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A Review on Disaster Resilient Residential Structure with Special Reference to Nepal

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Abstract: Natural disasters are counterproductive to developing countries' economic growth, as they may be accompanied by a reduction in the Gross Domestic Product (GDP), rise in imports, and deterioration in fiscal balances. The research was conducted during the period from September to December 2019. The main goal of this analysis was to find out the weakness of the construction of disaster-resilient residential in and around the world. The special focus is given to Nepal. Throughout this analysis, secondary literature received from various sources such as published reports, papers, thesis, database, and manuals were collected and the conclusion is drawn based on studied materials. It is noted that 21 major natural disasters in Southern African countries led to an overall worsening of the trade balance owing to an increase in import growth and, to a lesser extent, a reduction in export growth. Due to flooding in 2000, Mozambique lost over 10% of its total viable land, as well as the crops in the field, and about 40,000 head of cattle were washed away. The study also found that the Nepal's Building Codes were not properly enforced, which resulted in poor housing., the building construction materials are another culprit of the poor quality buildings in Kathmandu Valley along with the design of the residential structures. The study would like to suggest that the building codes should be implemented and the laws and bylaws prepared by the concerned authority should be strongly enforced. Furthermore, the practice of building designing of the residential houses by the owner themselves should be banned.

Keywords: Building Code, Material and Quality Control, Reinforced Cement Concrete Construction, Regular Supervision and Inspection

1. Introduction

The earth has been witnessing both natural and manmade disasters. Disasters caused by natural hazards and climate change are occurring more frequently and are becoming more expensive every day. The occurrence of such disasters and the distribution of their impacts may vary depending on geography, topography, level of preparedness, resource abundance, and the awareness level of people and their residing structure [1].

The history of Nepal shows that Nepal had experienced numerous big and small earthquakes, and at every 80 years (approximately) major earthquake of high magnitude (upto MMI Scale X) occurs [2], thus major earthquake is an unavoidable part of Nepal's future. Nepal lies above two tectonic plates – Indian and Eurasian plates which are making it vulnerable to the earthquake now and then. Nepal falls in the top 20 list of the most multi-hazard prone countries in the world and is ranked 4th, 11th and 30th in terms of climate change, earthquake, and flood risk respectively. Epidemics, landslides, floods, fire, thunderstorms, accidents, and earthquakes are some of the common hazards in Nepal [3-7].

Natural disasters are detrimental to the economic development of developing countries as they may be accompanied by a reduction in the Gross Domestic Product (GDP), an increase in imports, and deterioration in fiscal balances. Cowards found that 21 major natural disasters in Southern African countries led to an average worsening of the trade balance owing to an increase in import growth and, to a lesser extent, a reduction in export growth [8]. Due to flooding in 2000, Mozambique lost over 10% of its total productive fields, as well as the crops in the field, and about 40,000 head of cattle were washed away [9].

2. Findings from the Review of Literature

2.1. Disaster Risk Reduction

Disaster risk reduction is the concept and practice of reducing disaster risks through systematic efforts to analyze and reduce the causal factors of disasters. Reducing exposure to hazards, lessening vulnerability of people and property, wise management of land and the environment, and improving preparedness and early warning for adverse events are all examples of disaster risk reduction [10].

We need to manage risks, not just disasters. DRR is a part of sustainable development, and it must involve every part of society, government, non-governmental organizations, and the professional and private sectors. It, therefore requires a people-centered and multi-sector approach, building resilience to multiple, cascading, and interacting hazards and creating a culture of prevention and resilience [11]. Consequently, DRM includes strategies designed to avoid the construction of new risks, address pre-existing risks, and share and spread risk to prevent disaster losses being absorbed by other development outcomes and creating additional poverty.

2.1.1. History of Disaster Risk Reduction

The history of disaster risk reduction is briefly presented hereunder:

1. 1989 International Decade for Natural Disaster Reduction- with the increasing concern about the impact of disasters, the UN General Assembly declared 1990-1999 the International Decade for Natural Disaster Reduction (IDNDR) [12].
2. 1994 First World Conference on Disaster Reduction and the Yokohama Strategy for a Safer World - The Yokohama Strategy for a Safer World: it gives guidelines for Natural Disaster Prevention, Preparedness, and Mitigation and its Plan of Action was adopted at the World Conference on Natural Disaster Reduction [10].
3. The United Nations Office for Disaster Risk Reduction (UNDRR) was created in December 1999 to ensure the implementation of the International Strategy for Disaster Reduction also to promote public awareness and commitment, to expand networks and partnerships [12].
4. 2002 The Johannesburg Plan of Action - The World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa, came with an integrated, multi-hazard, inclusive approach to address vulnerability, risk assessment, and disaster management [10].
5. 2005 Second World Conference and the Hyogo Framework for Action 2005-2015 - The World Conference on Disaster Reduction was held in Kobe, Hyogo, Japan: came up with building the Resilience of Nations and Communities to Disasters [11].
6. 2011 Programme of Action for the Least Developed Countries for the Decade 2011-2020 - The Istanbul Programme of Action (IPoA) charts out the international community's vision and strategy for the sustainable development of LDCs for the next decade with a strong focus on developing their productive capacities [10].
7. 2012 United Nations Conference on Sustainable Development - Rio+20 - The outcome Document – *"The Future We Want"* –disaster risk reduction that sets a firm foundation for discussions on a post-2015 framework to continue guiding nations after the Hyogo Framework expires in 2015 [12].
8. 2015 Third World Conference and the Sendai Framework (2015-2030) The Third United Nations World Conference on Disaster Risk Reduction, Sendai, Japan, 2015. The Conference adopted the Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework) as the first major agreement of the Post-2015 Development Agenda, with seven global targets and four priorities for action [11].

2.1.2. International Strategies for Risk Reduction

Hyogo Framework for Action, Kobe, Hyogo, Japan, 18 to 22 January 2005

The first step in this process was the formal approval at the WCDR of the Hyogo Framework for Action (2005–2015) (HFA). This was the first globally accepted framework for DRR. It embark an ordered sequence of objectives (outcome – strategic goals – priorities), with five priorities for action attempting to 'capture' the main areas of DRR intervention [12].

This framework is an agreement signed by 168 governments and international organizations, consisting the World Bank Group and the United Nations, to support disaster prevention across the world. The proposed measurement of resilience in the Hyogo declaration is determined by *"the degree to the social system is capable of organizing itself to increase this capacity for learning from past disasters for better future protection and to improve risk reduction measures"* [11].

Nepal was also committed to achieve the vision of "Disaster Resilient Nepal" by formulating the strategies based on already identified gaps and issues for each of the Priorities for Action that are in line with the HFA priorities: The HFA, which ran from 2005 to 2015, set five specific priorities for action. These are: Making disaster risk reduction a priority, improving risk information and early warning, building a culture of safety and resilience, reducing the risks in key sectors, and strengthening preparedness for response [12].

Sendai Framework in Nepal

Government of Nepal formulated National DRR Policy and Strategic Action Plan: 2017-2030 in line with Sendai. This plan has following objectives

i. Disaster risk reduction focus
ii. Integrated within development sectors
iii. Multi-hazard management of disaster risk approach
iv. Requires the Government, private sector and all-of-

society engagement & partnership

v. Along with other guiding principles as outlined by the Sendai Framework

Management for the preparation of National Policy & Strategic Action Plan in Nepal

The overall process is led by the Government of Nepal (GON). Other relevant agencies and professionals provide support to the GON. The Working Committee (WC) formed to support and guide the process is led by the Head of Disaster Management Division, Ministry of Home Affairs (MoHA). Thematic Working Groups (TWGs): Six thematic working groups have been formed: Productive; Social; Infrastructure; Environment and Natural Resources; Cross-cutting; Preparedness, Response, Recovery, and Communication. Lead and Co-lead from government and other relevant organizations as TWG members [13].

2.1.3. Effect of Disaster on Economy

Huigen distinguished the economic effects of disasters as direct, indirect, and secondary. They defined direct effects as the economic damage to property and the loss of income. Direct effects may be in the form of the destruction of sites of production such as factories or farms as loss of capital (housing and farmland), loss of stocks, etc. However, indirect economic effects may be caused by direct losses, which result from the decline in production and the provision of services, for example, a reduction in the activity of suppliers [15].

According to Rasmussen the impacts may cause spillovers at the macro-economic level, as fiscal and external pressures can lead to imbalances that spark economic crises and an increase in the incidence of poverty can create social unrest. Syed stresses that the secondary effects of a disaster include inflation, balance of payment problems and, increases in fiscal expenditure and decrease in monetary reserves [16].

In developing communities, where resilient infrastructure is often sorely needed, damages are up to twenty times higher than developed countries when considered with the national gross domestic product (GDP) [17].

2.1.4. Relationship Between Resilience and Vulnerability

A high level of vulnerability does not necessarily mean that a community is not resilient; however high vulnerability is often indicative of an inability to resist or respond to disaster. Vulnerability and resilience both play a role in how a disaster will impact a community and how that community will recover. Therefore, indicators of both vulnerability and resilience must be accounted for in determining how pre-disaster conditions impact recovery [18].

Resilience shortens the period time between the disaster and full recovery. Resilient communities are adaptable, with the ability to "build back better" after a disaster. Being resilient means combining aspects of environmental sustainability, economic strength, risk management, emergency preparedness, and strong social communities to build a better community [19].

2.2. Growing Risk in Urban Areas

Today half the population, more than 3 billion lives in urban areas. Globally, urban growth peaked in the 1950s, with a population expansion of more than 3% per year. By the middle of the 21st century, the urban will almost double, increasing from approximately 3.4 billion in 2009 to 7 billion in 2050 [20]. By 2030 Asia will have a higher number of urban dwellers than any other major area of the world UN-HABITAT and Asia has been considered as the supermarket of disaster [22]. Around 40% of reported disasters occurred in Asia from 2003 to 2012 [23]. This can be associated with a high rate of urbanization and poverty [24].

2.2.1. Drivers of Risk in Urban Environment (Adopted from Urban Risk Management in South Asia)

Several elements contribute to urban vulnerability. It is their compound and the correlated effect that makes urban disaster risk reduction a challenge. These elements can be grouped into the following vulnerability attributes:

i. Unplanned Urbanization

The rapid expansion of cities results in haphazard growth exceeding the cities capacity to adequately plan and control development which in turn diminishes cities' ability to deal with disasters [12].

ii. Social and Physical Degradation

A significant proportion of urban resident lives and works in highly vulnerable buildings where they are at high risk from multiple hazards such as earthquake and the floods. Access to emergency vehicles is often difficult and can be completely obstructed by building debris in case of a hazard event [24].

iii. Neglected Urban Risk

Urban risk from extreme hazards has been largely ignored by local authorities compounding the problem. Schools, hospitals, essential facilities, housing, commercial and institutional property continue to be designed and built with little regard to safety to hazards such as earthquakes [24].

iv. Weak Institutional Arrangements

When it is recognized that disasters are initially local events, accountability, authority, and resources are not sufficiently decentralized to enable local government to assume ownership and take actions to manage disaster risk effectively [20].

v. Lack of Political Feasibility

Politicians, administrators, and community leaders all face conflicting priorities, and DR (Disaster Risk) almost invariably takes the back seat to other needs which may be considered more pressing or easier to solve [23].

vi. Insufficient Knowledge, Experience and Capacity

Disaster risk reduction is a complex, and few administrators have experience in DR implementation. It takes time, effort, tools, and training to assimilate disaster risk reduction in city function and ongoing operation [25].

vii. Lack of Standard Level of Practice

DRM is a professional practice that still lacks its own set of acceptable standards of practice. This results in a dispersion of effort and an ineffective use of resources. It also erodes the political support for local-level action on DRR

2.2.2. Concept of Resilience

Etymologically, the term resilience is formed on model of Latin "Resilientem" which means to rebound or recoil. Over time resilience has been defined and conceptualized by different disciplines, scholars, and institutions in different ways. Engineering resilience makes any system return to its pre-designed state after any disturbances while ecosystem resilience allows for desirable state. In this research, following definition of resilience will be used [25].

"The ability of a system, community, or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and function" [26].

2.2.3. Essentials of a Resilient City

Resilience is a difficult concept both to measure and apply to different operating contexts. However, an example of initiatives to apply the concept of resilience to urban context is UNISDR'S Making Cities Resilient Campaign (MCR). It has 1290 cities signed up so far for its campaign to strengthen local governance capacity for risk reduction [25].

Ten Essentials for making city resilience

i. Organization and coordination are to understand and reduce disaster risk, based on the participation of citizen. Local alliances should be built, and all departments should understand their role in disaster risk reduction and preparedness.
ii. A budget for disaster risk reduction must be allotted and should provide incentives for homeowners, low-income families, communities, businesses, to invest in reducing the risks they face.
iii. Maintain up-to-date data on hazards and vulnerabilities, prepare risk assessments, and use these as the basis for urban development plans and decisions. Ensure that this information and the plans for your city's resilience are readily available to the public and fully discussed with them.
iv. Invest in and maintain critical infrastructure that reduces risk, such as flood drainage, adjusted where needed to cope with climate change.
v. Assess the safety of all schools and health facilities and upgrade these as necessary.
vi. Apply and enforce realistic, risk compliant building regulations and land use planning principles. Identify safe land for low-income citizens and upgrade informal settlements, wherever feasible.
vii. Ensure that the education programs and training on disaster risk reduction are in place in schools and local communities.
viii. Protect ecosystems and natural buffers to mitigate floods, storm surges, and other hazards to which your city may be vulnerable. Adapt to climate change by building on good risk reduction practices.
ix. Install early warning systems and emergency management capacities in your city and hold regular public preparedness drills.
x. After any disaster, ensure that the needs of the affected population are placed at the center of reconstruction, with support for them and their community organizations to design and help implement responses, including rebuilding homes and livelihoods [27].

2.3. Failure of Buildings

Low-rise buildings most vulnerable to earthquakes do have the necessary stiffness, strength, and ductility to resist the forces of an earthquake or had walls that were not well anchored to a solid foundation, or both. Three types of buildings sustained the most significant damage:

i. Multi-story buildings with a ground floor consisting only of columns:

Most of these buildings were 3 to 4 stories tall with a parking garage or a living area with many large windows on the ground level. The columns may have been strong enough to hold up the structure but did not provide an adequate amount of racking resistance during a seismic event. When the earthquake shook the building side-to-side, the upper stories sometimes tipped over to one side. Whether built of wood, steel, or concrete they all suffered [28].

ii. Wood-frame houses with weak connections between the walls and foundation:

Wood-framed buildings are inherently ductile (flexible), which is an attribute during an earthquake. However, the shaking sent some of these houses sliding to one side. Frequently, the shear walls were strong enough, but the connection to the foundation was a weak point that gave way [29].

iii. Un-reinforced masonry or concrete buildings:

Masonry or concrete walls not reinforced with steel bars were not ductile enough to be effective shear walls. And if there is no steel connecting them to their foundation, the joint between walls and foundation can be a weak point [30].

2.3.1. Reinforced Concrete Buildings Behaviour

Reinforced concrete walls are a composite system: Concrete resists compression forces and reinforcing steel resists tensile forces produced by an earthquake. In reinforced concrete construction, the combination of concrete and steel provides the three most important properties for earthquake resistance: stiffness, strength, and ductility [28].

The concrete is cast around the bars, locking them into place. The exceptional ductility of the steel to resist tensile forces, coupled with the rock-like ability of concrete to resist compression, results in an excellent combination of the three most important earthquake resistance properties: stiffness, strength, and ductility. A study at Construction Technology Laboratories revealed that even a lightly reinforced concrete shear wall has over six times the racking load resistance as framed wall construction. It's no wonder that modern reinforced concrete buildings were found to survive these recent earthquakes with rarely any significant damage [31].

2.3.2. Behavior of Masonry Buildings to Ground Motion

Ground vibrations during earthquakes cause inertia forces at locations of mass in the building. These forces travel through the roof and walls to the foundation. The main emphasis is on ensuring that these forces reach the ground without causing major damage or collapse. Of the three components of a masonry building (roof, wall and foundation) [30].

In addition to the main earthquake design code 1893 the BIS (Bureau of Indian Standards) has published other relevant earthquake design codes for earthquake resistant construction Masonry structures (IS-13828 1993) which states:

i. Horizontal bands should be provided at plinth, lintel and roof levels as per code.
ii. Providing vertical reinforcement at important locations such as corners, internal and external wall junctions as per code.
iii. Grade of mortar should be as per codes specified for different earthquake zones.
iv. Irregular shapes should be avoided both in plan and vertical configuration.
v. Quality assurance and proper workmanship must be ensured at all cost without any compromise. In RCC framed structures (IS-13920).
vi. In RCC framed structures the spacing of lateral ties should be kept closer as per the code.
vii. The hook in the ties should be at 135 degree instead of 90 degree for better anchorage.
viii. The arrangement of lateral ties in the columns should be as per code and must be continued through the joint as well.
ix. Whenever laps are to be provided, the lateral ties (stirrups for beams) should be at closer spacing as per code [31].

2.4. National Disaster Management and Risk Reduction Law and Policy of Nepal

Nepal has relatively comprehensive body of legislation, developed over many years. Its national laws regulate a range of matters relevant to DRR, from the specific natural calamities (Relief) Act 2039 (1982) on disaster response to laws relating to building and construction, land use planning and environmental protection. It also has a legally mandated system of devolved decision making and local governance, which is central to DRR implementation. Some of the DRR related policies and laws are described in these sections [32].

2.4.1. Natural Calamity Relief Act, 1982, Amended 1992

Main legal instrument specifically directed towards disaster management in Nepal. Its focus is on response and reconstruction. Within the declared disaster area, the Government has wide-ranging power to order anyone concerned to assist in the rescue and relief effort, the evacuation of public and goods, measures to protect people, property and building, the establishment and deployment of aid group; and the use of government resources. These activities are coordinated by the Ministry of Home Affairs (MoHA), especially through its district level officers, the chief district officers (CDOs). The fundamental purpose of this act is for disaster relief and reconstruction [33].

2.4.2. Local Self-governance Act, 1999

The Act provides the municipality, District Development Committee (DDCS) and Village Development Committee (VDCs) a legal mandate to formulate and implement programs related to protection/conservation of environment during the formulation and implementation of a district level plan. The act also governs the participatory process for works relating to participatory planning, autonomy of local government, community mobilization, community monitoring, measures for marginalized groups including women [32].

2.4.3. Building and Construction

The building Act, 1998, the Building regulation 2009, are administered by Department of Urban Development and Building Construction (DUDBC). The DUDBC's direct regulatory responsibilities extend only to public buildings, whereas District and local Municipal/ VDC governments have the responsibility for implementation in private construction. There appears to be no specific law concerning the safety of current private buildings. This legislation must be implemented at local government level, and this is one of the major challenges facing by Nepal in reducing the risk from earthquake (IFRC, AusAID, 2011) [34].

2.4.4. National Building Code, 1993

There are 23 different title wise volume of building code, which form a single national building code of Nepal, 1993. The National Building Code was prepared in 1993 by the Ministry of Housing and Physical Planning (now MoUD). This code emphasizes the need for changes and improvement in the current building construction design and methods. The publication represents standard of good practices [32].

2.4.5. Tenth Five-year Plan and Three-year Interim Plan

For the first time in Nepal’s history, Government of Nepal has included Disaster Management Programs in the 10th National Development Plan (2002-2007) emphasizing irrigation and water-induced disaster preparedness and natural disaster management. Similarly, the three-year interim plan (2007/08-2009/10) and three year plan (2009/10-2012/13) also has given due consideration to natural disaster management. The three-year plan emphasizes on policy formulation, strengthening institutional mechanism, Early Warning System, coordinated approach for Disaster Risk Reduction and linking disaster management with climate change [34].

2.4.6. National Urban Policy, 2007

The National ‘Urban Policy, 2007 aims to promote a healthy, livable, safe and economically vibrant urban environment through planned provision of infrastructure services, facilities and amenities that ensure improved quality Of life of urban People. It also looks after importance of environment conservation while carrying out urban development works and natural source utilization, promoting development of compact city/ towns/ settlements, and preparation and implementation of Disaster Management Plan by local government agencies to cope with the loss of lives and properties resulting from natural disasters. [33].

2.4.7. The Environment Protection Act 1996

The Environment Protection Act 1996, Environment Protection Rule 1997 and Environment Impact Assessment concern both broad environmental management and environmental impact assessment of proposals to carry out development work or physical activity that may bring about change in the existing environment condition or any plan, project or program which changes the land use. It is administered by MoHA and MOLD officials at district level [32].

2.4.8. National Strategy for Disaster Risk Management, 2009

The National Strategy for Disaster Risk Management in Nepal (NSDRMN) has been approved on 2009 October 11. It endeavors to facilitate the required change in order to achieve the goal of disaster resilient Nepal by providing guidance for improving the policy and legal environment and by prioritizing the strategic interventions. It has put forth suggestion regarding institutional reorganization and development, and strategic improvement in the existing policy and legal environment for creating an enabling atmosphere for encouraging disaster risk reduction (DRR) and preparedness planning at all levels as well as for mainstreaming DRR strategies into the national development and poverty alleviation agenda. Thus, it is a road map that provides long term guidance in the area of disaster risk management planning and implementation in Nepal [34].

2.4.9. Nepal Risk Reduction Consortium, 2009

In 2009, Nepal Risk Reduction Consortium (NRRC) was formed to support Government of Nepal in developing a long-term Disaster Risk Reduction Action Plan building on the NSDRM. The members of the consortium are ADB, IFRC, UNDP, OCHA, ISDR and the World Bank. It aims for School and Hospital safety structural and nonstructural aspects; making schools and hospitals earthquake resilience. NRRC 2009 builds up emergency preparedness and response capacity. It looks after flood management in Koshi river basin and manage integrated community-based disaster risk reduction/ management [32].

2.5. Role & Responsibilities of Civil Engineers

It is not the earthquake which kills the people, but it is the unsafe buildings which is responsible for the devastation. Keeping in view the huge loss of life and property in recent earthquakes, it has become a hot topic and worldwide lot of research is going on to understand the reasons of such failures and learning useful lessons to mitigate the repetition of such devastation. If buildings are built earthquake resistant at its first place (as is being done in developed countries like USA, Japan etc) we will be most effectively mitigating the earthquake disasters. The professionals involved in the design and construction of such structures are civil engineers who are responsible for building earthquake resistant structures and keep the society at large in a safe environment. It is we the civil engineers who shoulder this responsibility for noble and social cause [34].

2.6. Institutions Involved and Urban Disaster Activities Carried out in Nepal

In the line with 1982 Act, the local disaster in any place of Nepal is addressed by District Disaster Relief Committee, chaired by CDO (Chief District Officer) and looks after execution, rescue, relief, and data collection and reports to Regional Natural Disaster Relief Committee which is chaired by regional administrator. RNDRC gets the instructions and fund of response Rescue and relief from Central Natural Disaster Relief Committee which is under Home Minister. On the top is the cabinet of Nepal which is responsible for the policy, Budget, emergency declaration, etc. funding mechanism of disaster control is governed by Prime Minister Relief Fund, Central Disaster Relief Fund, Line Minister Funding Arrangement, Local Disaster Management Fund [33].

2.6.1. National Society for Earthquake Technology (NSET)

NSET was founded on June 18, 1993 with the vision "earthquake Safe Communities in Nepal by 2020" with the main objective "to foster the advancement of science and practice of earthquake engineering and technology for mitigating the earthquake risk and increasing the seismic safety, to enhance professionalism, professional engineering and scientific ethics and to further the objectives of the International Association for earthquake Engineering as applicable to Nepal". Also, three strategic objectives have been outlined addressing Information Dissemination & Knowledge Transfer, Advocacy and Networking, and Establishment of Credible Institution & Resource Center [35].

2.6.2. National Disaster Risk Reduction Centre (NDRC)

NDRC was founded in 2003 which aims to assist and work closely with the Government and non-government, civil society institutions providing technical backstopping and facilitation towards Disaster Risk Reduction Initiatives, includes; Disaster Preparedness, Mitigation, Research and Advocacy, Knowledge Management Awareness, training, workshop, symposium and Policy debate activities in Nepal. NDRC Nepal allows and encourages promoting effective coordination and communication as well developing knowledge initiatives with its all stakeholders in Nepal [36].

2.6.3. The Kathmandu Valley Earthquake Risk Management Project (KVERMP)

The Kathmandu Valley Earthquake Risk Management Project (KVERMP) was implemented from 1 September 1997 to 30 December 1999 by the National Society for Earthquake Technology Nepal (NSET) in technical collaboration with Geohazards International (GHI), as a part of the Asian Urban Disaster Mitigation Program (AUDMP) of the Asian Disaster Preparedness Center (ADPC), with core funding by the United States Agency for International Development (USAID) Office of Foreign Disaster Assistance (OFDA). It has four main objectives:

i. To evaluate Kathmandu Valley's earthquake risk and prescribe an action plan for managing the risk.
ii. To reduce earthquake vulnerability of public schools;
iii. To raise awareness among the public, government officials, international community resident in Kathmandu, and international organizations about Kathmandu Valley's earthquake risk; and
iv. To build local institutions that can sustain the work launched in this project [37].

2.6.4. The Study on Earthquake Disaster Mitigation in Kathmandu Valley, Nepal (JICA/MOHA)

It is a joint effort of Government of Nepal and Government of Japan to implement a study on earthquake disaster mitigation in the Kathmandu Valley. The Government of Nepal, through Japan International Cooperation Agency (JICA), a study was carried out from January 2001 to March 2002 with the goals of protecting life and property in the Kathmandu Valley, strengthening socio-economic systems, and protecting the stability of governance even in the event of major earthquake [38].

2.7. Technique for Earthquake Resistant Building

After the several massive earthquakes around the world there were many exercise to find out if it's possible to build an earthquake-proof building? The answer is yes and no. There are of course, engineering techniques that can be used to create a very sound structure that will endure a modest or even strong quake. However, during a very strong earthquake, even the best engineered building may suffer severe damage. Engineers design buildings to withstand as much sideways motion as possible in order to minimize damage to the structure and give the occupants time to get out safely [39]. In order to building earthquake resilient, the following simple steps can be considered.

2.7.1. Use Skyscrapers Technology

In the last few decades, scientists managed to develop a system of skyscrapers which float on a system of ball bearings and padded cylinders. This acts just like a kind of shock absorber when situation of an earthquake is encountered. Some similar technique should be followed while constructing a building in order to make it earthquake proof [40].

2.7.2. Prefer Engineered Structure Design

These days, many advanced engineering equipment's and techniques have arrived in the market, which can easily make building fortified against the earthquake problem. Therefore, engineer's consult is most to get perfect engineered building first [41].

2.7.3. Use Good Quality Building Material

The building material that is in use to make a building also helps to fortify a building against the damage caused by an earthquake. The use of an improper cement/sand ratio, while constructing a building, makes it more prone to fall than the others built with a perfect cement/sand ratio [42].

2.7.4. A Perfectly Connected Masterpiece

According to a famous architect, if a building is in a connected kind of way, keeping the rooms short with no adulterated material used for building it, the building is sure to stay earthquake proof. According to him, it is the sudden release of an energy stored in the earth, which causes the most of trembling and destruction [41].

2.7.5. Watch out the Load

If the building is less loaded to the bottom, but heavy at its top, the building gets more prone to falling than the ones with fewer loads at top and more load at the bottom. The buildings should be constructed in such a way that there are more rooms at lower floors than the number of rooms at the upper floors. Iron bars should also be bought into use during construction to make the basement and walls strong enough to bear the impact of an earthquake [42].

2.8. Some World-renowned Earthquake Resilient Buildings

2.8.1. Utah State Capitol

The Utah State Capitol is the house of government for the state of Utah. The building has its own base isolation system made up of a network of 280 isolators built with laminated rubber laying on the foundation of the building. The lead-rubber isolators are attached with the foundation using steel plates. In case an earthquake happens, the isolator bearings allow the building to rock back and forth gently, moving only the foundation and not the rest of the structure. Sabiha Gokcen International Airport [43].

2.8.2. Sabiha Gokcen

It is one of the two international airports in Istanbul, Turkey, which is located near the North Anatolian fault. It was designed by the engineering firm Ove Arup to have 300 base isolator systems that can withstand up to a maximum of 8.0 Mw earthquake. The base isolators can reduce lateral seismic loadings by 80% which makes it one of the largest seismically isolated structure in the world [44].

2.8.3. Taipei 101, China

Taipei 101 in Xinyi District, Taipei, China is considered to be one of the tallest buildings in the world. The tower stands at 1,667 feet height with a tuned mass damper to prevent damage in the case of a natural disaster like typhoon or earthquake. An enormous mass is suspended by steel cables near the top of the structure, which works like a pendulum, moving back and forth in the direction opposite to the building to dissipate the energy. The gold ball weighing 730 tons, hanging with the Taipei 101 is one of the largest tuned mass dampers in the world [45].

2.8.4. Philippine Arena

The Philippine Arena is the world's largest domed arena and is the most amazing earthquake-proof structure. Philippine Arena's vast stadium roof, spanning 165m in the shortest direction, was engineered to withstand severe transient loadings such as earthquakes, winds, and typhoons. During an earthquake tremor, the lateral loads that generate throughout the structure can be up to 40% of its mass [46].

2.8.5. Burj Khalifa

The world's tallest building the Burj Kha lifa, located in Dubai, UAE rises to a height of 2,722 feet above the ground. The sky tearing skyscraper can stand earthquakes of magnitude 5.5 to 7.0 of the Richter scale. When an earthquake hit the area in 2008, the advanced engineering design of the building left Burj Khalifa unharmed [47].

2.8.6. The Yokohama Landmark Tower

ISituated in the Minato Mirai 21 district of Yokohama, Japan, the Yokohama Landmark Tower is the second tallest building in Japan with a height of 972 feet. The islands of Japan are one of the most earthquake prone areas on the planet. The Yokohama tower is placed on rollers, which prevent the skyscraper from shaking even when the earth below moves it. It is built with flexible materials that will cause the building to bend instead of breaking. A simple mass-damper system keeps the vibrations from causing any damage [48].

2.8.7. The Petronas Towers

Malaysia's Petronas Towers in Kualampur were the world's tallest building until 2004. The 452 meter high towers are built to resist earthquakes and stand to be the world's tallest twin towers. A two-story bridge connects the 41st and the 42nd floor of the towers which can slide in and out of the building to prevent the wind from putting loads on the building [47].

2.9. Case Studies

2.9.1. Marmara Earthquake, Turkey (1999)

Turkey is one of the most seismically active regions of the Europe with a long history of earthquakes that often occur with large progressive adjacent earthquake [49]. In the last century, 58 damaging earthquakes occurred in Turkey caused almost 1,00,000 casualties and more than 5.00.000 seriously damaged and collapsed housing units.

However, the Eastern Marmara Earthquakes (1999) have exceeded by far the other earthquake experiences in Turkey. The earthquake of August 17, 1999 having a magnitude of 7.4 and Golcuk as epicenter is one of the most destructive earthquakes in the history of Turkey. A total of 17,480 people died, and 43,953 people were injured. Almost 6,00,000 lost their home and many residential and commercial buildings were damaged to certain extent [50].

The most dramatic damage and greatest contributor to the disaster was the new residential building and the building between five and eight stories whereas the smaller and older houses performed quite well. The damages are attributed to bad subsoil [51]. Other causes of damage were inadequate quality of design, construction and building control. Additionally, the use of poor and inappropriate construction materials combined with sometimes poor workmanship added the problem.

The study reveals that the major factor for failure of building is low quality concrete fallowed by corrosion problem, service life end, bad concrete curing, and various architectural mistakes [52].

The Marmara earthquake of August 1999 demonstrated there were significant shortcomings in earthquake mitigation and preparedness measures. The 1997 Turkish Earthquake Resistant Design Code for Buildings, which is an adaptation of the Uniform Building Code in California, is sophisticated and strict; consequently, multistory buildings such as those which collapsed in the Marmara earthquake should all be highly earthquake resistant. However, the experience from Marmara earthquakes showed that they were not [53]. The main reason for this poor performance was the prevalent unsupervised construction. Moreover, between 1997 and 1999, less than 25% of all buildings in turkey conform to the update in Earthquake code in 1997 [54].

2.9.2. Nepal Bihar Earthquake, 1934

Nepal Bihar earthquake was the major earthquake to hit Nepal and India in 1934 AD. The magnitude of the earthquake was 8.4 on the Richter scale. Casualty figures were highest for any recorded earthquake in the history of Nepal. In total, 8519 people lost their lives in Nepal, a total of 1,26,355 houses were severely damaged and around 80,893 buildings were completely destroyed whereas in India it claimed 7188 people. In Nepal damage was destructive mainly in central Nepal including Kathmandu valley and eastern part [55].

2.9.3. Udayapur Earthquake, 1988

In August 20, 1988 after 54 years of the occurrence of the great Nepal Bihar earthquake, Nepal was hit by another earthquake of medium size of magnitude: 6.5 Richter scale with epicenter at Udaypur, 160 km southeast of Kathmandu. Damages were high in entire Eastern and part of the Central Development Regions. The epi-central intensity was found to be VIII MMI in Katari, Dharan and Dhankuta which suffered a higher order of damage. Structural damage and other effects were seen in intensity zone V11 and V1 also, there were 6 major aftershocks with magnitude greater than 4 Richter scale. The common ground effects that were observed are surface faulting and ground fissuring, landslides, liquefaction, lateral spreads, ground oscillation and sand boils [56].

The quake left 721 people dead and 6,553 people injured (1657 seriously injured and 4896 minor injured). The earthquake claimed 668 lives in Eastern Development Region and 53 in Central Development Region [57]. The earthquake left more than 460,000 persons homeless.

This earthquake showed that the current building construction practice was not strong enough to resist even moderate earthquakes. Consequently, it drew the attention of the government for the need of changes and improvement in current building construction practices in Nepal which led to the formation of National Building Code [58].

Human causalities will be approximately 40,000 deaths and 95,000 injuries (35). With rapid population growth and increased building construction trend, this figure could be much more in present scenario. Seismic geologist of Asia fear that Kathmandu Valley might face the similar situation as Haiti [58].

Most of the studies on Kathmandu valley are concentrated on the estimation of physical vulnerability. But there are other aspects of vulnerability, arising from various social, economic, and environmental factors. Vulnerability is the condition determined by physical, social, economic and environmental factors or processes, which increase the susceptibly of the community to impacts of hazards [59]. Examples may include poor design and construction of buildings, inadequate protection of assets, lack of public information and awareness, limited official recognition of risks and preparedness measures, and disregard for wise environmental management [10].

3. Conclusions

The study showed that the building in Kathmandu Metropolitan city are being vulnerable due to variations in design and drawings, financial crisis, administrative delays, political instability, insufficient monitoring and supervision. Likewise, many projects are not maintained through building codes and quality of building materials.

Thus the study would like to suggest that the owner should have clear vision of the proposed project, and should appoint efficient engineer for construction methodology and quality assurance of the project. Furthermore, limiting the political interference in construction regulation and making building code mandatory will ensure the systematic and strong building. Similarly, owner should keep on monitoring and controlling the project throughout the construction to maintain proper system of procurement and logistics. On the top most, the practice of constructing building by anyone with any design should to limited to certain parties to bring harmony in aesthetics and strength of building.

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