 0.9 DL + 1.25 EQ 0.9 DL - 1.25 EQ DL + 1.3 SL + 1.25 EQ DL + 1.3 SL - 1.25 EQ	1.5(DL + LL) 1.2(DL + LL+ EL) 1.2(DL + LL - EL) 1.5(DL+EL) 1.5(DL - EL) 0.9DL+1.5EL 0.9DL - 1.5EL

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Major Provisions of NBC and IS Code for Apartment buildings

The seismic safety of the high-rise apartment buildings are assured as per the NBC 105 -1994: Seismic Design of Buildings in Nepal or as per IS code 1893:2002 according to provisions of NBC 000. The codal provisions as per above two national and international codes are shown as in Table 15 and Table 16.

Table 16.Seismic design parameters as per NBC and IS code

S. No.	Codal provisions	As per NBC 105:1994	As per IS code 1893:2002
1	Dynamic Analysis	For • Regular structures of >40m in height and following irregular buildings • Buildings with irregular configurations • Buildings with abrupt changes in lateral resistance • Buildings with abrupt changes in lateral stiffness with height • Buildings with unusual shape, size or importance	For • Regular buildings — Those greater than 40 m in height in Zones IV and V and those greater than 90 m in height in Zones II and III. • Irregular buildings: all framed buildings higher than 12m in Zones IV and V and those greater than 40m in height in Zones II and III. • However, in either method, the design base shear (VB) shall be compared with a base shear (V'B) calculated using a fundamental period Ta. Where VB is less than V'B, all the response quantities shall be multiplied by V'B / VB
2	Design Lateral Deformations	Design lateral deformations = deformations resulting from forces or design spectrum *5/K	
3	Building Separations	To boundaries : Design lateral deformations or 0.002 hi or 25mm	=R*(sum of the calculated storey displacements as per 7.11.1 of each block) –when floor levels of two similar adjacent units or buildings are not at same level =R/2*(sum of the calculated storey displacements as per 7.11.1 of each block) When floor levels of two similar adjacent units or buildings are at the same elevation levels
		Within Site: Sum of the Design lateral deflections or 0.004 hi or 50 mm	
4	Inter-Storey Deflections	≤ 0.010 * storey ht. and < 60 mm	≤ 0.004 * storey ht.
5	Ductile Detailing	As per IS 13920 code	As per IS 13920 code

Tables 15 and 16, shows that the load combination in NBC 105 and IS 1893 are different, the load factor in NBC for earthquake load case is higher up to 1.5 in IS code but in NBC it is only 1.25. The time period of vibration is calculated in both of the codes by using different formula and in IS code the formula is given for both the moment resisting frame with brick infill and without brick infill. Similarly the formulas for base shear coefficient is quite different in both the codes and the response spectrum for transitional time period is calculated using different charts. The zone factor as per NBC is 0.9 to 1.1 all around the country but as per IS code the zone factor is normally 0.36 considering zone V. In NBC the structural performance factor (K) and in IS code Response reduction factor (R) are the ductility factors in both the codes and the value of K is 1 for ductile moment resisting frame whereas value of R is equal to 5 for the same moment resisting frame. However, the formula for seismic weight of the building and the formula for horizontal seismic base shear are same in both the codes. But the formula for distribution of base shear to each floor diaphragm in NBC is linear pattern and it is parabolic pattern in IS code. Table 16 shows the dynamic analysis is mandatory for all irregular buildings and regular structures taller than 40 m in NBC but in IS code the regular buildings taller than 40 m and 90 m lying in zone IV/V and taller than 90 m lying Zone II/III and irregular buildings

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taller than 12 m lying in zone IV/V and taller than 40 m lying Zone II/III. Similarly as per NBC the separations between two buildings in boundary not be lesser than design lateral deformation (deformation resulting from forces or response spectrum*5/K) or 0.002*h_i or 25 mm and within the site it shall not be lesser than sum of design lateral deformations of two block or 0.004*h_i or 50 mm however in IS code the separations between two blocks shall not be lesser than R * sum of displacement of each block if the blocks not have same floor level and R/2 * sum of displacement of each block if the blocks have same floor level. It shows that the NBC reveals greater value of seismic gap than from IS code for preventing the ponding mechanism of two blocks during earthquake. However the permissible inter-storey deformation is greater in NBC i.e. 0.010*h_i or 60 mm than in IS code 0.004*h_i.

Similarly, from the questionnaire Survey with the architects and structure engineers as per appendix B following results about the major provisions of building codes were found:

Regarding building code the architects were asked "Which code did you apply for design of high-rise apartment building?" and the result is 14.3% architects of apartment designers apply NBC code only, 85.7% architects apply both NBC and IS code, none of them use IS code only and also none of them use other codes.

Likewise, the structure engineers involved in apartment design were asked "Are you aware of provisions in national building code (NBC) for high-rise apartment buildings?" and the result is 100% "yes". This means all the structure engineers know about the provisions of the national building code for high-rise apartment buildings. Also the structure engineers were asked "Which code did you apply for design of high-rise apartment building?" and the result is 77.8% structure engineers apply both NBC and IS codes and 22.2% structure engineers use IS code only and none of them use NBC only. This shows that, though all of the structure engineer know about NBC, most of them apply both NBC and IS code and some of them apply IS code only but they didn't apply NBC only. This may be because the NBC is not complete and the codes such as ductile detailing code, loading code shall be applied from IS codes and the geographical location, cultural, social and economic situation of India and Nepal are similar.

Likely the structure engineers were asked "What did you find regarding seismic base shear value calculated differs from NBC 105-1994 and IS 1893-2002?" and the result shows that 77.8% of structure engineers found the base shear Value lesser from NBC 105-1994 than from IS 1893-2002 and 22.2% found the base shear Value from NBC 105-1994 more than from IS 1893-2002. This is because the base shear coefficient calculated from IS code is greater than from NBC and the seismic weight is same.

Approval and Monitoring & Supervision Mechanism

The second objective of the study was to find out the approval and building permit mechanism and also to find out the monitoring and supervision mechanism for quality control and quality assurance system for high rise apartment building construction in Nepal. The result of key informants interview with officials of concerned authorities, developers, desk study and literature review of legal documents are as follows:

Approval and Building Permit Process for Apartments

Figure 5 and 6, were developed showing the government institutions and stakeholders involved in approval and building permit process for apartment building as the result of Key informant's interview with officials of concerned authorities and developers, desk study and literature review of legal documents. Mishra AK, 2019; Mishra AK & Bhattarai SK, 2021; Regmi S & Mishra AK, 2020)

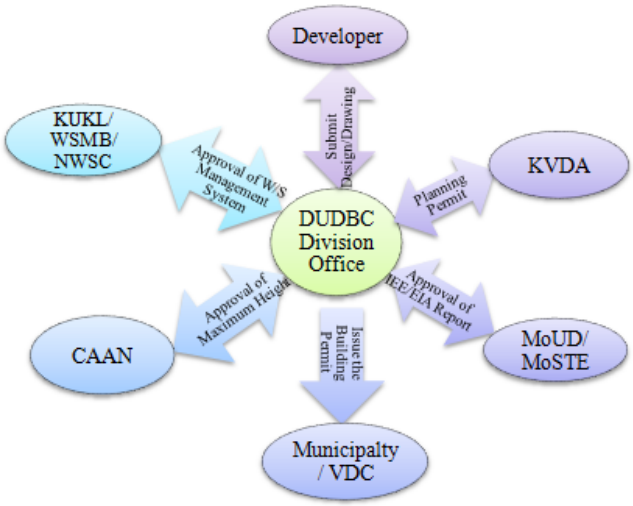

Figure 5.Institutions involved in approval/ permit process

Planning Permit Process

As shown in the Figure 4 and Figure 5, Developer submits application firm with Master plan, drawing, Design and other legal documents to DUDBC DO and after preliminary site investigation DUDBC submit one set of Master plan, drawing and other required documents to Kathmandu Valley Development Authority (KVDA) of respective districts (Kathmandu, Lalitpur & Bhaktapur). KVDA review and Check for full compliance of building byelaws in drawing and design and provide comments to developers if any.

The major provisions of building byelaws covered by planning permit include:

- Construction area, Access road width, front, side and rear set back, FAR, light plane
- Ground coverage, open space (Greenery) and other open spaces

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- Distance between two blocks and Parking facilities requirement
- And other Planning related issues like sewer, electrical systems, Guided Land development(GLD) lines, High-tension (HT) line, water supply system
- Waste water and solid waste management

Environmental Approval Process

Figure 4 and Figure 5, shows that, the developer conducts the environmental assessment and submit EIA or IEE Report if required as per Schedule I and II of Environment Protection Act (EPA), 1997 and Environment Protection Regulation (EPR), 1998 to DUDBC DO. The first task to undertake this process is to carry out the environmental screening so as to determine whether the project requires IEE or EIA, or it does not require any assessment at all. The screening criteria as mentioned in Schedule I and II of EPR, 1998 is shown in Table 17.

Table 17.Screening criteria for environmental assessment

S. No.	Criteria	No EA	IEE	EIA
1	Build Up Area	<5000 sq. m	5000-10000 sq. m	>10000 sq. m
2	No. of Story	<10	10-16	>16
3	Height of the Building	<25 m	25-50 m	>50 m
4	No of Inflow and Outflow at a time	<1000 person	1000-2000 persons	>2000 persons

DUDBC DO sends EIA/IEE report to Environment section of DUDBC and the section reviews the report and if there is any comments on the report the section provides comments to developer through DUDBC DO. Otherwise DUDBC forwards the IEE/EIA report with comment and recommendation to Ministry of Urban Development (MoUD). MoUD review IEE/EIA report and if there is any comments on the report MoUD provides comments to developer through DUDBC DO. Also if Environmental Assessment Report is the IEE report then the concerned authority i.e. MoUD grants approval of the IEE report and sends back to DUDBC DO. If the Environmental Assessment Report is EIA report MoUD forward the report to Ministry of Science, technology and Environment (MoSTE) with comments/ recommendations. MoSTE Review the EIA report and provide comments to the Developer and grant Approval of EIA report and send to DUDBC DO through MoUD.

The major aspects/ sectors covered by IEE/ EIA report is summarized as below:

- Project description covering construction planning
- Review of relevant policies in relation to the project implementation
- Alternative analysis
- Major adverse environmental impacts and their mitigation measures
- Major beneficial environmental impacts and their enhancement measures
- Environmental management plan including environmental monitoring plan covered

Approval for Maximum Height and Water Supply Management

DUDBC DO sends required documents, drawings, designs to Kathmandu Upatyaka Khanepani limited (KUKL) /water supply management board (WSMB)/ Nepal water supply corporation (NWSC) and also to Civil Aviation Authority (CAA).KUKL/WSMB/NWSC checks for Water supply management and Deep boring (ground water supply) system of apartment and provide comments to Developer through DUDBC DO if any. KUKL/WSMB/NWSC grant approval for water supply management and Deep boring (Ground water supply) system of apartment send to DUDBC DO. Likewise CAAN checks for maximum height with safe flight zone and provide comments to Developer through DUDBC DO if any and grant approval for maximum height of the apartment with respect to safe flight zone.

Apartment Building Approval and Building Permit

DUDBC Division office review/check the design and drawings for compliance of national building code (NBC) of Nepal. The major provisions of building code reviewed during code compliance checking by division office is as follows:

- Architectural Design requirements
- Light and ventilation system
- Staircase, exit requirement
- Lobby, lift, disable ramp, parapet height

Glazing system

- Structural Design requirements
- Geo-technical investigation
- Structural analysis and design as per NBC and relevant other international codes

Structural drawing with respect to output of structural design and ductile detailing requirement as per code

- Sanitary, water supply and planning system
- Water supply/ Treatment Plant/ Pumping System
- Toilet Bath fixtures and installation systems
- Liquid waste and solid waste management system

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Figure 6.Flowchart of Apartment building approval and Permit process

Rain water Harvesting Systems

- Firefighting system
- Fire Detector, Fire extinguisher, Firefighting Hose reels, Hose pipes, underground Water tank for firefighting requirement, Hydrant stations

Fire escape staircase, Exit, Lobby, Escape route

- Electrical system and design requirement
- Electrical Points, load calculation, Cable sizes
- Earthing, Lightning arrestor
- Safety against electrical hazards

Transformer, Generator and Panel Boards

- Operation and management plan (including safety management plan)
- Electrical, Sanitary services operation and management plan
- Fire safety management and earthquake safety management plan

Evacuation area, Exit, Use of Open Spaces during Disaster

The related documents to be submitted to Division office along with the proposal are:

- Application form
- Provision of details of Services/ Facilities
- Sample of Contract agreement paper. (As per clause 15 of OJHA 1997)
- Land and Company related ownership documents
- Proprietor, Developers Representatives
- Quality assurance documents and designer's affidavit papers
- Project brief reports, design reports and soil test reports
- Insurance letter

The division office may ask for presentation from designer for complex structures and designer makes a presentation to a multidisciplinary expert panel which include Structural expert, seismologist, Geotechnical expert, Electrical expert and sanitary expert in division office and the office send

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comments to the designer if there is any comments from the panel. There is also the provision for "review" by "expert panel" for complex structures. After the recommendation from the expert panel on the submitted designs of the apartment building and after the approval from all other concerned authorities i.e. KVDA, CAA and KUKL/WSMB/ NWSC, the division office issue the approval for apartment construction and send one set of all documents to the local bodies (municipalities/VDCs). Then the Local bodies charge there applicable taxes for apartment building and issue the building permit.

According to Figure 5 and Figure 6, there are total eight authorities involved in Approval and permit process for apartment building. Due to more authorities involved, the approval process is tedious and time consuming. The developer has to spend more than six months before they go for actual construction.

Supervision and Monitoring Mechanism

The flow chart was developed for supervision and monitoring process/mechanism of concerned bodies during apartment building construction and handover process as the result of key informant's interview with officials of concerned authorities, desk study and literature review of legal documents as shown in Figure 7.

According to the Figure 6, developer submits the quality assurance plan, quality control test reports and monthly progress reports to DUDBC DO and DUDBC DO supervise and monitor regularly until the construction is completed. However due to lack of technical manpower and lack of coordination between DUDBC DO and Developer the supervisions and monitoring is less effective. Similarly ABMCC monitor, coordinate and solve the problems seen in the apartment building construction.

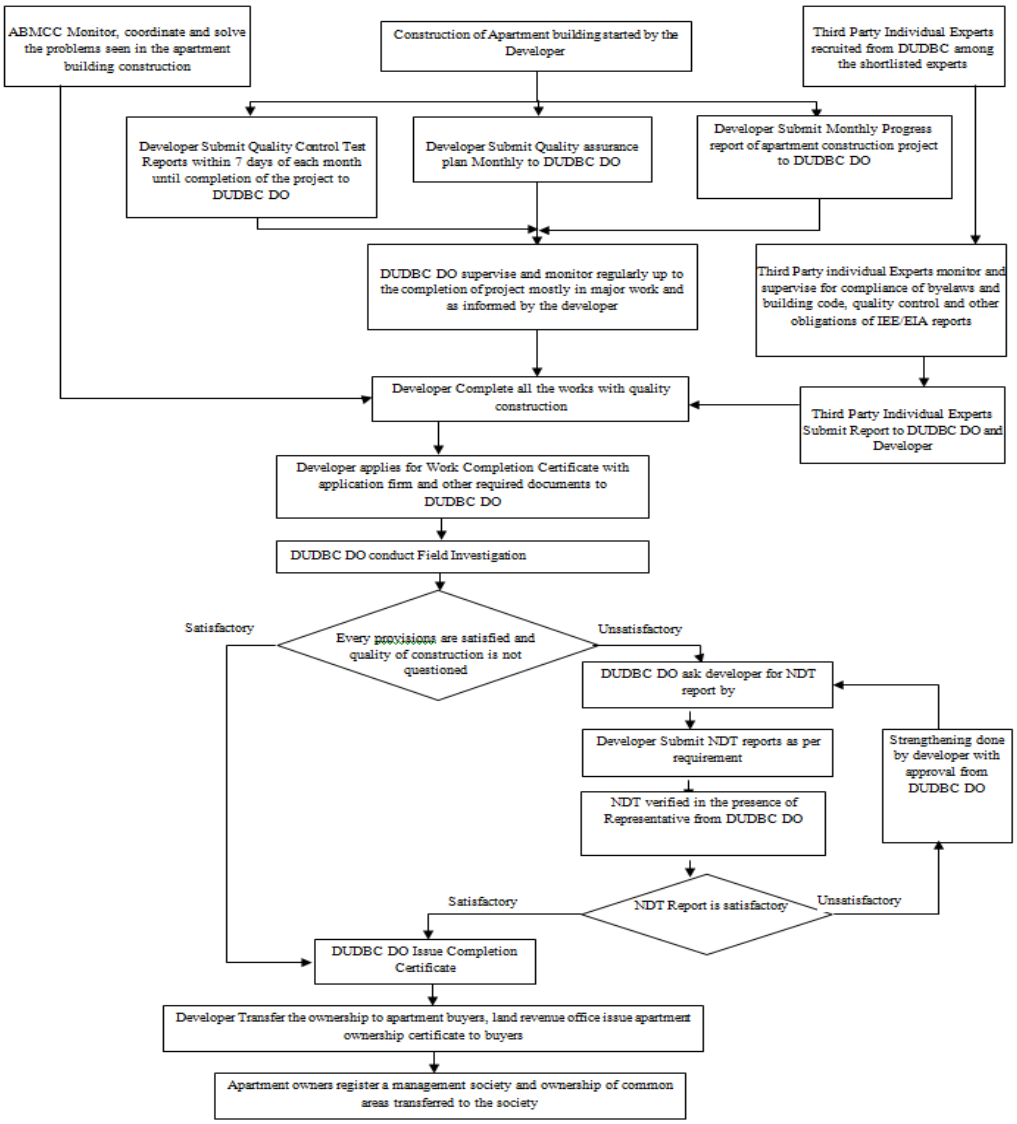

Figure 7.Flowchart of apartment building monitoring and supervision process

(Mishra AK, Karmacharya G & Aithal PS, 2021)

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Likewise there is a provision of third party individual experts for monitoring and supervising of compliance of byelaws and building code and other obligations but due to lack of resources the supervision and monitoring is done by DUDBC officials only. Monitoring and supervision from DO is mainly focused on checking of reinforcement detailing before/ during casting of important structural components e.g. foundation, column, slab and beam. Monitoring from DO also involves reviewing of the periodic progress reports and lab test reports, compliance of building byelaws e.g. setbacks, ground coverage, height during construction.

Regarding the second objectives of the study about supervision & monitoring mechanism/ process for apartment building construction the questionnaire survey from the structure engineers and the architects involved in design and construction of the apartment building were also done as per the Appendix A and Appendix B. The common question for structure engineers and the architects involved in apartments were asked about sufficiency and efficiency of supervision and monitoring mechanism from DUDBC DoK and the result is shown in figure 4.6:

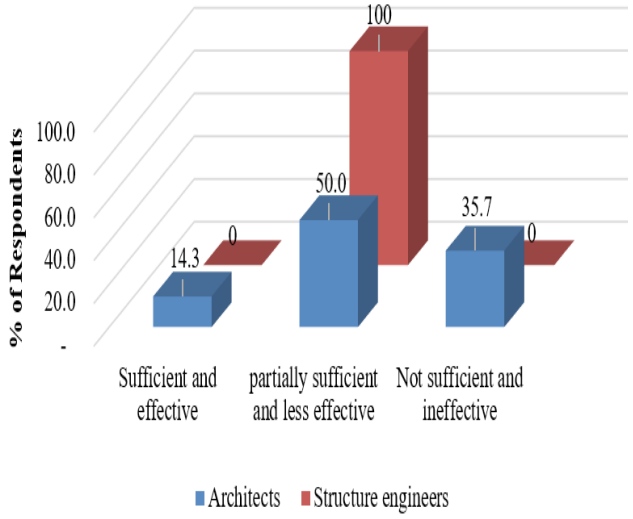

Figure 8.Sufficiency and effectiveness of supervision and monitoring

Figure 8, shows that 14.3% architects expressed their views, as the supervision and monitoring from DUDBC DoK is sufficient and effective, 50% architects expressed their views as partially sufficient and less effective and 35.7% architects' view is not sufficient and ineffective but 100% structure engineers' view i.e., all of the structure engineers' view is that the monitoring and supervision mechanism from DUDBC DoK is partially sufficient and less effective. The above result reveals that the supervision and monitoring mechanism from DUDBC DoK is partially sufficient and less effective.

Likewise, the common question for structure engineers and the architects involved in apartments were asked about the reason behind the weak supervision and monitoring mechanism from DUDBC DoK, the reasons found are grouped in three categories and the result is shown in Figure 9:

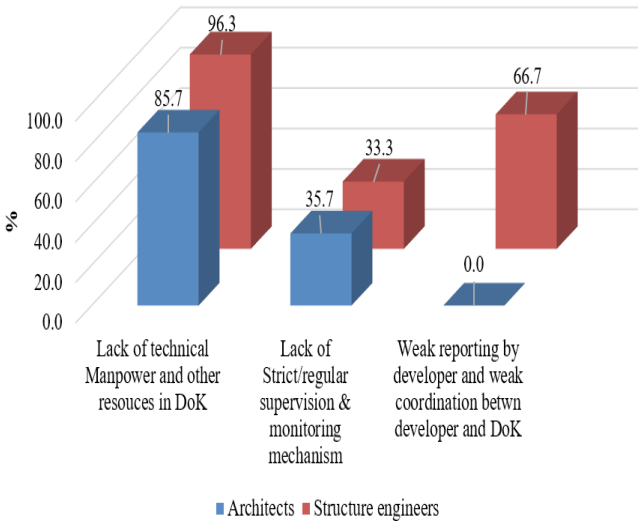

Figure 9.Reasons behind weak supervision and monitoring

Figure 9, shows that the main reasons for weak supervision and monitoring from DUDBC DoK during apartment building construction are lack of technical manpower and other resources in DUDBC DoK, Lack of strict/regular supervision and monitoring mechanism and weak reporting by developer and weak coordination between developer and office. Also according to the 85.7% architects and 96.3% of structure engineers lack of technical manpower and other resources in DoK is one of the major reason, 35.7% architects' and 33.3% of structure engineers' view shows that Lack of strict/ regular supervision and monitoring mechanism is another reason and 66.7% of structure engineers' view shows that weak reporting by developer and weak coordination between developer and office one of the reason for weak supervision and monitoring during apartment construction.

Use Approval Process of Damaged Apartment Building

After Gorkha earthquake 2015, for approval of the repair and maintenance and retrofitting works to be done in apartment buildings and to permit the use of apartment buildings the directive was approved from MoUD. The Flow chart as in figure 4.8 has been developed for process of Use Approval of Damaged Apartment Buildings after Earthquake, as the result of key informant's interview with officials of concerned authorities, desk study and literature review of legal documents.

According to the Figure 10, developer apply for use approval of damaged apartment building after earthquake, with the required documents i.e., detail damage assessment, detail

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damage mapping, Engineers' commitment & detail damage evaluation report with recommendation of engineering maintenance plan and restoration method, to DUDBC DO. DUDBC DO team which include government officials, professional society and private sector professionals, verify the detail damage evaluation report submitted after site observation. In detail damage evaluation the damages are classified to three different main categories Non-structural damage i.e. Masonry Wall Crack/ Category (M) damage, Local structural damage i.e. Structural Crack or Damage/ Category (SD) damage and Structural Failure/ Category (SF) damage and subcategories as per type and size of cracks observed. The three main categories and subcategories of damages are shown in Table 18.

shall be monitored by the verification team. Successive result of NDT confirms to use of the apartment. In case of unsatisfactory results in NDT test, the damage will be considered as Structural failure, damage category (SF). In case of damage category (SF) and failure in NDT in damage category (SD), the designer require to submit Evaluation of Seismic Capacity and Retrofitting Design of the apartment building as per IS 15988 or other relevant code.

From the retrofitting design if the building is not safe the building has to be demolished and if safe the submitted retrofit design is peer reviewed from expert/review consultant. After the peer review the designer and the expert consultant present in expert panel team. After

Table 18.Damage classification for earthquake damaged apartment buildings

S. No.	Damage Class	Damage Type	Indication
1.	Masonry Wall Crack, Category (M) damage	Crack Up to 0.5MM wide Crack Up to 5MM wide Crack Above 5MM wide Others	M1 M2 M3 M4
2.	Structural Crack or Damage, Category (SD) damage	Shear Crack width less than 0.2MM Flexural Crack with limited Sagging Beam Column Joint Crack Hair Crack in construction Joint Cover Concrete Spilt Others	SD1 SD2 SD3 SD4 SD5 SD6
3.	Structural Failure, Category (SF) damage	Plastic Hinge in Beam Buckling of Rebar Core Concrete Spilt Share Failure >0.2MM Width Foundation Settlement Inclination >1.5° Opening of Stirrups Others	SF1 SF2 SF3 SF4 SF5 SF6 SF7 SF8

MoUD, 2016.

The approval procedure depends upon damage category. In case of non-structural damage i.e. damage category (M) only, the repair, restoration and maintenance is permitted as per approved techniques submitted by designer. In case of local structural damages, damage category (SD), the repair, restoration and maintenance is permitted as approved techniques submitted by designer and after completion of restoration and the restoration points will be tested using Non Destructive Test (NDT) method. The NDT test

approval of retrofit design by the expert panel team, DUDBC DO approve the retrofit design and issue permits to restoration/retrofitting. Retrofit construction is started supervision and monitoring is done. Developer submit NDT report after completion of retrofit work and site verification of the NDT report is done by DUDBC Team. And then DUDBC DO issues the apartment building use/operation approval to the developer.

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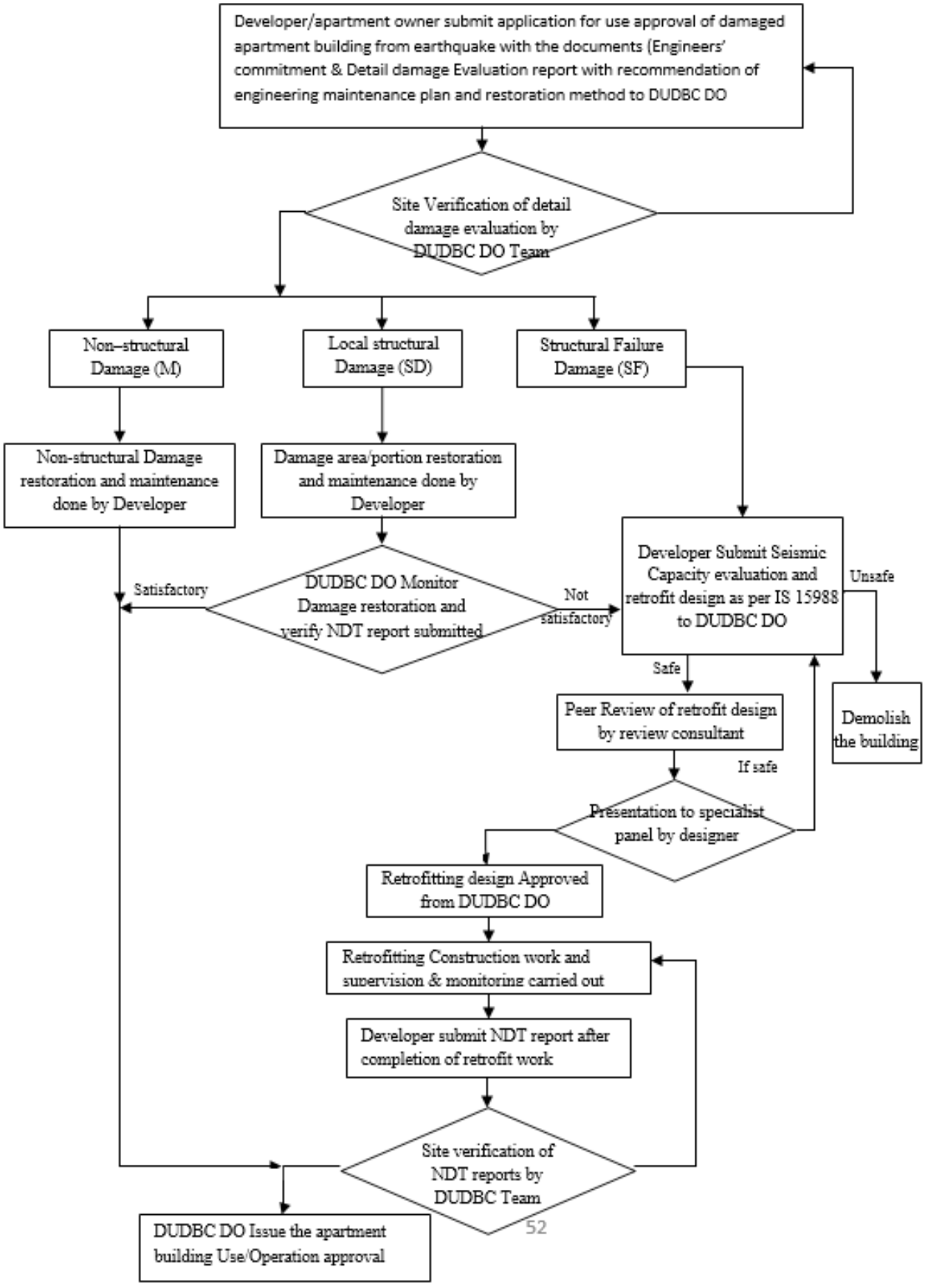

Figure 10.Use approval process of earthquake damaged building

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Conclusion

Major Provisions of Building Byelaws and Building Code

- Major provisions of building byelaws 2007, Floor Area Ratio and Allowable Ground Coverage Ratio for apartment building are in higher side and the Setbacks, Access Road width and Greenery Open Space for apartment building are in lower side than in Indian context. Allowable Ground Coverage and Floor Area Ratio are reasonable in context of Nepal and Greenery open space, setbacks and access road width are needed to be updated to higher value
- Major provisions of the building code for Seismic safety of apartment buildings are defined in Nepal National Building Code (NBC) 105:1994. According to NBC 000:1994 other international codes can also be used for design of buildings in Nepal. Generally, the design parameters for seismic design of the apartments according to NBC 105 are in lower side than that according to IS 1893:2002 code
- The Architectural design parameters in apartments shall be as per Architectural design requirements NBC 206:2003, Firefighting provisions with requirement of underground fire tank, Fire hydrant system, fire pump capacity shall be as per Sanitary and Plumbing Design Requirements NBC 207:2003 and the provisions of Fire Safety requirements shall be as per requirements of NBC 107:1994
- Both NBC and IS codes are used by the designers for design of apartment buildings since NBC is incomplete and some codes shall be referred to IS codes according to NBC

Approval/ Permit Process and Supervision and Monitoring Mechanism

- Total eight government authorities are directly involved for apartment buildings approval and permit process and thus the time taken for approval process is normally more than 6 months
- DUDBC Division office Kathmandu has major responsibility for supervision and monitoring of construction of apartment buildings and it is less effective and insufficient
- The supervision and monitoring of apartment construction is neglected or not done by the Municipalities and VDCs.
- Other concerning authorities (KVDA, MoSTE, KUKL/ WSMB/NWSC, CAAN) are not made responsible for supervision and monitoring process as per existing acts and rules
- Similarly the Use approval process to the earthquake damaged apartment is granted according to the damage category and severity of the damages in structural and nonstructural members

Recommendation

Seismic safety of high rise apartment buildings should be increased in NBC 105:1994 updating the seismic design parameters such as response spectra, load combination and maximum displacement limit. The full volumes of the NBC should be prepared to make it complete so that Indian and other codes are not required to refer.

It is recommended to update the allowable Ground Coverage to 33% and Floor Area Ratio to 3.0 for apartments. It is recommended to update minimum greenery open space to 30%, Setbacks to minimum 8.0 m and increased as required for height to setback ratio 4:1 and minimum access road to 8.0 m.

One door system should be adopted for approval and permit process so that the time period required for approval process is minimized. The developer should not go to all concerned authorities separately and DUDBC DoK should proceed to all concerned authorities to get required approval.

The strict and effective supervision/monitoring mechanism and proper coordination mechanism should be introduced in all concerned authorities involved in apartment building construction with sufficient allocation of resources. Independent third party monitoring and supervision should be done in all apartment building construction.

The nonstructural masonry infill walls should be replaced by the light weight, prefabricated materials to avoid the damage in masonry infill walls.

For minimizing the issues raised by the neighbors after Gorkha Earthquake 2015 the following should be done by the developer and the concerned authorities.

- Proper zoning for apartment construction
- Seismic vulnerability assessment of the existing apartments
- Insurance of Neighbors of the apartments

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