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Compliance Status of Nepal National Building Code (NBC: 105) within Pokhara Metropolitan City

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Abstract

Earthquake-induced structural failures globally emphasize the critical need for stringent building code compliance, particularly in seismically active regions like Nepal. This research evaluates the compliance status of Nepal National Building Code (NBC 105) in Pokhara Metropolitan City (PMC), following its 2022 revision post-Gorkha Earthquake (2015). Being Nepal's second-largest urban center with seismic zoning factor (Z) of 0.3 which is moderate in context of Nepal and have not experienced any major earthquake in recent decades, the study was necessary in the project area. The study aims to assess compliance during design and construction phases, identify barriers, and propose actionable solutions. A mixed-methods approach encompassing desk reviews, field surveys, and key informant interviews with 45 stakeholders was employed over nine months. Results revealed a meager 2.63% compliance during the design phase. These deficiencies compromise the seismic resilience of the 100,000+ buildings already constructed in PMC, raising significant safety concerns. The findings highlight that limited stakeholder awareness, insufficient technical training, economic constraints, and weak enforcement mechanisms are the primary barriers to adherence. Key recommendations include simplifying NBC provisions to enhance cost-effectiveness, implementing targeted capacity-building programs for engineers and contractors, and conducting public awareness campaigns to promote seismic safety. Additionally, retrofitting non-compliant structures and leveraging technology, such as Building Information Modeling (BIM) and remote sensing, for construction monitoring are vital steps forward. This study underscores the need for robust policy enforcement and strategic interventions to ensure seismic resilience in Nepal's urban development. By aligning safety with economic feasibility, these insights contribute to a sustainable and earthquake-resilient future.

Keywords: *Building code compliance, NBC 105, seismic resilience, urban development*

1. Introduction

Earthquakes, caused by abrupt movement between tectonic plates along fault lines, are among the most destructive natural disasters. Their impacts include ground shaking, soil liquefaction, landslides, avalanches, and tsunamis. Between 1998 and 2017, earthquakes were responsible for over 750,000 deaths globally, accounting for more than half of all-natural disaster-related fatalities, with 125 million people affected through injuries, displacement, or homelessness (WHO, 2017). The structural failure of buildings during earthquakes is often linked to the absence of stringent building codes and inadequate enforcement mechanisms (Usman, et al.,

2022). This underscores the critical need for robust seismic design standards and their effective implementation.

Nepal, situated at the tectonic junction of the Indian and Tibetan plates, is highly susceptible to large-magnitude earthquakes. Historical records since 1255 A.D. document 18 major earthquakes, including the catastrophic 1833, 1934, 1980, 1988 and 2015 events (Chaulagain, et al., 2018). These disasters have highlighted the need for seismic-resistant infrastructure. The development of Nepal's first National Building Code (NBC) began in 1993, followed by the enactment of the Building Act (2055 B.S.) and Regulations (2056 B.S.). To date, 23 NBC codes are in practice, ranging from NBC 000 to NBC 208, with NBC 105 specifically focusing on seismic design. However, despite these advancements, compliance remains a significant challenge (DUDBC, 2020).

Pokhara Metropolitan City (PMC), Nepal's second-most populous urban area (CBS, 2021), faces rapid urbanization. Over half a million residential structures in Nepal have suffered damage due to non-compliance with building codes, inadequate training, and the prevalent use of unskilled labor (Gautam, et al., 2016). Previous studies on seismic safety in Nepal primarily focus on structural aspects during the design phase or material strength during construction but lack insights into compliance with NBC standards. Department of Urban Development and Building Construction (DUDBC) being leading government entity for the formulation, monitoring and implementation of planning norms and building codes, initiated focusing at least a major city from each province and 10 municipalities from Kathmandu as a pilot project in improving NBC compliance. A baseline survey conducted by the DUDBC in collaboration with JICA on 200 under-construction buildings in Kathmandu highlighted the compliance rate with NBC. Figure 1 from this survey indicates that compliance was highest for column size (99%) but lowest for concrete sample testing (2%), with an average compliance rate of 55%. This baseline survey shows that compliance was particularly low in beam-column joints (22%), concrete mix ratio (6%), and concrete test piece sampling (2%). As part of this project from DUDBC, NBC implementation consultant was assigned to perform the task in Pokhara Metropolitan City (PMC) of Gandaki Province as well and this study was conducted during a nine-month engagement (Kartik 2079-Ashadh 2080).

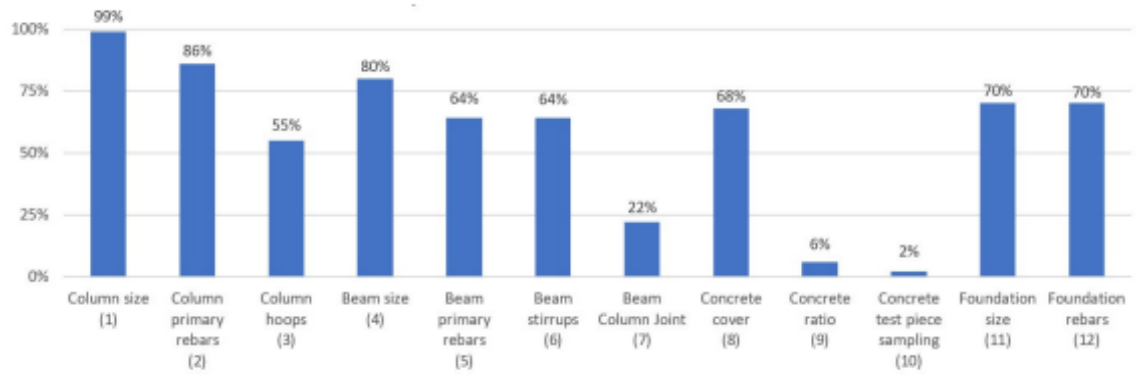

Figure 1: NBC compliance rate (NBCC Baseline Survey Report, 2022).

This study aims to evaluate the compliance status of NBC 105 within Pokhara Metropolitan City (PMC), focusing on both the design and construction phases. It seeks to analyze the current compliance rates, assess stakeholder familiarity with the code, and identify challenges that hinder adherence. Based on these findings, the study recommends measures to improve compliance and enhance seismic resilience. Ultimately, the insights gained are expected to

contribute to safer building practices in Pokhara and other regions, fostering a more robust approach to earthquake resistance.

2. Data and Methods

2.1 Study Area

Pokhara Metropolitan City, located at 28°12'30'' N and 83°59'20'' E with an elevation of approximately 822 meters in Kaski district, Gandaki, is the second most populous city in Nepal, after Kathmandu, with a population of 518,452 residing in 101,669 households (pokharamun, 2022). The city's humid sub-tropical climate, moderate temperatures, and adequate precipitation make it an ideal place to live. Since the 1990s, Pokhara has seen rapid urbanization, with service-sector industries increasingly contributing to the local economy, surpassing traditional agriculture. Additionally, the city is emerging as an education and healthcare hub for the Gandaki province.

Based on federal restructure of Nepal as per Constitution of Nepal-2072, PMC the largest metropolitan city in Nepal in terms of area covering (i.e. 464.2 k.m.^{2}) was established initially on 10th March 2017 AD as Pokhara Lekhnath Metropolitan City and later renamed as Pokhara Metropolitan City on August 8, 2018 (pokharamun, 2022). Regarding seismic hazard, Pokhara lies in a zone with a seismic zoning factor (Z) of 0.3, considered moderate in the context of Nepal. The site's sub-soil category is typically Type B or Type C (DUDBC, 2020). While the Gorkha earthquake of 2015 severely affected cities like Kathmandu, Lalitpur, Bhaktapur, and Bharatpur, Pokhara and the western part of Nepal experienced relatively less damage. This is not due to stronger buildings, but rather the direction of seismic waves, which were transmitted eastward from the epicenter, leaving the west relatively safe. However, this seismic zone has not released significant energy for an extended period, and there is potential for seismic waves to occur at any time in the future. With over 100,000 houses already built in the area and an annual construction rate of approximately 4,000 to 5,000 houses, it is critical to ensure that both new and existing buildings are designed to withstand seismic hazards.

2.2 Methodology

The technical approach and methodology were developed based on a thorough understanding of the study's scope and objectives, including anticipated challenges and their resolutions. Activities and detailed tasks were carefully formulated to ensure the achievement of the desired outputs. The research primarily employed qualitative methods, supplemented by limited quantitative data analysis. Ontological perspectives emphasized the significance of building codes in construction practices, highlighting their critical role in ensuring structural safety. Epistemologically, the study linked historical analysis, observations, and perceptions to identify issues, challenges, and opportunities in building code compliance. Axiologically, the researcher's values and beliefs underpinned a systematic, unbiased approach to constructing a clear understanding and generating scientific knowledge for effective code implementation. Methodologically, a combination of inductive and deductive reasoning within a qualitative framework was employed. This critical-interpretative-constructive paradigm ensured the alignment of research methods with the study's objectives (Joshi & Pokharel, 2022). The following approach and methodology were adopted to achieve the main objective and scope of work.

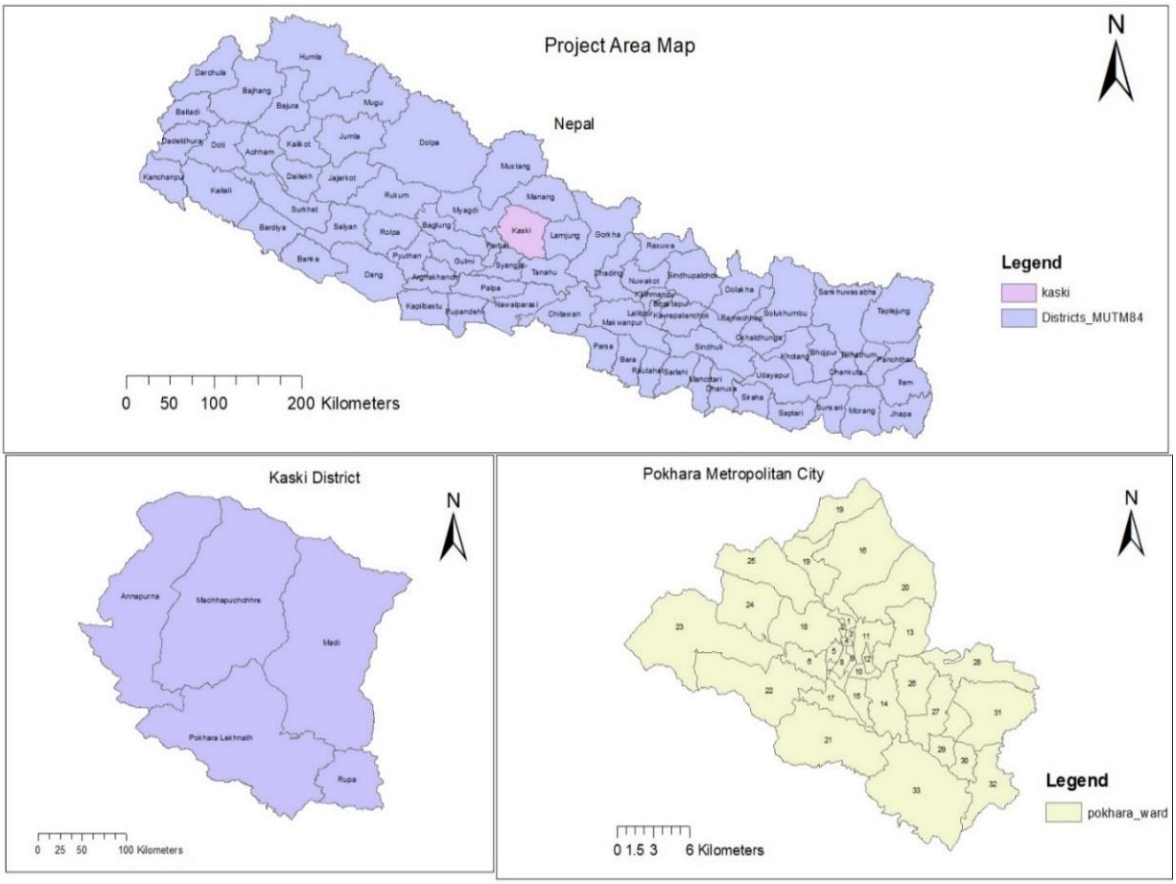

Figure 2: Study Area Map (Created using Arc-GIS).

Figure 3: Flowchart of Methodology.

2.2.1 Desk studies

During the study, the original, firsthand data from direct survey or question for this specific objective were collected as primary data along with the already published or collected and cleaned data as secondary data. The primary data including KII to the municipality officials, baseline study etc. were also collected. Secondary data were collected in the form of reports, articles, profiles, and maps to understand the study area, site location, and geological and environmental conditions. Relevant reports on past projects and policies were reviewed alongside existing legislation, regulations, and standards applicable in Nepal, including norms, specifications, guidelines, and codes. Key documents reviewed included municipal profiles, maps, national acts and regulations related to buildings, building codes, and national plans and policies. This comprehensive desk study provided the foundational knowledge necessary for evaluating NBC 105 compliance within the study area.

2.2.2 Survey/KII and Discussion with municipal authorities

Data for the study was collected through a combination of municipal records, ward office visits, and stakeholder engagement. Municipal authorities, as key stakeholders, provided official data and valuable insights into the study area's current state. Information on buildings with a plinth area greater than 1,000 square feet was extracted from the Electronic Building Permit System (EBPS) of the Metropolitan City Office, while data for smaller buildings with a plinth area less than 1,000 square feet were obtained during visits to all 33 ward offices. Key Informant Interviews (KIIs) were conducted with a total of 45 stakeholders, including one representative (Engineer, Sub-Engineer, or Ward Secretary) from each ward office and 5 officials from the Metropolitan City Office, such as the Chief Administrative Officer (CAO), the heads of the Urban Development and Infrastructure Division and Building Permit Section, the Administrative Officer of the Building Permit Section, and the IT Officer followed by 7 representative from consulting firm, designers and contractors. Checklists were developed based on the literature review and study objectives to guide data collection and discussions. These checklists covered aspects such as the base codes followed in building designs, the frequency of site visits by technical personnel, common faulty practices observed, and reasons for complexities in NBC non-compliance, public awareness campaigns, and suggestions for improvement. Building code compliance during construction was assessed using data from municipal and ward-level technical personnel, supervision consultants, direct site visits, and prior studies. Critical parameters influencing structural strength, such as beam and column size, concrete mix ratio and techniques, rebar size and bending, beam-column joints, lapping and hooks, foundation size and type, curing time, and methods, were systematically analyzed. This comprehensive approach ensured the inclusion of diverse perspectives and reliable insights into building code compliance in Pokhara Metropolitan City.

3. Results and Discussion

3.1 Present Status of Building Permit Process

Pokhara, as one of the pioneering cities in Nepal, has implemented the building permit process since 2036 B.S. The Pokhara Metropolitan City (PMC) has established the Earthquake Safety and Building Permit unit within the Urban Development and Building Construction Division, consisting of 17 staff members, as shown in Table 1.

Table 1: Manpower details of building permit unit in metropolitan office.

C**urrently working Manpower**	**Number**	**Remarks**
Senior Engineer	1	Unit head
Engineer	4	7th level
Sub- Engineer	5	7th level
Assistant sub-Engineer	1	7th level
Administrative officer	1	7th level
Administrative Assistant	3	4th level
Helper	2	

Source: PMC Building Permit Section,2079

The Earthquake Safety and Building Permit unit is present in all 33 wards of the city, each with a team authorized to issue permits for simple group 'C' buildings (i.e., buildings with a plinth area < 1000 sq. ft.). Table 2 summarizes the manpower allocation across these wards. Since 2073 B.S., the Electronic Building Permit System (EBPS) has been implemented. This system maintains records of building permits, including temporary and permanent permits, completion certificates, ownership details, land certificates, and engineering drawings, all in digital format. Although the system is effective, there is an ongoing need for more advanced management and storage software, with digitization efforts starting in fiscal year 2079/080.

Table 2: Manpower details of building permit unit in different ward office.

C**urrently working manpower**	**Number**	**Remarks**
Engineer	1	In all 33 wards
Sub- Engineer	1 or 2	In all 33 wards
Administrative officer	1	In all 33 wards
Administrative Assistant	1	In all 33 wards
Amin	1	In all 33 wards

Source: Building Permit Section of PMC, 2079

3.2 Building Permit and Construction Completion Rate in Last Few Years

An analysis of the provided data from the PMC and various ward offices reveals a significant decline in building construction during the Covid pandemic. Before the pandemic, approximately 5,000 houses were constructed annually, but this number has decreased to around 2,000-3,000 houses per year (PMC, 2021). Despite this, the urbanization rate in Pokhara remains high, and the building permit process is smooth, with the construction completion rate nearly equal to the number of temporary permits issued, suggesting efficient and timely services. The recent building construction registration and completion trend also suggest the rate of type c building i.e. plinth area <1000 Sq. ft. are increasing whereas the type A and B building's are continuously goes on decreasing which may be due to financial crisis after the covid and the subconcious fear of Gorkha earthquake-2015.

3.3 Implementation of NBC: 105 in Building Permit Process

Buildings taller than 17 meters or those with more than five stories are classified as high-rise buildings (PMC, 2075). These buildings must adhere to NBC 105 regulations for design. Other buildings follow NBC guidelines for architecture, but use IS codes for seismic design, as outlined in Table 3.

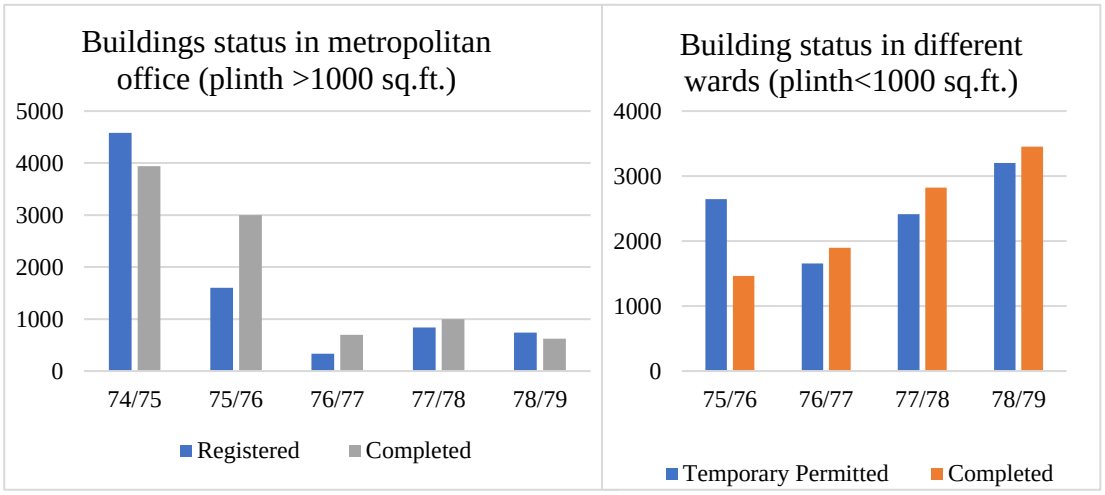

Figure 4: Building Permit Details of Building from Metropolitan City Office and Ward Offices (i- Category A and B, ii- Category C).

Table 3: Type of Codes followed in different Building Design.

S.N.	Type of building	Permission from	Code followed in design
1	Small building having plinth area<1000 sq. ft. (MRT)	Ward office	NBC (101,201,205,202)
2	Any type of building having plinth area >1000 sq. ft.	Metropolitan office	All NBC codes and IS codes (for seismic design)
3	High rise building (Ht. > 17m. or 5 storey)	Metropolitan office after approval of technical committee	All NBC codes

Data from the fiscal year 2078/079 as per building permit section's record in PMC reveals that only 2.63% of buildings followed NBC 105:2020, while 15.6% adhered to IS codes, and the remaining 81.76% followed MRT standards. The primary reasons for the low compliance with NBC 105 include lack of public awareness about seismic hazards and the economic benefits of

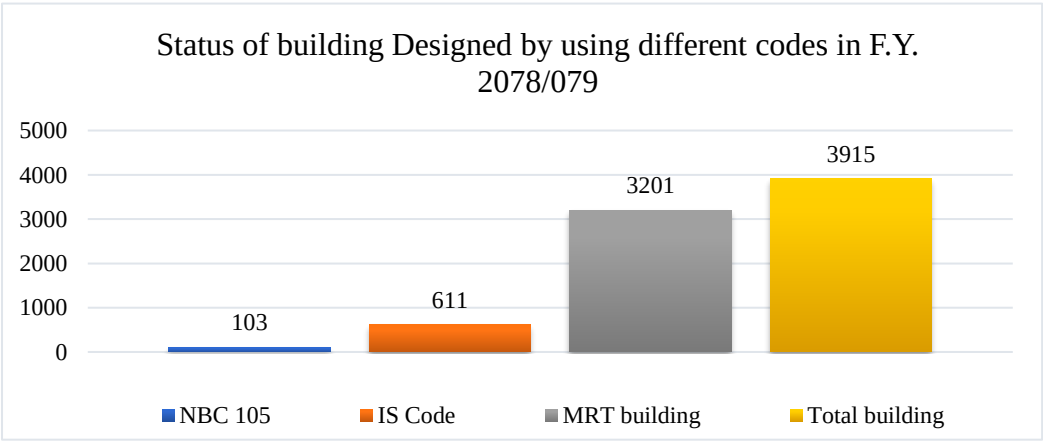

Figure 5: NBC and other codes compliance status.

IS designs, as noted in clauses 4.2.1 and 4.4.2 of NBC 105 (2020), which require larger cross-section for structural elements. Proper seismic design alone does not ensure structural safety during an earthquake. Quality materials and skilled labor are critical, as is continuous

supervision throughout construction. Although high-rise buildings in PMC follow NBC 105, construction and supervision of such buildings have been suboptimal.

In PMC, a similar to Kathmandu trend as shown in Figure 1 was observed during site visits and compliance checks. Based on the answer from technical person within the metropolitan city who had carried out the construction supervision and site verification, the construction time compliance has ranked on the following order.

Table 4: Ranking of Construction time compliance.

S.N.	Parameters observed during site visit	Rank based on issues in compliance
1	Sample Testing	1
2	Concrete mix ratio	2
3	Beam-Column joint	3
4	Stirrups hook/bending and rebar's spacing	4
5	Clear cover	5

Construction time compliance was mainly analyzed based on the answer related to site visit experience of municipal technical persons and few building construction sites visited by the researcher. Low NBC compliance during construction is largely attributed to insufficient training for municipal engineers, designers, contractors, and masons, compounded by poor supervision from consultants and municipality engineers. Dedicated technical manpower for the building supervision in the municipality, technical skill development training, use of remote sensing technology for the continuous monitoring during construction phase and advance building information modeling (BIM) integrated EBPS system could really be beneficial in the compliance of building code and enhance of seismic safety within PMC. With over 100,000 buildings already constructed in PMC, there is uncertainty regarding the seismic safety of these structures when an earthquake hits Pokhara.

4. Conclusions

The evaluation of compliance with Nepal National Building Code (NBC 105) in Pokhara Metropolitan City (PMC) reveals significant gaps in adherence, threatening the seismic safety of this rapidly urbanizing region. Despite PMC's pioneering efforts in implementing a building permit system since 2036 B.S., only 2.63% of buildings adhered to NBC 105 standards during the design phase. Specific areas of concern during construction phase include concrete sample testing, beam-column joint detailing, concrete mix ratio, rebars spacing and stirrups hook/bending and clear cover. These deficiencies are largely attributed to limited awareness among stakeholders, insufficient training for municipal engineers and contractors, economic disincentives due to the high cost of compliance, and inadequate supervision mechanisms. Over 100,000 buildings constructed in PMC, combined with an annual construction rate of 4,000-5,000 houses, exacerbate concerns about the region's seismic vulnerability. To address these challenges, simplifying NBC provisions for cost-effectiveness is essential, alongside capacity-building initiatives targeting municipal engineers, designers, and contractors. Internationally, it has been observed that many of the challenges related to building code compliance can be minimized through proactive measures such as training, raising awareness, and providing technical support to code users (Nwadike & Wilkinson, 2020). Additionally, leveraging technologies such as Building Information Modeling (BIM) and remote sensing for continuous construction monitoring could enhance compliance rates. Retrofitting non-compliant existing structures must be prioritized to mitigate risks. The findings of this study underscore the critical

need for robust enforcement of NBC standards and proactive measures to foster a culture of compliance. These strategies are essential not only for safeguarding life and property in PMC but also for setting a precedent in achieving seismic resilience across Nepal.

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