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THESIS NO.: 080/MsCoM/001

A Comparative Study of Facade Guideline Compliance and Construction Management Issues in Residential Buildings within Heritage Zones of Bhaktapur and Patan

By

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A THESIS

SUBMITTED TO THE DEPARTMENT OF CIVIL ENGINEERING

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER IN CONSTRUCTION MANAGEMENT

DEPARTMENT OF CIVIL ENGINEERING

LALITPUR, NEPAL

APRIL, 2026

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I hereby declare that the thesis entitled "**A Comparative Study of Facade Guideline Compliance and Construction Management Issues in Residential Buildings within Heritage Zones of Bhaktapur and Patan**", submitted to the Department of Civil Engineering in partial fulfillment of the requirement for the degree of Master of Science in Construction Management, is a record of work done under the supervision of Assoc. Prof. Nagendra Bahadur Amatya and Er. Subash Kumar Bhattarai, Institute of Engineering, Pulchowk Campus. The thesis contains only my own work except for the consulted material, which has been duly referenced and acknowledged.

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ABSTRACT

Bhaktapur and Patan are historic cities within the Kathmandu Valley World Heritage Site, recognized for their traditional Newari residential architecture. Both municipalities and the Department of Archaeology have issued building guidelines regulating visible facade elements including wall materials, windows, doors, and roofs. The extent to which individual residential buildings comply with these guidelines has not been systematically examined, and no field-based comparative study between the two cities has been previously reported.

This study reviews applicable facade guidelines, compares compliance levels between the two cities, and identifies the construction management issues underlying non-compliance. A total of 80 residential buildings were assessed through structured visual observation 40 in each city using a 20-parameter checklist derived from the Bhaktapur Municipality Building Bylaws, the Patan Heritage Zone Building Regulations, and the Department of Archaeology guidelines. Patan buildings performed better overall, with a mean compliance score of 84.6% against 78.9% in Bhaktapur. In Patan, 70% of buildings were fully compliant, compared to 52.5% in Bhaktapur.

The most common violations in both cities were metal rolling shutters, flat concrete rooftops, and excess storey construction. These failures reflect shared construction management challenges: high cost of traditional materials, limited availability of skilled craftsmen, post-earthquake preference for flat RCC structures, and persistent demand for additional living and rental space. Chi-square analysis confirmed that the violation rates for these three elements are not statistically significantly different between the two cities (all $p > 0.05$), indicating that these are shared barriers driven by common economic pressures rather than city-specific factors. Addressing these barriers through targeted economic incentives, material subsidies, and coordinated enforcement is essential if facade guideline compliance is to become the practical default in both heritage zones.

Keywords: Facade Compliance, Bhaktapur, Patan, Building Guidelines, Heritage Construction Management

ACKNOWLEDGEMENTS

First and foremost, I would like to express my sincere gratitude to my thesis supervisors, Assoc. Prof. Nagendra Bahadur Amatya and Er. Subash Kumar Bhattarai for the guidance, constructive feedback, and continuous encouragement provided throughout this study. I am also deeply thankful to Asst. Professor Mahendra Raj Dhital, the Program Coordinator, for the support and for providing the opportunity to pursue this thesis as part of the Master of Science in Construction Management program at IOE, Pulchowk Campus.

I am grateful to Bishwanath Sujakhu, Architect, Bhaktapur Municipality and Barsha Shrestha, Architect, Lalitpur Metropolitan City for generously sharing their practical insights on heritage construction management during the field survey period. Their perspectives provided valuable contextual understanding that enriched the findings of this study. I am also grateful to the Bhaktapur Municipality and Lalitpur Metropolitan City for providing access to relevant regulatory documents and building bylaw materials. I extend my thanks to the Department of Archaeology for making heritage zone guidelines available for review. My appreciation also goes to the residents, building owners, and local community members of Bhaktapur and Patan whose buildings formed the basis of this field study, and who welcomed observations with patience and hospitality.

I would also like to acknowledge the support of my colleagues and fellow students in the MSc Construction Management program, whose discussions and encouragement were a constant source of motivation throughout the course of this research.

Finally, I express my heartfelt gratitude to my family for their unwavering support, patience, and belief in me throughout this journey. This work would not have been possible without their encouragement.

Aashish Koirala

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LIST OF ABBREVIATIONS

BS	Bikram Sambat (Nepali Calendar)
BKT	Bhaktapur
DoA	Department of Archaeology
FAR	Floor Area Ratio
GF	Ground Floor
GPS	Global Positioning System
WDS	World Geodetic System
IOE	Institute of Engineering
KVTDC	Kathmandu Valley Town Development Committee
LMC	Lalitpur Metropolitan City
MSc	Master of Science
NRA	National Reconstruction Authority
PTN	Patan
RCC	Reinforced Cement Concrete
TU	Tribhuvan University
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHS	World Heritage Site

CHAPTER ONE: INTRODUCTION

1.1 Background

The Kathmandu Valley was inscribed as a UNESCO World Heritage Site in 1979, recognized for the outstanding universal value of its historic cities - Kathmandu, Bhaktapur, and Patan. Among these, Bhaktapur and Patan stand out as two of the most intact examples of traditional Newari urban settlement in South Asia. Their significance rests not only on the famous temples and palace complexes that draw international visitors, but equally on the continuous fabric of residential buildings that line every street and courtyard. It is this everyday built environment - rows of brick houses with carved wooden windows, projecting eaves, raised plinths, and clay-tiled roofs - that gives these cities their distinctive visual identity and sustains their living heritage character (Bonapace & Sestini, 2003); (Silva, 2017)

Traditional Newari residential architecture evolved over many centuries through the accumulated knowledge and skill of local craftsmen. Buildings were typically three to four storeys in height, constructed with brick masonry laid in mud mortar, and finished with exposed brickwork left unplastered on the exterior. Carved wooden windows in odd-paneled configurations were placed in vertical alignment across all floors. Wooden struts braced projecting roof eaves, and the roofs themselves were covered with traditional double-fired clay tiles, locally known as *Jhingati*. Horizontal cornice bands separated each storey and aligned continuously across adjacent buildings, maintaining the visual coherence of the streetscape. Together, these elements were not simply aesthetic features; they were the visible expression of a deeply rooted construction culture shaped by locally available materials, climatic conditions, craft tradition, and social organization (Suwal, 2021); (Bhattarai & Shrestha, 2024)

Bhaktapur, located approximately 14 kilometers east of Kathmandu, was the political center of the Malla dynasty from the twelfth to the eighteenth centuries. It is recognized under the World Heritage criteria as a testimony to the Newar cultural tradition, manifested in its exceptional architectural typologies, urban fabric, and craftsmanship of brick, timber, and bronze. (Silva, 2017) Patan, historically known as Lalitpur, flourished during the same Malla period, which is widely regarded as the golden era of architectural development in the Kathmandu Valley. Both cities contain a high concentration of palatial, religious, and vernacular residential architecture within a

well-preserved urban setting, and together they form two of the seven monument zones that constitute the Kathmandu Valley World Heritage Site (UNESCO World Heritage Committee, 1997).

To preserve the traditional architectural character of these areas in the face of growing urbanization and modernization pressures, both the Bhaktapur Municipality and the Lalitpur Metropolitan City have issued formal building guidelines for their respective heritage zones. The Department of Archaeology has additionally issued guidelines specifically for the monument protection zones surrounding the Durbar Squares in both cities. These regulations specify, in considerable detail, what residential buildings within heritage areas should look like from the outside - which materials are required on walls, what type and style of windows and doors are permitted, what the roof must consist of, how many floors a building may have, and how modern service installations such as water tanks, air conditioning units, and satellite dishes must be concealed from public view. In this way, the guidelines serve as a regulatory framework designed to guide both new construction and the renovation of existing buildings within designated heritage zones.

Despite the existence of these guidelines, their implementation in practice has been inconsistent. Rapid urbanization, changing lifestyles, the high cost of traditional materials, the scarcity of craftsmen skilled in traditional construction techniques, and limited enforcement capacity have all contributed to a situation where modern elements increasingly appear on heritage residential facades. Aluminium window frames replace carved timber. Metal rolling shutters cover what should be traditional wooden doorways. Flat concrete rooftops replace clay tile roofs. Painted or cement-plastered walls replace exposed brick. Each of these changes, individually or collectively, alters the visual character that the guidelines were designed to protect (Shrestha, 2021); (Maharjan, 2019).

Bhaktapur and Patan, while sharing the same broad architectural tradition and both forming part of the same World Heritage Site, are governed by different municipalities, operate under partially different regulatory frameworks, and have distinct histories of conservation effort. Bhaktapur is widely regarded as having a more intact traditional urban fabric, shaped in part by the Bhaktapur Development Project supported by German development cooperation between 1974 and 1983, which introduced formal conservation standards and material controls. Patan, governed by Lalitpur Metropolitan

City, operates within a more layered regulatory environment involving overlapping jurisdiction between the municipality, the Kathmandu Valley Town Development Committee, and the Department of Archaeology. Whether these institutional differences translate into measurable differences in facade guideline compliance has not previously been examined through a systematic, field-based comparative study.

1.2 Problem Statement

The facade guidelines for the heritage zones of Bhaktapur and Patan are legally backed, publicly available, and integrated into the building approval process of both municipalities. Yet observation of residential streetscapes in both cities reveals widespread non-compliance: flat concrete rooftops beside traditional tiled houses, metal rolling shutters where wooden doors are required, additional storeys above the permitted limit, and cement-plastered walls alongside exposed brick. This gap is not merely aesthetic. UNESCO periodic monitoring reports have repeatedly identified unauthorized construction and failure to enforce building regulations as among the most serious threats to the integrity and authenticity of the Kathmandu Valley World Heritage Site (UNESCO World Heritage Committee, 1997); (Subedi & Shrestha, 2023) and continued non-compliance in the residential building stock - which forms the majority of the built fabric of both heritage zones - directly undermines the values for which the site was inscribed.

Despite this, the actual state of compliance in the residential buildings of both cities has not been systematically measured. Existing research has focused primarily on policy and institutional dimensions of heritage management, post-earthquake reconstruction, and typological analysis of traditional facades, without producing a field-based comparative compliance assessment. Equally, the construction management reasons behind non-compliance - including the high cost of traditional materials and the scarcity of skilled craftsmen - have received limited systematic attention outside the post-earthquake context. A structured field-based study that measures compliance and links observed violations to the construction management challenges shaping owner decisions is needed to inform targeted and practical interventions.

1.3 Research Questions

The three objectives are addressed through the following research questions:

1. What are the key facade-related guidelines applicable to residential buildings in the heritage zones of Bhaktapur and Patan?

2. How does the level of facade guideline compliance in residential buildings compare between Bhaktapur and Patan?

3. What are the differences in construction management issues affecting facade guideline implementation in the two study areas, as visible in the building facades?

1.4 Research Objectives

The primary objective of this study is to compare Facade Guideline Compliance and Construction Management Issues in Residential Buildings within Heritage Zones of Bhaktapur and Patan. Whereas, secondary objectives are:

1. To review and identify the key facade-related guidelines applicable to residential buildings in the heritage zones of Bhaktapur and Patan.

2. To compare the level of compliance of residential building facades with the identified guidelines between Bhaktapur and Patan.

3. To compare the construction management issues reflected in residential building facades in the two study areas.

1.5 Significance of Study

This study makes several contributions to knowledge and practice in heritage conservation management and construction management in the Kathmandu Valley. First, it provides the first systematic, field-based comparative assessment of facade guideline compliance in residential buildings across two heritage cities of the Kathmandu Valley World Heritage Site. The evidence base it generates fills a significant gap in the literature and provides municipal authorities and heritage managers with specific, building-level data on the state of compliance in the residential heritage stock.

Second, the compliance checklist developed in this study is an original instrument derived directly from the applicable guidelines. It provides a replicable and transparent

methodology for monitoring compliance that can be adopted and expanded by municipal authorities in future monitoring programmes.

Third, the study's comparative design allows it to identify not only the overall state of compliance in each city, but also the specific facade elements that are consistently well-preserved or consistently violated across both cities. This element-level analysis is directly actionable for policy: it allows heritage managers to focus enforcement and incentive efforts on the specific elements where non-compliance is most widespread, rather than addressing the problem in general terms.

Finally, the study situates its compliance findings within the construction management context, linking the pattern of violations to the economic and practical challenges that building owners face. This connection between compliance assessment and construction management analysis makes the study relevant not only to heritage conservation professionals but also to construction managers, municipal planners, and policymakers working on building regulation in heritage areas.

1.6 Scope and Limitations

This study is limited to the heritage zones of Bhaktapur and Patan and does not extend to other parts of the Kathmandu Valley, including the Kathmandu city heritage area. Institutional, religious, and heritage monument buildings are excluded.

The assessment method is limited to structured visual observation of street-facing facades from public streets and courtyards. No building was entered. Rear facades and interior conditions were not assessed. The study relies primarily on field observation and photographic documentation, without detailed structural or material testing. Interaction with building owners, builders, and municipal officials was limited to brief informal conversations used only for contextual background, and not as a primary data source. The sample of 80 buildings represents only a portion of the total residential building stock in both heritage zones and may not capture the full range of conditions present across all neighborhoods.

CHAPTER TWO: LITERATURE REVIEW

2.1 Traditional Newari Residential Architecture

The traditional residential architecture of the Newari communities of the Kathmandu Valley represents one of the most coherent and distinctive urban building traditions in South Asia. (Bonapace & Sestini, 2003) provide the most comprehensive technical documentation of the materials and construction technologies used in Kathmandu Valley buildings, establishing that the principal characteristics of traditional Newari residential construction are the use of handmade fired brick (dachhi appa) laid with silay mortar on external walls, exposed without plaster or paint; carved wooden windows in traditional styles including the multi-paneled Tikijhya and the circular Aakhyi Jhyal; wooden door frames with carved surrounds; inclined wooden struts (Tundal) bracing projecting roof eaves; and double-pitched roofs covered with double-fired clay tiles (Jhingati). These elements are not stylistic choices but the product of centuries of accumulated craft knowledge applied to the local materials, climate, and social structure of Newari urban communities.

Detailed documentation of the construction technology and functional organization of traditional Newari residential buildings in Bhaktapur is provided by (Suwal, 2014) (Suwal, 2021) , through which it is described how the vertical distribution of space in a traditional Newari house is shaped by a specific social and religious ordering of domestic life - with storage and animal keeping assigned to the ground floor, living and working spaces accommodated on the intermediate floors, and religious and sleeping spaces reserved for the upper floors. The building's height - typically three to four storeys including the attic (buigal) - and its horizontal alignment with neighbouring buildings through continuous cornice bands and aligned window positions are not accidental features but deeply embedded conventions of the urban building tradition. (Bhattarai & Shrestha, 2024) further document how traditional Newari architectural principles reflect a sophisticated integration of cultural values, climatic responsiveness, and craft tradition.

Important typological analyses of the facade design of traditional townhouses in Bhaktapur and other Newari cities are contributed by (Yamamoto, et al., 2016) (Yamamoto, et al., 2019) and (Korn, 2023). Through these studies, it is established that the visual character of Newari residential facades is defined by a consistent grammar

of facade elements - window type, paneling, and positioning; eave projection and strut type; roof form and tile material; plinth height; and cornice alignment — and that significant typological variation is found to exist within this grammar, reflecting differences in building age, status, and location within the urban fabric. (Korn, 2023) specifically examines the relationship between original facade design and subsequent extension and reconstruction, documenting how the process of vertical extension and horizontal modification over time has altered the typological consistency of many streetscapes. These typological studies establish the methodological foundation for the present study's visual assessment approach.

2.2 Regulatory Framework for Heritage Zones

The regulatory framework governing building construction in the heritage zones of Bhaktapur and Patan is complex, layered, and involves multiple overlapping jurisdictions. (Subedi & Shrestha, 2023) provide the most recent comprehensive review of the existing policy framework for the conservation and management of cultural heritage in the Kathmandu Valley, identifying four principal levels of regulation: the Building Act, 2055 BS; the Kathmandu Valley Town Development Committee (KVTDC) Basic Building Construction Standards, 2072 BS; the individual municipality building bylaws; and the Department of Archaeology (DoA) guidelines for the monument protection zones surrounding the Durbar Squares, which impose the most stringent heritage-specific requirements.

The specific provisions of these regulatory instruments in the context of private house conservation in the three Durbar Square areas of the Kathmandu Valley are examined by (Maharjan, 2019), through which the key requirements for facade materials, window and door design, roof form, storey count, and the treatment of modern service installations are identified. Maharjan notes that the multiple overlapping jurisdictions create practical confusion for building owners and contractors, who may be subject to different and sometimes inconsistent requirements from the municipality and the DoA for the same building. This institutional complexity is identified as a contributing factor to non-compliance, alongside the more fundamental economic and practical barriers.

The Heritage Homeowner's Preservation Handbook for the Kathmandu Valley World Heritage Site was produced by (Ranjitkar, 2006) as a practical guide for building owners, through which the requirements of the heritage zone regulations and the means

of complying with them are explained. This handbook remains the most accessible practical guidance available to heritage zone residents, but its age - published two decades ago - means that it predates both the revised bylaws of 2072 BS and the post-earthquake reconstruction regulations, and may not reflect the current regulatory requirements in all respects.

2.3 Facade Typology and Visual Assessment

The use of structured visual observation as a method for assessing the characteristics of built heritage facades is well-established in the Kathmandu Valley context. The typological studies of (Yamamoto, et al., 2019) and (Korn, 2023) demonstrate that systematic visual classification of facade elements provides reliable and replicable data on the design characteristics of Newari residential buildings at the streetscape scale. These studies use photographic documentation combined with structured element-by-element analysis to classify facade types and track changes over time, establishing a methodological template that the present study adapts for compliance assessment purposes.

A similar visual assessment approach is applied by (Bajracharya, et al., 2025) in their study of residential building use in the historic buffer zone of Nagbahal, Patan, through which the relationship between the physical condition and use patterns of heritage buildings in a specific residential courtyard complex and heritage management outcome is examined. This study provides both a methodological reference and substantive findings relevant to the Patan context of the present study, including the observation that heritage buildings in Patan's buffer zone remain more resilient where community ties and active economic use support ongoing maintenance.

2.4 Heritage Conservation Challenges in the Kathmandu Valley

The literature on heritage conservation challenges in the Kathmandu Valley converges on a common set of findings. Rapid urbanization, population growth, and economic development create persistent pressure for densification and modernization of the building stock within heritage zones. (Silva, 2017) provides a comprehensive analysis of heritage values and conservation practices in Bhaktapur, documenting how the city's conservation history - including the Bhaktapur Development Project of the 1970s and 1980s - has shaped current institutional arrangements and conservation capacity. Silva notes that Bhaktapur's reputation for relatively strong conservation enforcement is real

but partial: the core areas around the three Durbar Squares tend to be well-maintained, while peripheral streets and outer residential areas show more pronounced modernization.

What is termed the conflict in the World Heritage Sites of the Kathmandu Valley between conservation objectives and the practical needs and preferences of private building owners is examined by (Maharjan, 2019). Maharjan finds that non-compliance with heritage building regulations in all three Durbar Square areas is primarily driven by rational economic and practical decisions rather than principled opposition to conservation: building owners choose modern materials because they are cheaper, easier to maintain, and more functionally convenient, and choose to add storeys because the economic return from additional floor space outweighs the deterrent effect of enforcement.

2.5 Post-Earthquake Reconstruction and Compliance

The 2015 Gorkha earthquake and its aftershocks caused severe damage to the built heritage of the Kathmandu Valley, destroying or damaging thousands of residential buildings in the heritage zones of Bhaktapur and Patan. The subsequent reconstruction process has been extensively documented and provides important context for understanding the current state of facade compliance in both cities.

The community-led post-earthquake heritage reconstruction process in Patan is documented by (Shrestha, 2021), through which the cost differential between traditional and modern construction - estimated at approximately twice the cost of modern RCC construction for full traditional heritage buildings - is identified as the most fundamental practical barrier to compliance. Many building owners who wished to rebuild traditionally were unable to do so without financial support, and those who rebuilt without support typically chose modern construction methods that were cheaper and faster.

A detailed analysis of the reconstruction process in Bhaktapur specifically is provided by (Suji, et al., 2021), through which it is documented how widespread non-compliance with Bhaktapur's heritage bylaws during reconstruction was led to by the combination of limited financial incentives for traditional construction, the availability of low-interest loans from banks for modern RCC construction, and the activities of contractors who promoted RCC construction. Suji et al. also documents how building owners

deliberately sought additional storeys during reconstruction, treating the need to rebuild as an opportunity to expand living and rental space beyond the permitted limit.

2.6 Literature Gaps

The review of existing literature reveals several important limitations and gaps. First, while the policy and institutional dimensions of heritage conservation in the Kathmandu Valley have been relatively well studied, there is a striking absence of field-based research that assesses the actual compliance of individual residential buildings with applicable facade guidelines. Most studies are qualitative analyses of policy frameworks, institutional conflicts, or post-earthquake reconstruction processes.

Second, the existing literature has not adequately explored how visually observable facade elements can be used as direct indicators of guideline compliance. The facade typology work of (Yamamoto, et al., 2016) and (Korn, 2023) established that visual observation is a rigorous method for studying Newari building facades, but this methodological insight has not been applied explicitly to the question of compliance assessment. The present study addresses this gap by developing a structured compliance checklist directly from the guideline provisions, and by using this checklist as the primary instrument for measuring compliance across a sample of 80 buildings.

Third, there is a lack of comparative research examining whether compliance patterns and construction management challenges differ between Bhaktapur and Patan. The two cities share the same architectural tradition and are both subject to heritage zone regulations, but they are governed by different municipalities, have different histories of conservation enforcement, and operate within different institutional environments. This study addresses that gap directly by conducting a balanced comparative assessment of 40 buildings in each city.

Finally, the existing literature has given limited attention to the practical construction management challenges - particularly cost-related barriers - that influence compliance at the individual building level under non-emergency conditions. The present study contributes to filling this gap by recording observable construction management issues in field assessments and linking them to the pattern of compliance and non-compliance across the two study areas.

CHAPTER THREE: METHODOLOGY

3.1 Research Approach and Design

This study adopts a descriptive, comparative, and inferential research approach, combining qualitative and quantitative methods to address its three objectives. The qualitative component involves a systematic document review of facade-related guidelines applicable to residential buildings in the heritage zones of Bhaktapur and Patan, from which the key regulatory parameters are identified and compared. The quantitative component involves a structured visual field assessment of 80 residential buildings - 40 in each city - using a compliance checklist derived from the guideline review. The results are analysed using descriptive statistics, comparative analysis, and chi-square tests of independence to identify patterns of compliance and non-compliance across both cities and at the level of individual facade parameters.

The descriptive and comparative approach is appropriate for this study because the primary aim is to systematically describe and compare the state of facade guideline compliance in two heritage cities. Descriptive statistics - including mean, median, standard deviation, frequency, and percentage - are used to summarize compliance scores and element-level compliance rates for each city. Comparative analysis is used to examine differences between Bhaktapur and Patan at both the overall and element level. Chi-square tests of independence are additionally applied to determine whether the observed differences in facade physical condition and in the violation rates of the three most violated elements are statistically significant, or whether they could reasonably be attributed to chance given the sample size. A significance level of $\alpha = 0.05$ is applied throughout. Figure 1 presents the overall research methodology as a flowchart.

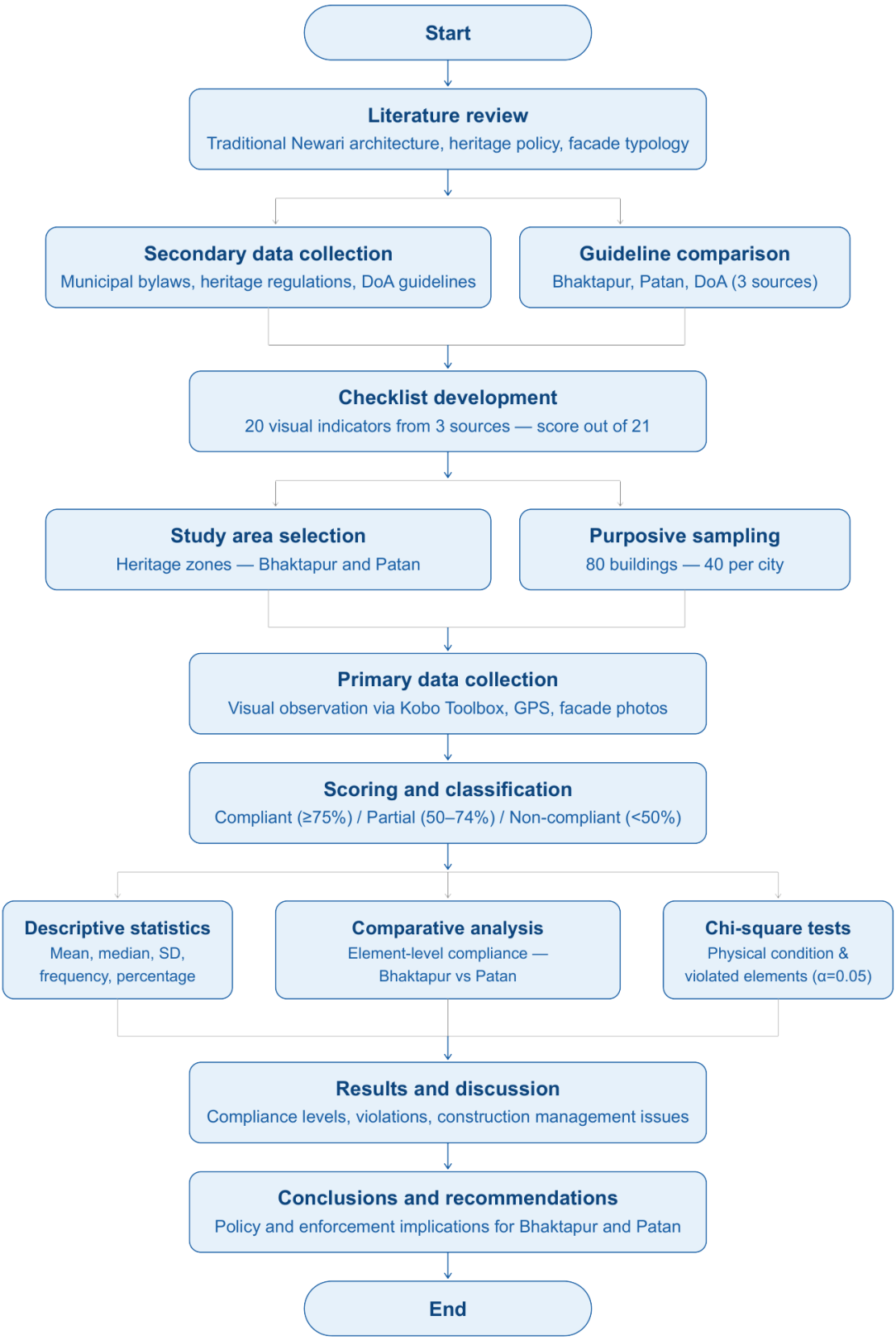


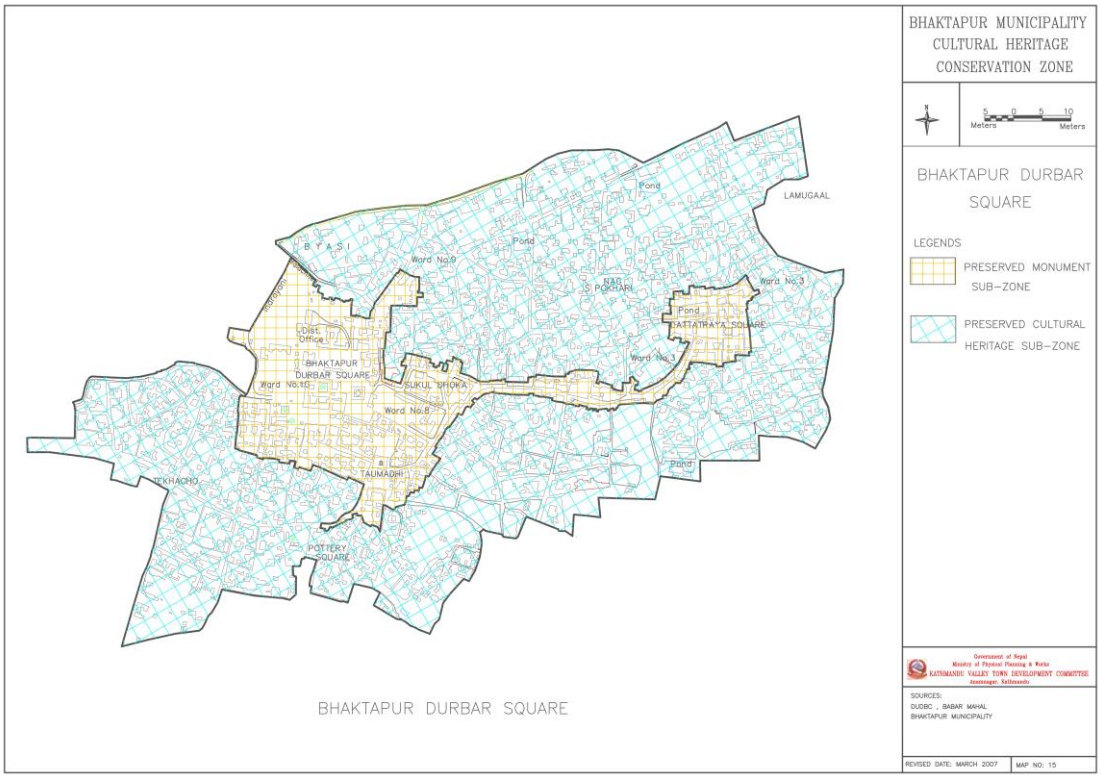
Figure 1 Flowchart of Research Methodology

3.2 Study Area

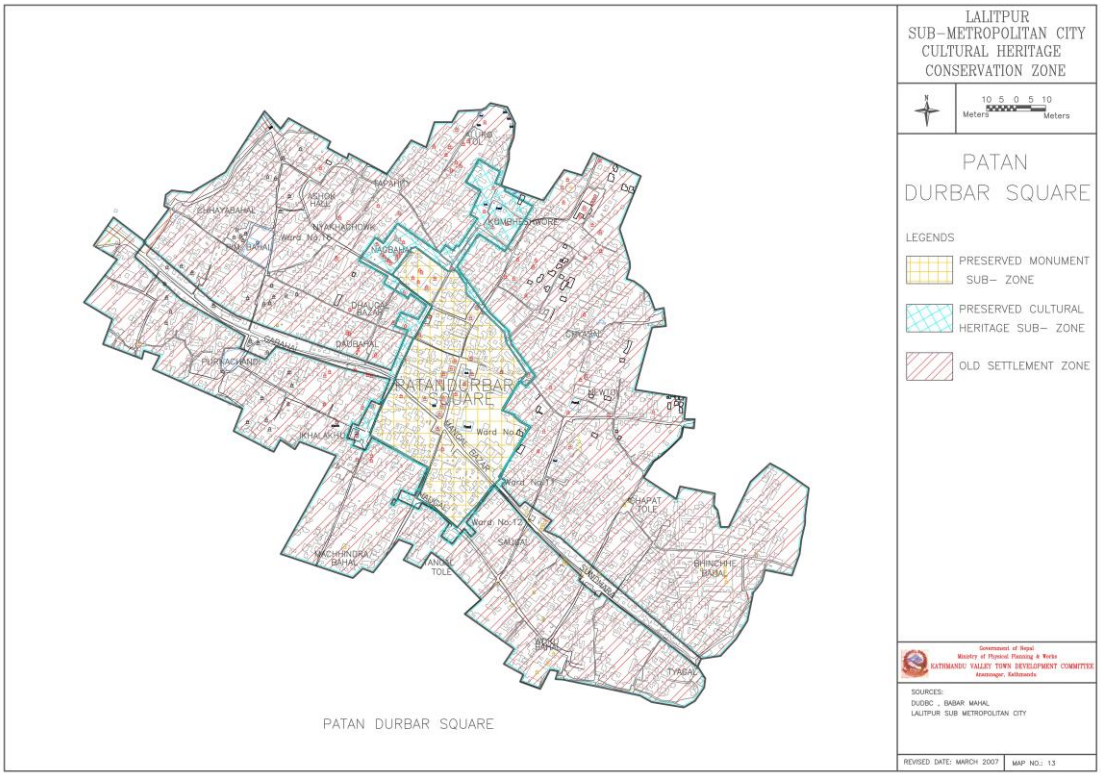
The study is conducted in the heritage zones of Bhaktapur and Patan, both of which form part of the Kathmandu Valley World Heritage Site. The two cities are located in Bagmati Province of Nepal, approximately 14 kilometers apart. Bhaktapur is governed by Bhaktapur Municipality and its heritage zone centers on the three interlinked public squares of Durbar, Taumadhi, and Dattatreya, connected by traditional streets and surrounded by residential neighborhoods of considerable architectural and historical significance. Patan, governed by Lalitpur Metropolitan City, contains the Patan Durbar Square monument zone and a surrounding residential heritage area that was formally demarcated as a buffer zone by the Department of Archaeology in 2006 following UNESCO requirements.

Within each city, the study areas include traditional residential clusters with heritage significance, comprising streets and courtyards where a substantial proportion of the building stock consists of traditional Newari residential construction. In Bhaktapur, sample buildings were selected from residential streets in and around the core heritage zone. In Patan, sample buildings were selected from residential streets within and immediately adjacent to the monument protection zone, including areas around Patan Heritage zones. Figure 3 shows the location of the two study areas within the Kathmandu Valley.

The heritage zone boundaries that define the study area are those formally gazetted by the respective regulatory authorities. In Bhaktapur, the heritage zone boundary follows the demarcation established under the Bhaktapur Municipality Physical Infrastructure and Construction Standards Bylaws (2072 BS) (Bhaktapur Municipality, 2072), which distinguishes from the outer buffer areas subject to modified standards. In Patan, the study area boundary corresponds to the monument protection zone and buffer zone formally demarcated by the Department of Archaeology in 2006 in response to UNESCO requirements, as governed by the DoA Guidelines (2064 BS) (Department of Archaeology, Government of Nepal, 2064) (Department of Archaeology, Government of Nepal, 2064) and the KVTDC Basic Building Construction Standards (2072 BS) (Government of Nepal, Ministry of Physical Planning and Construction, Kathmandu Valley Town Development Committee, 2064). The GPS-recorded locations of all 80 sampled buildings, shown in Figure 3, confirm that every building assessed falls within these formally defined heritage zone boundaries.



(a) Bhaktapur Municipality Cultural Heritage Conservation Zone



(b) Lalitpur Sub-Metropolitan City Cultural Heritage Conservation Zone

Figure 2 Heritage Conservation Zone boundaries - Bhaktapur (a) and Patan (b)

(Source: Kathmandu Valley Town Development Committee, 2007)

(a) Bhaktapur

(b) Patan

Figure 3 GPS-recorded locations of sampled buildings - Bhaktapur (a) and Patan (b), recorded via Kobo Toolbox

3.3 Population, Sampling Method and Sample Size

The population of this study comprises all residential buildings located within the designated heritage zones of Bhaktapur and Patan. The exact number of residential buildings within the heritage zone boundaries of both cities could not be precisely determined, as comprehensive and updated building inventories were not available from Bhaktapur Municipality or Lalitpur Metropolitan City at the time of this study. The population is therefore treated as unknown (infinite) for the purposes of sample size determination.

Cochran's (1977) formula for unknown or infinite populations was applied to determine the minimum required sample size:

$$\mathbf{n_0 = (Z^2 \times p \times q) / e^2}$$

Where:

$\mathbf{n_0}$ = minimum required sample size

Z = 1.645 (standard normal value at 90% confidence level)

p = 0.5 (maximum variability, used when population proportion is unknown)

q = 1 − p = 0.5

e = 0.10 (acceptable margin of error = 10%)

Substituting the values:

$$n_0 = (1.645)^2 \times 0.5 \times 0.5 / (0.10)^2$$

$$n_0 = 2.7060 \times 0.25 / 0.01$$

$$n_0 = 0.6765 / 0.01 = 67.65 \approx \mathbf{68}$$

The minimum required sample size was thus determined to be 68 buildings (34 per city). To ensure a more robust comparative analysis and to account for potential data gaps during field observation, the sample size was increased to 80 buildings - 40 per city. This exceeds the Cochran minimum and provides a sufficient basis for descriptive statistical analysis and element-level compliance comparison between the two cities.

Purposive sampling was adopted for this study. This approach is widely used in heritage and urban research where the objective is not statistical generalization to a total population, but the capture of meaningful variation across a contextually complex built

environment (Bajracharya, et al., 2025). Random sampling would not be appropriate in this context because the heritage zones contain a heterogeneous mix of building types and conditions, and a random sample might not include sufficient representation of both traditional and modified buildings to support a meaningful compliance analysis.

Buildings were selected for inclusion in the sample if they met all three of the following criteria: first, the building was primarily residential in function, either entirely residential or mixed-use with residential occupation on the upper floors; second, the building was located within the defined heritage zone boundary of either Bhaktapur or Patan; and third, the street-facing facade of the building was visible and accessible for direct observation from a public street or courtyard. Buildings with fully obscured facades were excluded.

A total of 80 residential buildings were selected for the study, with 40 buildings from Bhaktapur and 40 from Patan. This equal distribution was deliberate, ensuring that the comparative analysis between the two cities is based on equivalent sample sizes and is not skewed by an imbalance in the number of observations. The sample size of 40 per city was considered sufficient to provide a meaningful basis for descriptive statistical analysis and for identifying patterns of compliance at both the overall level and the individual parameter level.

3.4 Methods of Data Collection

3.4.1 Secondary data

Secondary data collection involved the systematic review of regulatory documents as well as a review of relevant literature on traditional Newari architecture, heritage conservation policy in the Kathmandu Valley, and previous studies on facade typology and compliance. The regulatory documents reviewed were obtained from the Bhaktapur Municipality office, the Lalitpur Metropolitan City office, and the Department of Archaeology.

3.4.2 Primary data - field observation

Primary data were collected through structured visual field observation of the selected buildings during fieldwork carried out in the heritage zones of Bhaktapur and Patan. Each building was observed directly from the street or courtyard and assessed against the 21-item compliance checklist. The observer walked the full width of the street-

facing facade, recording each checklist item based on direct visual inspection. Buildings were not entered at any point during the observation.

Data were recorded using Kobo Toolbox, a digital data collection platform widely used in field research. The Kobo Toolbox form was designed to mirror the compliance checklist structure, with each item presented as a binary choice - compliant or non-compliant - with provision for conditional follow-up questions where applicable. The platform also captured the GPS coordinates of each building and a full facade photograph for reference and quality checking. In addition to the formal checklist assessment, limited informal conversations were held with building owners, local residents, and shopkeepers during the fieldwork to clarify ambiguous observations.

In addition to the compliance checklist, the overall visual character of each building's street-facing facade was recorded as a supplementary observational rating during field survey. Each facade was classified into one of three categories based on how closely its overall appearance reflected traditional Newari facade character. A facade was rated Good if the overall visual appearance was predominantly traditional - traditional materials, openings, and architectural elements were clearly dominant on the street-facing facade with little or no visible modern intervention. Moderate was assigned when the facade showed a mixed appearance some traditional elements were retained but modern materials, alterations, or insertions were also clearly visible, creating a partially traditional overall character. Poor was assigned when the facade appeared predominantly non-traditional - modern materials, flat surfaces, aluminium frames, painted or plastered walls, or other non-traditional interventions dominated the street-facing facade such that the traditional character was largely lost. The field recording form is presented in Appendix B.

3.5 Data Analysis

The collected field data were analysed using a structured scoring system and a set of statistical procedures. The following subsections describe the scoring method applied to each building and the analytical steps used to examine compliance patterns and compare results between the two cities.

3.5.1 Scoring system

Each checklist item was scored as 1 (compliant) or 0 (non-compliant) for each building. Items with conditional follow-up questions were scored as described in Section 4.1.2 -

where the triggering feature is absent, the follow-up item is treated as not applicable and scored as compliant by default. The total compliance score for each building was calculated out of a fixed denominator of 21. The compliance percentage for each building was then calculated using the formula:

Compliance (%) = (Total Score / 21) × 100

Buildings were then classified into one of three compliance categories based on their compliance percentage: Compliant (≥75%), Partially Compliant (50–74%), and Non-compliant (<50%). The 75% threshold for the "Fully Compliant" category was selected because it represents a level where the majority of facade parameters are met and the overall traditional character of the building remains visually intact. A building scoring exactly 75% would have only 5 violations out of 20 parameters - but if those 5 violations include a flat rooftop, rolling shutters, and excess storeys together, the facade has clearly departed from what the guidelines intend. The threshold therefore reflects a practical and meaningful boundary rather than an arbitrary number. It is acknowledged that any such threshold involves a degree of judgment, and the key findings of this study remain consistent whether a threshold of 70% or 80% is applied instead.

3.5.2 Analytical Procedures

Data analysis was carried out in two stages. In the first stage, descriptive statistics were calculated for the full sample and for each city separately. These included the mean compliance score, median compliance score, standard deviation, minimum, and maximum, as well as the frequency and percentage of buildings in each of the three compliance categories. In the second stage, compliance rates were calculated for each of the 20 facade parameters individually, expressed as the percentage of buildings in each city that complied with that parameter. This element-level analysis makes it possible to identify which specific facade elements are most and least compliant in each city, and to compare the pattern of compliance across the two cities at a granular level.

The physical condition of each facade was also recorded during fieldwork as an additional observation, classified into three categories: Good, Moderate, or Poor, based on the overall visible state of repair of the facade. All data processing and statistical calculations were performed using Microsoft Excel. Results are presented in tabular and graphical form in Chapter Four. To examine whether observed differences in facade physical condition and compliance patterns between the two cities were statistically

significant, chi-square (χ^2) tests of independence were applied. Tests were conducted for facade physical condition ratings and for the three most violated facade elements - rolling shutters, traditional sloped tile roof, and storey count compliance. For each test, a significance level of $\alpha = 0.05$ was applied. The null hypothesis in each case was that there is no significant association between city and the measured outcome. Expected frequencies were calculated as (Row Total × Column Total) / Grand Total, and the chi-square statistic was computed as $\chi^2 = \Sigma (O - E)^2 / E$ with degrees of freedom $df = (r - 1) \times (c - 1)$.

3.6 Research Matrix

Table 1 presents the research matrix, which summarizes how each objective of the study is addressed through specific research questions, the data required, the sources from which that data is drawn, and the methods and tools used for collection and analysis.

Table 1 Research matrix

S.N.	Objective	Research Question	Data Required	Data Source	Methods / Tools
1	To review and identify key facade-related guidelines applicable to residential buildings in heritage zones of Bhaktapur and Patan	What are the key facade-related guidelines applicable to residential buildings in the study areas?	Facade guidelines, building regulations, bylaws	Municipal bylaws, heritage regulations, DoA guidelines	Document review, content analysis, extraction of facade parameters
2	To compare the level of facade guideline compliance of residential building facades between Bhaktapur and Patan	How does facade guideline compliance compare between the two cities?	Facade characteristics (storeys, materials, openings, etc.), facade physical condition	Field observation, facade photographs, Kobo Toolbox records	Structured observation checklist, scoring system, descriptive statistics, comparative analysis
3	To compare the construction management issues reflected in residential building facades in the two study areas	What differences in construction management issues affect facade guideline implementation in the two study areas?	Visible issues (materials, alterations, deviations, violation patterns)	Field observation, photographs, expert consultation with municipal architects	Visual analysis, checklist-based recording, chi-square tests of independence ($\alpha = 0.05$), descriptive analysis, comparative analysis

CHAPTER FOUR: RESULTS AND DISCUSSION

This chapter presents the findings of the study organized according to the three research objectives. Section 4.1 presents the results of the guideline review and checklist development. Section 4.2 presents the compliance assessment findings, including overall compliance statistics, compliance classification, storey count analysis, element-level compliance rates, and facade physical condition. Section 4.3 presents the construction management issues reflected in the building facades of both cities, supported by chi-square tests of independence. Section 4.4 presents an integrated discussion of the findings in relation to the research objectives and the existing literature.

4.1 Review and identification of key facade-related guidelines applicable to residential buildings in the heritage zones of Bhaktapur and Patan.

The first objective of this research was to review and identify the key facade-related guidelines applicable to residential buildings in the heritage zones of Bhaktapur and Patan. For this purpose, a systematic review of three principal regulatory documents was carried out: the Bhaktapur Municipality Physical Infrastructure and Construction Standards Bylaws (2072 BS), the Basic Building Construction Standards (2072 BS) issued by the Kathmandu Valley Town Development Committee, and the Department of Archaeology Guidelines for Conservation and Construction in the Bhaktapur and Patan Durbar Square Protected Monument Areas (2064 BS). Each document was reviewed in full and all provisions relating to the visible exterior facade of residential buildings were extracted, recorded, and compared across the three sources. From this review, twenty visually observable facade parameters were identified as common across all three regulatory sources, and a structured compliance checklist of twenty-one scored items was developed directly from these parameters to serve as the primary data collection instrument for the field assessment. The following sections present the findings of this guideline review and the resulting checklist.

4.1.1 Review of Guidelines

The first stage of the study involved a systematic review of three regulatory documents that govern the appearance of residential buildings in the heritage zones of Bhaktapur and Patan. These are: (i) the Bhaktapur Municipality Physical Infrastructure and Construction Standards Bylaws, 2060 BS (revised 2072 BS); (ii) the Basic Building

Construction Standards, 2072 BS, issued by the Kathmandu Valley Town Development Committee, which governs the broader heritage zone in Patan; and (iii) the Department of Archaeology Guidelines for Conservation and Construction in the Patan and Bhaktapur Durbar Square Protected Monument Areas, 2064 BS. Each document was read in full and all provisions relating to the visible exterior facade of residential buildings were extracted and recorded.

The review confirmed that the three sources are broadly consistent in what they require for heritage residential facades. All three require exposed brick walls without cement plaster or paint, wooden windows and doors in traditional style, traditional clay tile roofs, wooden struts under eaves, horizontal cornice bands aligned with neighboring buildings, a raised plinth, and the concealment of modern service installations from the street-facing facade. Differences exist in specific provisions - for example, the maximum storey count in the Bhaktapur guidelines allows five storeys overall with four permitted in the World Heritage Zone, while the Patan Heritage Zone regulations restrict buildings to four storeys including the attic. Table 2 presents the complete comparative summary of facade guidelines across the three sources.

Table 2 Comparative summary of facade-related guidelines - Bhaktapur, Patan, and DoA (20 parameters)

Comparative Summary of Facade-Related Guidelines — Bhaktapur, Patan, and DoA				
S.N.	**Facade Parameter**	**Bhaktapur Municipality Bylaws (2072 BS)**	**Patan / KVTDC Regulations (2072 BS)**	**Dept. of Archaeology Guidelines (2064 BS)**
1	**Facade material & finish**	Exposed local brick; no cement plaster or paint; pointing allowed	Exposed local brick; no cement/lime plaster or paint; pointing allowed	Exposed local brick; no cement/lime plaster or paint; pointing allowed
2	**Structural visibility**	RCC/steel frame not visible on facade	RCC/steel frame must be concealed	RCC/steel frame not visible; must be concealed from street
3	**Window material & style**	Wooden; traditional Malla/Shah/Rana style and proportions	Wooden; traditional Malla/Shah/Rana style and proportions	Wooden; traditional Nepali style and proportions
4	**Window vertical alignment**	Windows on each floor vertically aligned	Windows on each floor vertically aligned	Windows on each floor vertically aligned
5	**Window paneling (odd-panel)**	Windows must be odd-paneled	Windows must be odd-paneled; minimum panel width applies	Windows must be odd-paneled; minimum frame width applies
6	**Ground floor windows**	Single-panel openings only on ground floor	Single-panel openings only on ground floor	Single-panel openings only on ground floor
7	**Door material**	Wooden doors; iron rolling shutters/grills not permitted	Wooden doors; rolling shutters/metal gates not permitted	Wooden shutters; iron rolling shutters/grills not permitted
8	**Rolling shutters**	Not permitted; if required for shops, must be concealed	Not permitted; if required, must be concealed or wooden front provided	Not permitted; if required for shops, must be concealed
9	**Roof type & material**	Traditional double-pitched tile (Jhingati) roof; single slope if 3 sides enclosed	Traditional double-pitched tile roof; single slope if 3 sides enclosed	Traditional double-pitched tile roof; single slope if 3 sides enclosed
10	**Wooden struts (Tundal)**	Required below eaves/roof; simple or decorative	Required below eaves/roof; simple or decorative	Required; RCC cantilever must incorporate wooden struts with traditional detailing
11	**Raised plinth (Peti)**	Required; aligned with adjacent buildings	Required; aligned with adjacent buildings	Required; height and alignment as per adjacent buildings
12	**Modern services concealment**	Water tanks, AC units, satellite dishes not visible from street/courtyard	Water tanks, antennas, AC, solar panels not visible from street/courtyard	Water tanks, dish antennas, AC, solar not visible; conceal or design to avoid visual impact
13	**Maximum storeys**	Max 5 storeys (35 ft); max 4 in World Heritage Zone without attic	Max 4 storeys including attic (buigal)	Max 4 storeys; total height max + sloped roof
14	**Cantilever projection**	Not permitted; eaves/overhang at top floor only	Not permitted; top-floor eaves allowed	Simple cantilever slab not permitted; overhang at 3rd floor only
15	**Facade symmetry & order**	Visual order and proportionality of elements required	Visual order and proportionality of elements required	Visual order and proportionality of elements required
16	**Building alignment with street**	Must align with neighbouring buildings in height, setback, and visual rhythm	Must align with neighbouring buildings in height, setback, and visual rhythm	Must align with neighbouring buildings in setback and height
17	**Balcony (Bardali)**	Traditional wooden; from 2nd floor upward on road-facing side	Allowed from 3rd floor on own land; not on main street/courtyard	Traditional wooden; from 2nd floor upward; width and setback as specified
18	**Cornice alignment**	Cornice bands present; aligned with adjacent buildings	Cornice present; aligned with adjacent buildings	Cornice aligned with adjacent buildings; plain or decorative
19	**Aakhyi Jhyal ventilation**	Traditional eye-shaped ventilation openings may be provided	Traditional eye-shaped ventilation openings may be provided	Traditional Aakhyi Jhyal (eye windows) encouraged
20	**Traditional ornamentation**	Traditional carvings and decorative elements encouraged and to be maintained	Traditional carvings and decorative elements encouraged and to be maintained	Traditional carvings and decorative elements encouraged and to be maintained

The comparative review of the three regulatory documents - the Bhaktapur Municipality Building Bylaws (2072 BS), the Patan/KVTDC Regulations (2072 BS), and the Department of Archaeology Guidelines (2064 BS) - reveals a broadly consistent regulatory framework governing the visible facades of residential buildings in both heritage zones, with notable differences in specific provisions that reflect the distinct institutional mandates and conservation priorities of each authority.

All three documents are in full agreement on the most fundamental facade requirements. Exposed local brick without cement plaster or paint is universally required across all three sources, as is the concealment of RCC or steel structural frames from the street-facing facade. Windows must be wooden and of traditional style in all three documents, and must be vertically aligned across floors and arranged in odd-panel configurations. Ground floor windows are restricted to single-panel openings in all three sources. Wooden doors are required throughout, and metal rolling shutters or iron grills are prohibited in all three documents, though the Patan/KVTDC regulations offer a slight flexibility by permitting concealed shutters or a wooden front panel where a shutter is functionally unavoidable. The traditional double-pitched Jhingati tile roof is required by all three sources, with a single slope permitted only where three sides of the building are enclosed. Wooden struts (Tundal) below the eaves are required in all three documents. The raised plinth (Peti) aligned with neighboring buildings, the concealment of modern service installations including water tanks, AC units, satellite dishes and solar panels, and the requirement for visual order and proportionality of facade elements are also consistently present across all three sources. Building alignment with neighboring structures in height, setback, and visual rhythm is required by all three, as is the alignment of cornice bands with adjacent buildings. Traditional carvings and decorative elements are encouraged and to be maintained in all three documents.

Differences between the three sources are most apparent in provisions relating to storey count, cantilever projections, and balcony placement. On storey count, the Bhaktapur Municipality Bylaws permit a maximum of five storeys or 35 feet overall, but restrict this to four storeys in the World Heritage Zone without an attic. The Patan Regulations set a maximum of four storeys including the attic (buigal), while the DoA Guidelines similarly restrict buildings to four storeys with a total height not exceeding the

maximum plus a sloped roof. This means that Bhaktapur technically permits one additional storey outside the core World Heritage Zone, creating a regulatory distinction that does not exist in Patan. On cantilever projections, the Bhaktapur Bylaws and Patan Regulations both prohibit cantilevers and permit eaves or overhang only at the top floor, while the DoA Guidelines are more specific in prohibiting simple cantilever slabs and restricting overhang to the third floor only. On balconies, the Bhaktapur Bylaws permit traditional wooden balconies from the second floor upward on the road-facing side, and the DoA Guidelines similarly allow balconies from the second floor with specified width and setback requirements, while the Patan Regulations are more restrictive, permitting balconies only from the third floor upward and prohibiting them on the main street or courtyard frontage. A further difference is observed in the treatment of wooden struts under the DoA Guidelines, which explicitly require that RCC cantilever elements incorporate wooden struts with traditional detailing - a provision that reflects the DoA's stricter approach to the integration of modern structural elements within a traditional visual language.

Overall, the three regulatory sources are sufficiently consistent in their core requirements to support the development of a single unified compliance checklist applicable to residential buildings in both heritage zones. The differences identified are primarily matters of degree or specific application rather than fundamental contradictions, and they were accounted for in the checklist scoring system by adopting the more conservative of the applicable provisions where differences existed between Bhaktapur and Patan requirements.

4.1.2 Development of Checklist

From the guideline review, twenty facade parameters were identified that are common across the three regulatory sources and can be assessed through direct visual observation from a public street or courtyard without entering the building. For each of the twenty parameters, a specific visual indicator was formulated - a clear, observable criterion that can be scored as either compliant or non-compliant during field observation. For example, the parameter "Facade Material and Finish" was translated into the visual indicator "Natural exposed brick visible on external walls; no paint, cement plaster, cladding, or tiling present".

The resulting checklist contains 21 scored items. Some parameters include a parent question and a follow-up conditional question depending on whether a particular feature is present. For example, if a balcony is present on the building, it is further assessed for whether it is of traditional wooden construction. If no balcony is present, the follow-up question is treated as not applicable and automatically scored as compliant, since the absence of a non-traditional element does not constitute a violation. This conditional scoring approach prevents buildings from being unfairly penalized for the absence of features that they were never built with, and focuses the assessment on active violations of the guideline requirements. The complete checklist with all twenty parameters, their visual indicators, and scoring criteria as used during field observation is presented in Appendix A.

4.2 Comparison of the level of compliance of residential building facades with the identified guidelines between Bhaktapur and Patan.

The second objective of this research was to compare the level of compliance of residential building facades with the identified guidelines between Bhaktapur and Patan. For this purpose, the eighty residential buildings assessed during field observation forty in each city were evaluated against the twenty-one item compliance checklist derived from the guideline review. Each building was scored on a binary compliant or non-compliant basis for each checklist item, and an overall compliance percentage was calculated for every building. Buildings were then classified into three categories - Compliant (≥75%), Partially Compliant (50–74%), and Non-Compliant (<50%) to enable meaningful comparison between the two cities at both the overall and element level. The following sections present the results of this compliance assessment, beginning with overall compliance statistics, followed by compliance classification, storey count analysis, and element-level compliance rates for all twenty facade parameters.

4.2.1 Overall Compliance for Bhaktapur and Patan

Table 3 presents the summary compliance statistics for Bhaktapur and Patan. The results show that buildings in Patan follow the facade guidelines more closely on average than those in Bhaktapur. The mean compliance score for Patan was 84.6% compared to 78.9% for Bhaktapur - a difference of 5.7 percentage points. The median scores were 85.7% and 81.0% respectively, indicating that the typical building in both

cities sits in the upper-middle compliance range rather than at the extremes, and that the differences observed at the mean level are representative of the central tendency of the data rather than driven by outliers.

Table 3 Overall compliance statistics - Bhaktapur and Patan

Statistic	**Bhaktapur**	**Patan**
Mean (%)	78.9	84.6
Median (%)	81.0	85.7
Standard deviation	13.8	10.2
Minimum (%)	47.6	47.6
Maximum (%)	100.0	100.0

The standard deviation for Bhaktapur (13.8%) is notably higher than for Patan (10.2%), indicating that compliance levels in Bhaktapur are more variable across the sample. While both cities produced buildings with perfect compliance scores of 100%, and both had a minimum score of 47.6%, the wider spread in Bhaktapur reflects greater variation between neighborhoods: buildings close to the Durbar Square core tend to be highly compliant, while those in outer areas of the heritage zone show more frequent and more pronounced deviations from the guidelines. Patan's lower standard deviation suggests a more consistent level of compliance across the sampled buildings, possibly reflecting the stronger concentration of intact traditional fabric around the Patan Durbar Square area and the influence of heritage tourism (Bajracharya, et al., 2025).

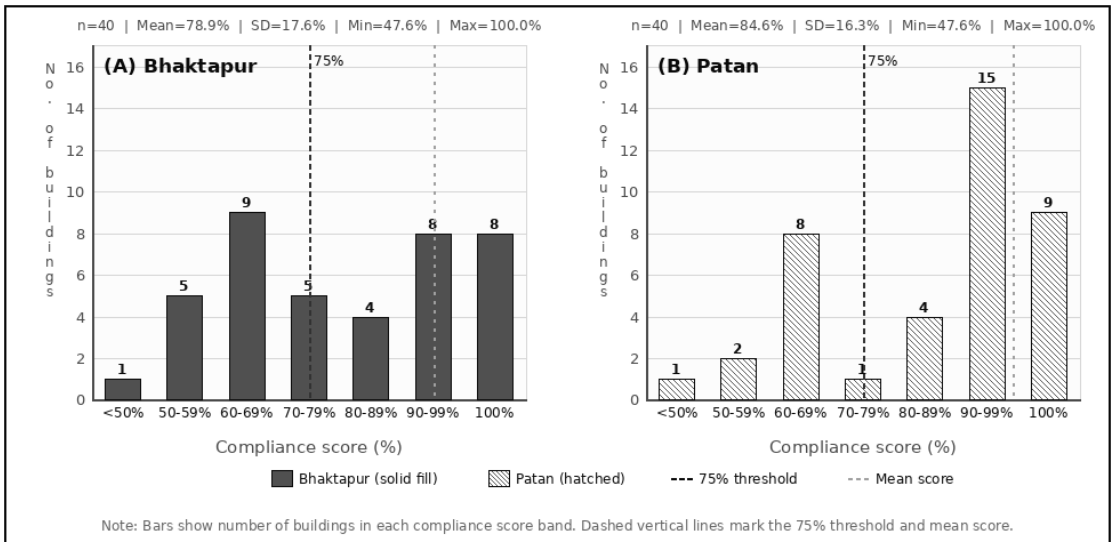


Figure 4 Compliance score distribution - Bhaktapur (left) and Patan (right)

4.2.2 Compliance Classification

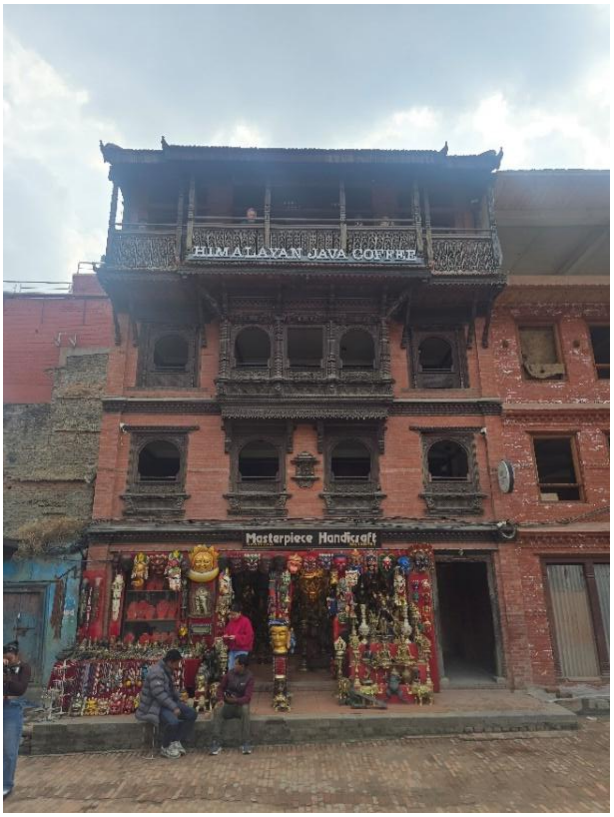
Table 4 presents the distribution of buildings across the three compliance categories. In Patan, 70.0% of buildings were classified as Compliant (scoring ≥75%), compared to only 52.5% in Bhaktapur. Partially Compliant buildings - those scoring between 50% and 74% - were considerably more common in Bhaktapur at 45.0%, compared to 27.5% in Patan. Only one building in each city fell below the 50% threshold and was classified as Non-compliant, representing 2.5% of the sample in both cities.

Table 4 Compliance classification of buildings by city

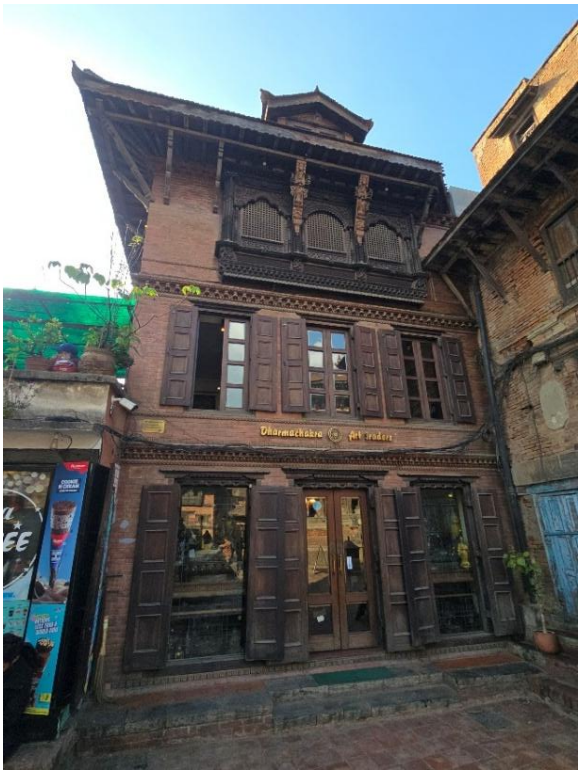
Classification	Bhaktapur (n)	Bhaktapur (%)	Patan (n)	Patan (%)	Remarks
Compliant (≥75%)	21	52.5	28	70.0	Higher in Patan by 17.5 pp
Partially compliant (50–74%)	18	45.0	11	27.5	Higher in Bhaktapur by 17.5 pp
Non-compliant (<50%)	1	2.5	1	2.5	Equal in both cities
Total	40	100	40	100	

The higher proportion of fully compliant buildings in Patan is consistent with the finding of (Bajracharya, et al., 2025) that the Patan heritage zone, particularly around Durbar Square, benefits from a concentration of intact traditional buildings that create a strong visual context and a degree of peer pressure for neighboring buildings to maintain compatible facades. The presence of active heritage tourism in the area also reinforces the economic case for maintaining traditional building appearances. In Bhaktapur, the larger proportion of Partially Compliant buildings reflects the greater variation across the heritage zone, where buildings in the core areas around the three squares tend to be more compliant while those in peripheral streets and outer residential areas show more deviation.

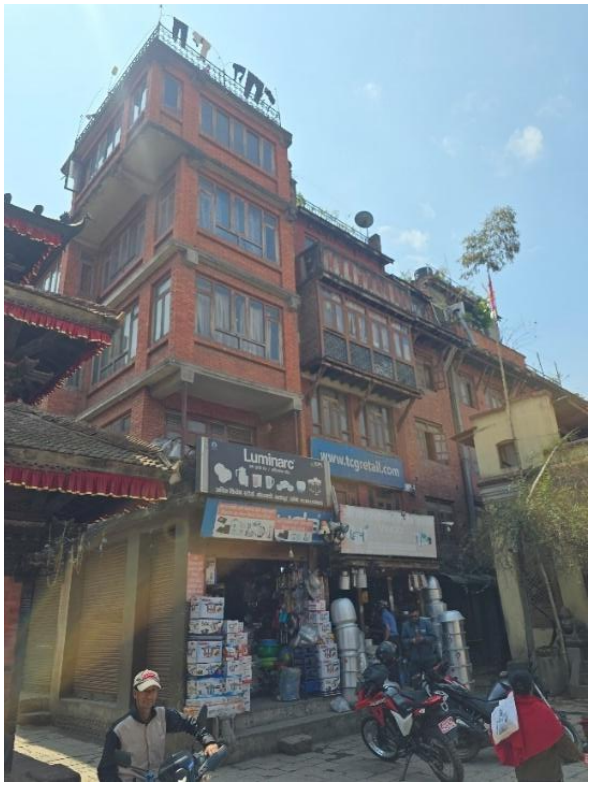
The two buildings classified as Non-Compliant BKT-09 in Golmadi, Bhaktapur (Picture 3) and PTN-20 in Tichhu Galli, Patan (Picture 4) both scored 47.6%, the lowest in their respective cities. Both buildings exhibited flat concrete rooftops, aluminium window frames, metal rolling shutters on the ground floor, painted or plastered exterior walls, and storey counts exceeding the permitted maximum. These buildings illustrate how comprehensively a building within a designated heritage zone can depart from the guidelines when effective enforcement is absent at the individual building level (Maharjan, 2019) (Subedi & Shrestha, 2023)



Picture 1 Fully compliant buildings - BKT-25, Taumadi, Bhaktapur



Picture 2 Fully compliant buildings - PTN-25, Durbar Square, Patan



Picture 3 Least compliant buildings - BKT-09, Golmadi, Bhaktapur

Picture 4 Least compliant buildings - PTN-20, Tichhu Galli, Patan

4.2.3 Storey Count

Table 5 presents the distribution of buildings in the sample by number of storeys. In Bhaktapur, 55.0% of buildings had four or fewer storeys, which is the maximum permitted in the World Heritage Zone under the Bhaktapur Municipality Bylaws. The remaining 45.0% exceeded this limit, with 35.0% at five storeys and 10.0% at six or more. In Patan, 72.5% of buildings were within the compliant storey range, while 22.5% had five storeys and 5.0% had six or more.

Table 5 Distribution of buildings by number of storeys

Number of storeys	Bhaktapur (n)	Bhaktapur (%)	Patan (n)	Patan (%)
≤4 storeys (compliant)	22	55.0	29	72.5
5 storeys	14	35.0	9	22.5
6 or more storeys	4	10.0	2	5.0
Total	40	100	40	100

Excess storey construction is one of the most persistent and visible forms of heritage guideline violation in both cities. The pattern has been documented over several decades: (Suwal, 2014) noted that buildings in Bhaktapur began exceeding traditional height limits from the 1970s onwards, and (Suji, et al., 2021) found that building owners deliberately violated the storey restriction during post-earthquake reconstruction because they considered the sloped *Jhingati* roof requirement impractical and because the demand for additional living and rental space consistently outweighed the deterrent effect of municipal enforcement. The present data confirm that this pattern persists and is measurably more pronounced in Bhaktapur than in Patan.

4.2.4 Element-Level Compliance

Table 6 and Figure 5 presents the compliance rate for each of the 20 facade parameters, expressed as the percentage of buildings in each city that complied with that parameter. The results reveal a highly uneven pattern: some elements achieve perfect compliance in both cities, while others show very low compliance rates that are consistent across both cities.

Table 6 Element-level compliance rates by city (%)

S.N.	Facade parameter	Bhaktapur (%)	Patan (%)	Remarks
1	Exposed brick facade	77.5	87.5	10 pp gap; cement plaster and paint common in Bhaktapur
2	Modern structure concealed	80.0	90.0	Exposed RCC columns more frequent in Bhaktapur
3	Windows wooden (traditional)	72.5	82.5	Aluminium frames widespread in both cities
4	Windows vertically aligned	85.0	92.5	Generally preserved; better in Patan
5	Windows odd-paneled	80.0	87.5	Even-paneled windows more common in Bhaktapur
6	GF windows single-panel (if present)	100.0	100.0	Full compliance in both cities
7	Doors wooden	87.5	90.0	Near-compliant in both; minor differences
8	No visible rolling shutters	40.0	50.0	Weakest element; metal shutters very common
9	Traditional sloped tile roof	45.0	62.5	Second weakest; flat concrete rooftops widespread
10	Wooden struts (Tundal) present	100.0	100.0	Full compliance in both cities
11	Raised plinth (peti) visible	87.5	92.5	Well preserved in both cities

S.N.	Facade parameter	Bhaktapur (%)	Patan (%)	Remarks
12	No visible modern elements	72.5	80.0	AC units and tanks visible on many facades
13	Storey count compliant (≤4)	55.0	72.5	45% of Bhaktapur buildings exceed limit
14	No cantilever projection	82.5	90.0	Generally compliant; better in Patan
15	Facade ordered/symmetrical	80.0	87.5	Visual coherence better maintained in Patan
16	Building aligned with street	67.5	92.5	Largest gap (25 pp); Bhaktapur outer areas show misalignment
17	Balcony traditional wooden (if present)	100.0	100.0	Where present, balconies are traditional in both cities
18	Cornice aligned with neighbours	100.0	100.0	Full compliance in both cities
19	Aakhyi Jhyal ventilation (if present)	100.0	100.0	Full compliance where feature is present
20	Traditional ornamentation (if present)	100.0	100.0	Owners preserve carvings when originally present
	Overall mean	78.9	84.6	

Elements with full compliance

Five parameters achieved 100% compliance in both Bhaktapur and Patan: ground floor window single-panel arrangement, wooden struts (Tundal), cornice alignment with neighboring buildings, Aakhyi Jhyal ventilation openings, and traditional

ornamentation. These elements share a common characteristic - they are either features that survive intact from the original building stock or decorative elements that building owners actively choose to preserve because they are highly visible markers of heritage identity and craftsmanship. Wooden struts and traditional ornamentation in particular carry strong cultural and aesthetic meaning for Newar communities, and their preservation appears to be the result of genuine cultural pride rather than regulatory enforcement (Silva, 2017). The full compliance on cornice alignment suggests that even in buildings that deviate from the guidelines in other respects, owners tend to maintain the horizontal visual rhythm of the streetscape at the floor level - possibly because this alignment is largely determined by the existing built context and requires no active effort to conform.

Weakest compliance elements

The two elements with the lowest compliance rates in both cities are the prohibition on visible metal rolling shutters and the requirement for a traditional sloped clay tile roof. Rolling shutter non-compliance was recorded on 60.0% of Bhaktapur buildings and 50.0% of Patan buildings, making it the single most widespread violation in both cities. Metal rolling shutters are found almost exclusively on ground floor shopfronts, where building owners prioritize security and ease of operation over compliance with heritage design standards. All three regulatory sources explicitly prohibit visible metal rolling shutters on heritage facades and require wooden doors or shutters to be used instead. This finding aligns with (Maharjan, 2019), who identified the prioritization of practical daily needs over heritage compliance as a primary driver of non-compliance in all three Durbar Square areas.

The traditional sloped clay tile roof was absent - replaced by a flat concrete rooftop - in 55.0% of Bhaktapur buildings and 37.5% of Patan buildings. This finding is consistent with (Shrestha, 2021), who identified the *Jhingati* tile roof as one of the costliest elements to construct or restore traditionally, and documented that many building owners opt for flat concrete rooftops as a cheaper, lower-maintenance alternative. The higher rate of flat rooftops in Bhaktapur compared to Patan is consistent with the overall pattern of weaker compliance in Bhaktapur's outer areas, where enforcement pressure is lower.

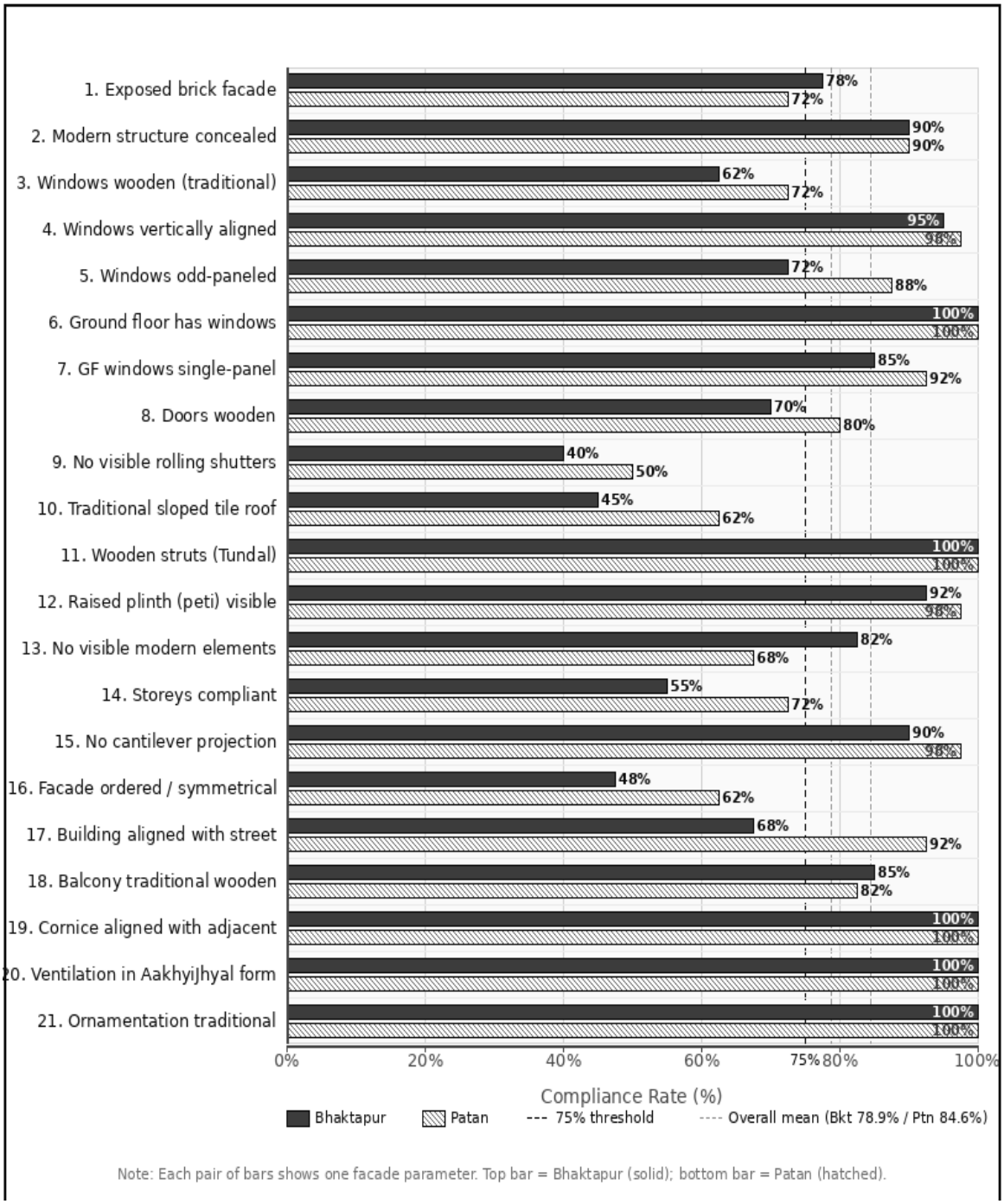


Figure 5 Element-level compliance comparison - Bhaktapur vs Patan

Picture 5 Examples of Non-compliance (rolling shutter violations)

Picture 6 Examples of Non-compliance (flat rooftop violations)

Notable compliance gaps between cities

The largest compliance gap between the two cities is in building alignment with the street context - 67.5% in Bhaktapur versus 92.5% in Patan, a difference of 25 percentage points. This suggests that buildings in Patan, particularly around the Durbar Square area, are more consistently positioned in alignment with the line and height of neighboring structures. In Bhaktapur, setback violations and buildings constructed out of alignment with the traditional street line are more common, particularly in peripheral neighborhoods. Wall material compliance (77.5% in Bhaktapur versus 87.5% in Patan) and window material compliance (72.5% versus 82.5%) also show consistent 10 percentage point gaps in favor of Patan, suggesting that the use of non-traditional materials is more widespread in Bhaktapur.

Facade Physical Condition

Table 7 presents the overall physical condition of the observed facades. Buildings in Patan were in better overall condition, with 70.0% rated as Good compared to 55.0% in Bhaktapur. Buildings in Poor condition were twice as common in Bhaktapur (10.0%) as in Patan (5.0%).

Table 7 Facade physical condition by city

Condition	**Bhaktapur (n)**	**Bhaktapur (%)**	**Patan (n)**	**Patan (%)**
Good	22	55.0	28	70.0
Moderate	14	35.0	10	25.0
Poor	4	10.0	2	5.0
Total	40	100	40	100

The physical condition results closely mirror the compliance results: buildings with higher compliance scores also tend to be in better physical condition. This relationship reflects the fact that maintaining a facade in good physical condition generally requires ongoing investment in traditional materials and skilled maintenance - the same investment that the guidelines require. A building owner who is committed to maintaining the traditional facade is more likely both to comply with the guidelines and

to keep the facade well repaired. This finding is consistent with (Bajracharya, et al., 2025), who found that heritage buildings in Patan's buffer zone remain more resilient where community ties and active economic use support ongoing maintenance.

4.3 Comparison of the construction management issues reflected in residential building facades in the two study areas

The third objective of this research was to compare the construction management issues reflected in residential building facades in the two study areas. While the compliance assessment presented in the preceding section measured the extent to which individual buildings follow the applicable facade guidelines, this section examines the underlying construction management reasons why specific violations occur and whether these reasons differ between Bhaktapur and Patan. The construction management issues examined here are those that are directly visible and inferable from the street-facing facades of the sampled buildings - including the use of non-traditional materials, the installation of metal rolling shutters, the replacement of traditional clay tile roofs with flat concrete structures, and the addition of storeys beyond the permitted maximum. These observable violations serve as indicators of the practical and economic decisions that building owners and contractors make during construction and renovation within the heritage zones. The following sections discuss the facade physical condition ratings recorded during fieldwork, the results of chi-square tests of independence applied to the most violated facade elements, and a broader discussion of the construction management challenges that the compliance findings reflect across both cities.

4.3.1 Facade Physical Condition: Bhaktapur and Patan Comparison

A chi-square (χ^2) test of independence was performed to determine whether the distribution of facade physical condition ratings differs significantly between Bhaktapur and Patan. The null hypothesis (H_0) states that there is no significant association between city and facade physical condition. The alternative hypothesis (H_1) states that the distribution of condition ratings differs significantly between the two cities.

Table 8 Observed and Expected Frequencies - Facade Physical Condition

Category	Observed (O)	Expected (E)	O − E	(O − E)²	(O − E)² / E
Bhaktapur - Good	22	25.0	−3.0	9.000	0.360
Bhaktapur - Moderate	14	12.0	+2.0	4.000	0.333
Bhaktapur - Poor	4	3.0	+1.0	1.000	0.333
Patan - Good	28	25.0	+3.0	9.000	0.360
Patan - Moderate	10	12.0	−2.0	4.000	0.333
Patan - Poor	2	3.0	−1.0	1.000	0.333
Total	**80**	**80**	**0**	**28.000**	**2.053**

(Detailed step-by-step calculation is presented in Appendix G.1.)

The critical value of χ^2 at a 0.05 significance level with 2 degrees of freedom is 5.991. Since the calculated value of 2.053 is less than the critical value of 5.991, the null hypothesis cannot be rejected.

This indicates that the observed difference in facade physical condition between Bhaktapur and Patan is not statistically significant at the 95% confidence level ($p = 0.358 > 0.05$). While the descriptive data shows that Patan has a higher proportion of Good-condition facades (70.0%) compared to Bhaktapur (55.0%), this difference is not large enough to be statistically confirmed given the current sample size of 40 buildings per city.

The Poor condition category contains small cell counts - 4 buildings in Bhaktapur and 2 in Patan - which reduces the statistical power of the test. A larger sample covering additional neighborhoods in both cities would provide greater power to detect whether a genuine difference in physical condition exists. Despite the absence of statistical significance, the descriptive pattern remains consistent with the overall compliance findings of this study: buildings with higher compliance scores also tend to be in better physical condition, reflecting that maintaining a visually traditional facade requires the same commitment to traditional materials and upkeep that guideline compliance demands.

4.3.2 Most Violated Facade Elements: Bhaktapur and Patan Comparison

Chi-square (χ^2) tests of independence were performed for the three facade parameters with the lowest compliance rates in both cities: no visible rolling shutters, traditional sloped tile roof, and storey count compliance. For each element, the null hypothesis (H_0) states that there is no significant association between city and compliance outcome. The alternative hypothesis (H_1) states that compliance differs significantly between Bhaktapur and Patan. A significance level of $\alpha = 0.05$ was applied throughout.

Table 9 Summary of Chi-Square Test Results - Most Violated Elements

Facade Element	**BKT Comply**	**PTN Comply**	**BKT Violate**	**PTN Violate**	**χ^2**	**p-value**
No Visible Rolling Shutters	16 (40.0%)	20 (50.0%)	24 (60.0%)	20 (50.0%)	0.808	0.369
Traditional Sloped Tile Roof	18 (45.0%)	25 (62.5%)	22 (55.0%)	15 (37.5%)	2.464	0.117
Storey Count Compliant	22 (55.0%)	29 (72.5%)	18 (45.0%)	11 (27.5%)	2.650	0.104

Note: Critical value at $\alpha = 0.05$, $df = 1$ is 3.841.

Table 9 shows summary of Chi-Square Test results for most violated elements and these individual elements test results are shown below:

(a) Rolling Shutters: Bhaktapur and Patan Comparison

Table 10 Observed and Expected Frequencies - No Visible Rolling Shutters

Category	**O**	**E**	**O − E**	**$(O - E)^2$**	**$(O - E)^2 / E$**
Bhaktapur - Compliant	16	18.0	-2.0	4.000	0.222
Bhaktapur - Non-Compliant	24	22.0	+2.0	4.000	0.182
Patan - Compliant	20	18.0	+2.0	4.000	0.222
Patan - Non-Compliant	20	22.0	-2.0	4.000	0.182

Category	O	E	O − E	(O − E)²	(O − E)² / E
Total (χ^2)					**0.808**

(Detailed step-by-step calculation is presented in Appendix G.2.)

The calculated χ^2 value of 0.808 is less than the critical value of 3.841. The null hypothesis cannot be rejected ($p = 0.369 > 0.05$). The difference in rolling shutter violation rates between Bhaktapur (60%) and Patan (50%) is not statistically significant. Both cities share this violation at similar rates, reflecting the same underlying cause - the absence of a guideline provision that accommodates the security needs of ground floor commercial uses.

(b) Traditional Sloped Tile Roof: Bhaktapur and Patan Comparison

Table 11 Observed and Expected Frequencies - Traditional Sloped Tile Roof

Category	O	E	O − E	(O − E)²	(O − E)² / E
Bhaktapur - Compliant	18	21.5	-3.5	12.250	0.570
Bhaktapur - Non-Compliant	22	18.5	+3.5	12.250	0.662
Patan - Compliant	25	21.5	+3.5	12.250	0.570
Patan - Non-Compliant	15	18.5	-3.5	12.250	0.662
Total (χ^2)					**2.464**

(Detailed step-by-step calculation is presented in Appendix G.3.)

The calculated χ^2 value of 2.464 is less than the critical value of 3.841. The null hypothesis cannot be rejected ($p = 0.117 > 0.05$). Although Bhaktapur has a higher flat rooftop rate (55%) compared to Patan (37.5%), this difference is not statistically significant. Both cities are affected by the same post-earthquake preference for flat RCC construction and the high cost of traditional *Jhingati* tile roofs.

(c) Storey Count: Bhaktapur and Patan Comparison

Table 12 Observed and Expected Frequencies - Storey Count Compliant

Category	O	E	O − E	(O − E)²	(O − E)² / E
Bhaktapur - Compliant	22	25.5	-3.5	12.250	0.480
Bhaktapur - Non-Compliant	18	14.5	+3.5	12.250	0.845
Patan - Compliant	29	25.5	+3.5	12.250	0.480
Patan - Non-Compliant	11	14.5	-3.5	12.250	0.845
Total (χ^2)					**2.650**

(Detailed step-by-step calculation is presented in Appendix G.4.)

The calculated χ^2 value of 2.650 is less than the critical value of 3.841. The null hypothesis cannot be rejected ($p = 0.104 > 0.05$). Although more Bhaktapur buildings exceed the storey limit (45%) compared to Patan (27.5%), this difference is not statistically significant. The demand for additional living and rental space is a persistent driver of excess storey construction in both cities.

Summary of Compliance Differences Between Cities

Of the three most violated facade elements tested, none show a statistically significant difference between Bhaktapur and Patan (all $p > 0.05$). Rolling shutters ($p = 0.369$), flat tile rooftops ($p = 0.117$), and excess storey construction ($p = 0.104$) are violations shared across both cities, driven by the same underlying barriers - the high cost of traditional materials, post-earthquake structural preferences, and persistent demand for additional floor space. This confirms that compliance failures are not city-specific but systemic, and that effective solutions require national-level policy interventions rather than city-specific enforcement alone.

These findings align with (Maharjan, 2019) finding that non-compliance in Kathmandu Valley heritage zones reflects rational owner decisions under economic pressure and inadequate institutional support, and with (Shrestha, 2021) finding that the cost differential between traditional and modern construction - estimated at approximately

twice the cost of full traditional heritage construction - remains the most fundamental practical barrier to compliance. The findings were further validated through informal discussions with the Architect at Bhaktapur Municipality and the Architect at Lalitpur Metropolitan City, both of whom independently confirmed that cost barriers, demand for additional floor space, and ground floor security concerns are the most frequently cited drivers of non-compliance in their respective heritage zones.

Overall, partial compliance is the dominant pattern in both cities. Full compliance remains the exception in Bhaktapur, where only 52.5% of buildings met the ≥75% threshold, while even in Patan, three out of every ten buildings still fell short despite its higher overall performance. This persistent pattern of incomplete compliance, despite legally backed regulatory frameworks, points to structural barriers that go beyond individual building owner decisions and must be addressed at a systemic level.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The first objective of this study was to review and identify the key facade-related guidelines applicable to residential buildings in the heritage zones of Bhaktapur and Patan. The review of three regulatory documents - the Bhaktapur Municipality Building Bylaws (2072 BS), the KVTDC Basic Building Construction Standards (2072 BS), and the Department of Archaeology Guidelines (2064 BS) - confirmed that a comprehensive and largely consistent set of facade-related requirements exists for residential buildings in both heritage zones. Twenty visually observable parameters were identified as common across all three sources, covering requirements for exposed brick walls, wooden windows and doors in traditional style, a traditional Jhingati clay tile roof, wooden struts (Tundal) under the eaves, cornice bands aligned with neighbouring buildings, a raised plinth, a maximum of four storeys in the World Heritage Zone, concealment of modern service installations, and the prohibition of metal rolling shutters and non-traditional balcony forms. Differences between the three sources were identified in specific provisions relating to storey count, balcony placement, and cantilever projections, and were accounted for in the compliance checklist by adopting the more conservative applicable provision where divergence existed.

The second objective was to compare the level of facade guideline compliance between the two cities. The field assessment of 80 residential buildings produced clear evidence that partial compliance is the dominant pattern in both cities, with Patan performing consistently better than Bhaktapur. The mean compliance score for Patan was 84.6% compared to 78.9% for Bhaktapur, and 70.0% of Patan buildings were classified as fully compliant against 52.5% in Bhaktapur. Five facade elements achieved 100% compliance in both cities - wooden struts, cornice alignment, ground floor window configuration, Aakhyi Jhyal ventilation, and traditional ornamentation - reflecting the strong cultural meaning these elements carry for Newar building owners. The weakest compliance elements were identical in both cities: rolling shutter prohibition (40.0% in Bhaktapur and 50.0% in Patan) and the traditional sloped tile roof requirement (45.0% in Bhaktapur and 62.5% in Patan).

The third objective was to compare the construction management issues reflected in the building facades of the two study areas. The field assessment revealed a consistent pattern of practical and economic barriers driving non-compliance in both cities. Rolling shutter violations reflect the unmet security needs of ground floor commercial uses. Flat rooftops reflect the high cost of traditional Jhingati tile construction and post-earthquake preference for flat RCC structures, a pattern confirmed by municipal architects at both Bhaktapur Municipality and Lalitpur Metropolitan City. Excess storey construction reflects persistent demand for additional living and rental space. Chi-square testing confirmed that violation rates for all three elements are not statistically significantly different between the two cities (all $p > 0.05$), establishing that these are shared challenges driven by common economic barriers rather than city-specific factors. The overarching conclusion is that the compliance gap in both heritage zones is not a product of owner indifference, but of the absence of the economic incentives, technical support, and coordinated enforcement needed to make compliance the practical default in heritage residential construction.

5.2 Recommendation from study

Based on the findings of this study, the following recommendations are directed to Bhaktapur Municipality, Lalitpur Metropolitan City, the Department of Archaeology, and policymakers at the national level.

a. Establish a unified enforcement mechanism A clear inter-agency protocol should be developed assigning specific monitoring and enforcement responsibilities to the DoA, municipalities, and KVTDC, eliminating gaps created by overlapping jurisdiction. Post-construction monitoring should be formalized to detect violations before they become permanent.

b. Strengthen and expand existing incentive programmes for traditional materials Existing subsidy and tax relief mechanisms should be reviewed and strengthened - expanding eligibility, simplifying application procedures, and increasing subsidy values for Dachhi Appa bricks, Jhingati tiles, and carved timber - so that the cost difference between traditional and modern construction is meaningfully reduced at the individual building owner level.

c. Revise guidelines to accommodate ground floor security needs The guidelines should be revised to permit concealed rolling shutter mechanisms installed behind a traditional wooden facade panel, providing the security function that ground floor commercial users require while maintaining a compliant traditional appearance.

d. Conduct targeted awareness programmes on traditional roof form Heritage authorities should develop accessible technical guidance materials explaining the structural logic, thermal benefits, and cultural significance of the Jhingati tile roof, and addressing the widespread post-earthquake perception that flat concrete roofs are structurally safer.

e. Establish a periodic compliance monitoring system Both municipalities should adopt a standardized visual assessment approach covering key facade parameters as the basis for routine inspections of heritage residential buildings. Low-cost digital tools such as Kobo Toolbox are field-friendly and scalable for municipal staff use, enabling consistent monitoring over time.

f. Introduce a graduated response framework for non-compliant buildings A tiered remediation system should be established rather than relying on punitive enforcement alone. Excess storeys should be screened using traditional parapet forms at next renovation. Buildings with rolling shutters should be offered a subsidized wooden facade panel as a condition of future permit approval. Flat rooftops should be eligible for a phased Jhingati tile conversion scheme with municipal technical support. Practical, staged remediation tied to the renovation cycle is more likely to achieve lasting improvement than enforcement action alone.

5.3 Recommendation for further studies:

a. Combine visual assessment with qualitative interviews Further research should incorporate structured interviews with building owners, contractors, and municipal officials alongside visual facade assessment. This would provide a deeper understanding of the decision-making processes behind specific compliance failures and the motivations that lead building owners to preserve certain traditional elements while abandoning others.

b. Expand the study to a larger sample and additional cities A larger sample covering additional neighborhoods in both cities, and extending to the heritage zone of Kathmandu city, would allow more robust generalization of the findings and enable a statistically stronger comparison of compliance patterns across all three historic cities of the Kathmandu Valley World Heritage Site.

c. Conduct longitudinal compliance monitoring research Longitudinal research tracking compliance levels in the same buildings over time would provide valuable evidence on whether compliance is improving or deteriorating in response to enforcement efforts, incentive programmes, or broader economic changes. Such a study would be particularly useful in evaluating the long-term effectiveness of any policy interventions introduced in response to the findings of the present study.

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APPENDIX A: Facade Compliance Observation Checklist - Full Scoring Form (Kobo Toolbox Form)

Facade Compliance Observation Checklist - Full Scoring

General Information

Survey ID
Example: BKT-01 or PTN-01

City
- ◯ Bhaktapur
- ◯ Patan

Location / Area
Enter ward, tole, street, or local area name.

GPS Location
Capture GPS point.

latitude (x.y °)

longitude (x.y °)

altitude (m)

Section A. Compulsory Checks

1. Exposed brick façade
No paint / plaster / cladding.
- ◯ Yes
- ◯ No

2. Modern structure concealed
RCC / steel not visible on façade.
- ◯ Yes
- ◯ No

3. Windows wooden (traditional)
- ◯ Yes
- ◯ No

4. Windows vertically aligned
- ◯ Yes
- ◯ No

5. Windows odd-paneled
- ◯ Yes
- ◯ No

6. Ground floor has windows?
- ◯ Yes
- ◯ No

7. If yes, are ground-floor windows single-panel?
- ◯ Yes
- ◯ No

8. Doors wooden
- ◯ Yes
- ◯ No

9. No visible rolling shutters
Or they are concealed.
- ◯ Yes
- ◯ No

10. Traditional sloped tile roof
- ◯ Yes
- ◯ No

11. Wooden struts (Tundal) present under roof / balcony
- ◯ Yes
- ◯ No

12. Raised plinth (peti) visible
- ◯ Yes
- ◯ No

13. No visible modern elements
Example: AC units, tanks, etc.
- ◯ Yes
- ◯ No

14. Number of storeys
Visual count.

15. No cantilever projection visible
- ◯ Yes
- ◯ No

16. Façade ordered / symmetrical
- ◯ Yes
- ◯ No

17. Building aligned with street context
- ◯ Yes
- ◯ No

Section B. Conditional / Optional Elements

18. Balcony present?
- ◯ Yes
- ◯ No

19. If yes, is the balcony traditional wooden?
- ◯ Yes
- ◯ No

20. Cornice present?
- ◯ Yes
- ◯ No

21. If yes, is the cornice aligned with adjacent buildings?
- ◯ Yes
- ◯ No

22. Ventilation present?
- ◯ Yes
- ◯ No

23. If yes, is the ventilation in Aakhyjhyal (Eyed-window) form?
- ◯ Yes
- ◯ No

24. Small eaves / overhang present?
- ◯ Yes
- ◯ No

25. If yes, is it only at top level?
- ◯ Yes
- ◯ No

26. Any ornamentation present?
- ◯ Yes
- ◯ No

27. If yes, is it traditional?
- ◯ Yes
- ◯ No

28. General façade condition
- ◯ Good
- ◯ Moderate
- ◯ Poor

Remarks
Optional notes.

Total Score = 0 / 21
Compliance = 0%

APPENDIX B: Building Field Recording Form

The following form was used to record building identification details, GPS coordinates, storey count, overall facade condition, compliance score, and field notes for each building in the sample. Data were collected using Kobo Toolbox on a mobile device during field observation.

Field	**Entry**
Survey ID	Example: BKT-01 or PTN-01
City	◯ Bhaktapur ◯ Patan
Location/Area	Enter ward, tole, street, or local area name
GPS location	Latitude/Longitude captured automatically
Full facade photo	Photograph uploaded via Kobo Toolbox
SECTION A: COMPULSORY CHECKS	
1. Exposed brick facade	◯ Yes ◯ No (No paint/plaster/cladding)
2. Modern structure concealed	◯ Yes ◯ No (RCC/steel not visible on facade)
3. Windows wooden (traditional)	◯ Yes ◯ No
4. Windows vertically aligned	◯ Yes ◯ No
5. Windows odd-paneled	◯ Yes ◯ No
6. Ground floor has windows?	◯ Yes ◯ No
7. If yes, are ground-floor windows single-panel?	◯ Yes ◯ No (conditional)
8. Doors wooden	◯ Yes ◯ No
9. No visible rolling shutters	◯ Yes ◯ No (or they are concealed)

Field	Entry
10. Traditional sloped tile roof	◯ Yes ◯ No
11. Wooden struts (Tundal) present	◯ Yes ◯ No
12. Raised plinth (peti) visible	◯ Yes ◯ No
13. No visible modern elements	◯ Yes ◯ No (e.g., AC units, tanks)
14. Number of storeys	Visual count (enter number)
15. No cantilever projection visible	◯ Yes ◯ No
16. Facade ordered/symmetrical	◯ Yes ◯ No
17. Building aligned with street context	◯ Yes ◯ No
SECTION B: CONDITIONAL/OPTIONAL ELEMENTS	
18. Balcony present?	◯ Yes ◯ No
19. If yes, is the balcony traditional wooden?	◯ Yes ◯ No (conditional)
20. Cornice present?	◯ Yes ◯ No
21. If yes, is cornice aligned with adjacent buildings?	◯ Yes ◯ No (conditional)
22. Ventilation present?	◯ Yes ◯ No
23. If yes, is ventilation in Aakhyi Jhyal form?	◯ Yes ◯ No (conditional)
24. Any ornamentation present?	◯ Yes ◯ No

Field	Entry
25. If yes, is it traditional?	◯ Yes ◯ No (conditional)
26. General facade condition	◯ Good ◯ Moderate ◯ Poor
Remarks	Optional notes
Total score	___ / 21
Compliance (%)	____%

APPENDIX C: Building-by-Building Compliance Data

Bhaktapur (BKT-01 to BKT-40)

Table C.1 presents the compliance score, compliance percentage, compliance category, storey count, roof type, rolling shutter status, and key violations recorded for each of the 40 buildings observed in Bhaktapur.

ID	Neighborhood	Score/21	Score %	Category	Storeys	Roof	Shutters	Key violations
BKT-01	Dattatreya	18	85.7	Compliant	4	Tiled	No	Minor wall plaster
BKT-02	Dattatreya	19	90.5	Compliant	4	Tiled	No	None significant
BKT-03	Taumadhi	21	100.0	Compliant	4	Tiled	No	None
BKT-04	Taumadhi	20	95.2	Compliant	4	Tiled	No	AC unit visible
BKT-05	Taumadhi	21	100.0	Compliant	3	Tiled	No	None
BKT-06	Durbar Sq.	17	81.0	Compliant	4	Tiled	No	Aluminium windows
BKT-07	Durbar Sq.	16	76.2	Compliant	5	Tiled	Yes	Rolling shutter, extra storey
BKT-08	Golmadi	15	71.4	Partial	5	Flat	Yes	Flat roof, shutters, extra storey

ID	Neighborhood	Score/21	Score %	Category	Storeys	Roof	Shutters	Key violations
BKT-09	Golmadi	10	47.6	Non-compliant	6	Flat	Yes	Multiple violations
BKT-10	Golmadi	14	66.7	Partial	5	Flat	Yes	Flat roof, shutters
BKT-11	Sukuldhoka	16	76.2	Compliant	4	Tiled	No	Cement plaster
BKT-12	Sukuldhoka	15	71.4	Partial	4	Flat	Yes	Flat roof, shutters
BKT-13	Sukuldhoka	17	81.0	Compliant	4	Tiled	Yes	Rolling shutter
BKT-14	Mangal Tole	18	85.7	Compliant	4	Tiled	No	Minor deviations
BKT-15	Mangal Tole	16	76.2	Compliant	5	Tiled	No	Extra storey
BKT-16	Mangal Tole	13	61.9	Partial	5	Flat	Yes	Flat roof, shutters, extra storey
BKT-17	Bhadrakali	17	81.0	Compliant	4	Tiled	No	Minor
BKT-18	Bhadrakali	15	71.4	Partial	4	Flat	Yes	Flat roof, shutters
BKT-19	Bhadrakali	18	85.7	Compliant	4	Tiled	No	Aluminium windows

ID	Neighborhood	Score/21	Score %	Category	Storeys	Roof	Shutters	Key violations
BKT-20	Bhadrakali	14	66.7	Partial	5	Flat	Yes	Extra storey, flat roof
BKT-21	Taumadhi	19	90.5	Compliant	4	Tiled	No	Minor
BKT-22	Taumadhi	17	81.0	Compliant	4	Tiled	Yes	Rolling shutter
BKT-23	Durbar Sq.	16	76.2	Compliant	4	Tiled	No	Paint on wall
BKT-24	Durbar Sq.	15	71.4	Partial	5	Tiled	Yes	Shutters, extra storey
BKT-25	Taumadhi	21	100.0	Compliant	4	Tiled	No	None
BKT-26	Dattatreya	18	85.7	Compliant	4	Tiled	No	Minor
BKT-27	Dattatreya	16	76.2	Compliant	4	Flat	No	Flat roof
BKT-28	Golmadi	14	66.7	Partial	5	Flat	Yes	Flat roof, shutters
BKT-29	Golmadi	15	71.4	Partial	4	Flat	Yes	Flat roof, shutters
BKT-30	Sukuldhoka	17	81.0	Compliant	4	Tiled	No	Minor

ID	Neighborhood	Score/21	Score %	Category	Storeys	Roof	Shutters	Key violations
BKT-31	Sukuldhoka	16	76.2	Compliant	4	Tiled	Yes	Shutters
BKT-32	Sukuldhoka	13	61.9	Partial	5	Flat	Yes	Flat roof, shutters, extra storey
BKT-33	Mangal Tole	18	85.7	Compliant	4	Tiled	No	Minor
BKT-34	Mangal Tole	15	71.4	Partial	5	Tiled	Yes	Shutters, extra storey
BKT-35	Bhadrakali	17	81.0	Compliant	4	Tiled	No	Aluminium windows
BKT-36	Bhadrakali	14	66.7	Partial	5	Flat	Yes	Flat roof, extra storey
BKT-37	Taumadhi	19	90.5	Compliant	4	Tiled	No	None
BKT-38	Durbar Sq.	17	81.0	Compliant	4	Tiled	No	Minor
BKT-39	Durbar Sq.	15	71.4	Partial	5	Flat	Yes	Flat roof, shutters
BKT-40	Golmadi	16	76.2	Compliant	4	Tiled	Yes	Shutters

Patan (PTN-01 to PTN-40)

Table C.2 presents the compliance score, compliance percentage, compliance category, storey count, roof type, rolling shutter status, and key violations recorded for each of the 40 buildings observed in Patan.

ID	Neighborhood	Score/21	Score %	Category	Storeys	Roof	Shutters	Key violations
PTN-01	Durbar Sq.	19	90.5	Compliant	4	Tiled	No	Minor
PTN-02	Durbar Sq.	20	95.2	Compliant	4	Tiled	No	None
PTN-03	Durbar Sq.	21	100.0	Compliant	4	Tiled	No	None
PTN-04	Mangal Bazar	19	90.5	Compliant	4	Tiled	No	AC unit
PTN-05	Mangal Bazar	18	85.7	Compliant	4	Tiled	No	Minor
PTN-06	Mangal Bazar	17	81.0	Compliant	4	Tiled	Yes	Shutters
PTN-07	Mangal Bazar	18	85.7	Compliant	4	Tiled	No	Aluminium windows
PTN-08	Oku Bahal	17	81.0	Compliant	4	Tiled	No	Minor
PTN-09	Oku Bahal	19	90.5	Compliant	4	Tiled	No	None
PTN-10	Oku Bahal	16	76.2	Compliant	4	Flat	No	Flat roof

ID	Neighborhood	Score/21	Score %	Category	Storeys	Roof	Shutters	Key violations
PTN-11	Oku Bahal	18	85.7	Compliant	4	Tiled	Yes	Shutters
PTN-12	Tichhu Galli	15	71.4	Partial	5	Flat	Yes	Flat roof, shutters
PTN-13	Tichhu Galli	16	76.2	Compliant	4	Flat	No	Flat roof
PTN-14	Tichhu Galli	17	81.0	Compliant	4	Tiled	Yes	Shutters
PTN-15	Tichhu Galli	14	66.7	Partial	5	Flat	Yes	Extra storey, flat roof
PTN-16	Haka Bahal	18	85.7	Compliant	4	Tiled	No	Minor
PTN-17	Haka Bahal	19	90.5	Compliant	4	Tiled	No	None
PTN-18	Haka Bahal	17	81.0	Compliant	4	Tiled	No	Minor
PTN-19	Haka Bahal	16	76.2	Compliant	5	Tiled	Yes	Extra storey, shutters
PTN-20	Tichhu Galli	10	47.6	Non-compliant	5	Flat	Yes	Multiple violations
PTN-21	Durbar Sq.	20	95.2	Compliant	4	Tiled	No	None

ID	Neighborhood	Score/21	Score %	Category	Storeys	Roof	Shutters	Key violations
PTN-22	Durbar Sq.	19	90.5	Compliant	4	Tiled	No	Minor
PTN-23	Mangal Bazar	18	85.7	Compliant	4	Tiled	No	Minor
PTN-24	Mangal Bazar	17	81.0	Compliant	4	Tiled	Yes	Shutters
PTN-25	Durbar Sq.	21	100.0	Compliant	4	Tiled	No	None
PTN-26	Oku Bahal	18	85.7	Compliant	4	Tiled	No	Minor
PTN-27	Oku Bahal	16	76.2	Compliant	4	Flat	Yes	Flat roof, shutters
PTN-28	Tichhu Galli	15	71.4	Partial	5	Flat	Yes	Extra storey, flat roof
PTN-29	Tichhu Galli	17	81.0	Compliant	4	Tiled	No	Minor
PTN-30	Haka Bahal	18	85.7	Compliant	4	Tiled	No	None
PTN-31	Haka Bahal	19	90.5	Compliant	4	Tiled	No	None
PTN-32	Haka Bahal	16	76.2	Compliant	4	Flat	No	Flat roof
PTN-33	Mangal Bazar	18	85.7	Compliant	4	Tiled	No	Minor

ID	Neighborhood	Score/21	Score %	Category	Storeys	Roof	Shutters	Key violations
PTN-34	Mangal Bazar	15	71.4	Partial	5	Flat	Yes	Flat roof, shutters
PTN-35	Durbar Sq.	20	95.2	Compliant	4	Tiled	No	None
PTN-36	Oku Bahal	17	81.0	Compliant	4	Tiled	No	Minor
PTN-37	Tichhu Galli	14	66.7	Partial	5	Flat	Yes	Extra storey, flat roof
PTN-38	Haka Bahal	18	85.7	Compliant	4	Tiled	No	Minor
PTN-39	Durbar Sq.	19	90.5	Compliant	4	Tiled	No	None
PTN-40	Mangal Bazar	17	81.0	Compliant	4	Tiled	Yes	Shutters

APPENDIX D: Glossary of Key Newari Architectural Terms

Aakhyi Jhyal: Small circular or eye-shaped ventilation opening found in traditional Newari facades, typically positioned at the uppermost level of the wall or attic.

Bardali: Traditional wooden balcony projecting from the upper storeys of a Newari house, typically supported by wooden brackets and carved in traditional style.

Buigal: The attic or upper habitable space beneath the roof of a traditional Newari house; counted as a storey under the heritage zone regulations.

Cornice: Horizontal projecting band at each floor level of a traditional Newari facade, separating the storeys and aligning with corresponding bands on neighboring buildings.

Dachhi Appa: The traditional hand-made fired brick used for external walls in Kathmandu Valley construction, smaller and thinner than a standard brick, laid with very tight joints using silay mortar.

Jhingati: Traditional double-fired clay tile used for roofing in Newari construction; the standard roof material required by heritage zone guidelines.

Peti/Plinth: The raised platform or base course at the bottom of a traditional Newari house, elevating the ground floor above street level to protect walls from damp and flood water.

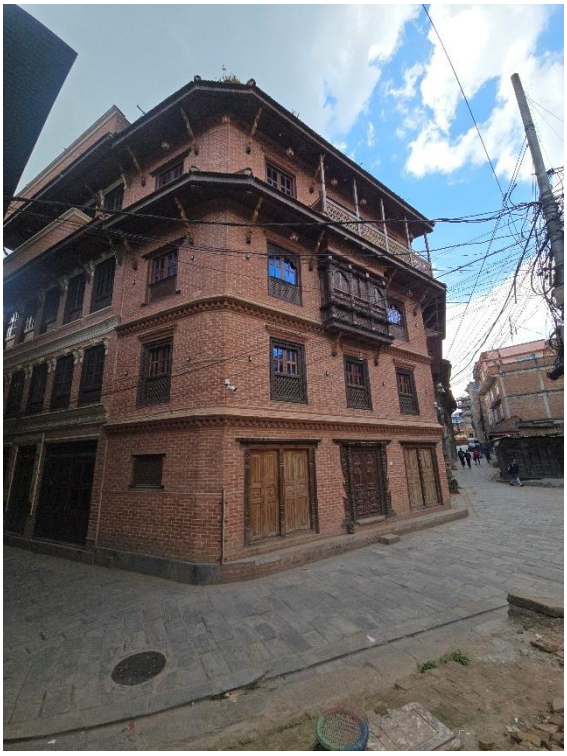
Silay: Traditional jointing mortar used with dachhi appa bricks on external walls, made from oil, vegetable resin, and red clay; provides water resistance and a characteristic deep-red colour.

Tikijhya: Traditional carved wooden window frame and surround used in Newari residential facades, typically multi-bayed and elaborately carved.

Tundal/Strut: Inclined wooden structural member supporting the projecting eaves or roof of a traditional Newari building, typically carved with decorative motifs.

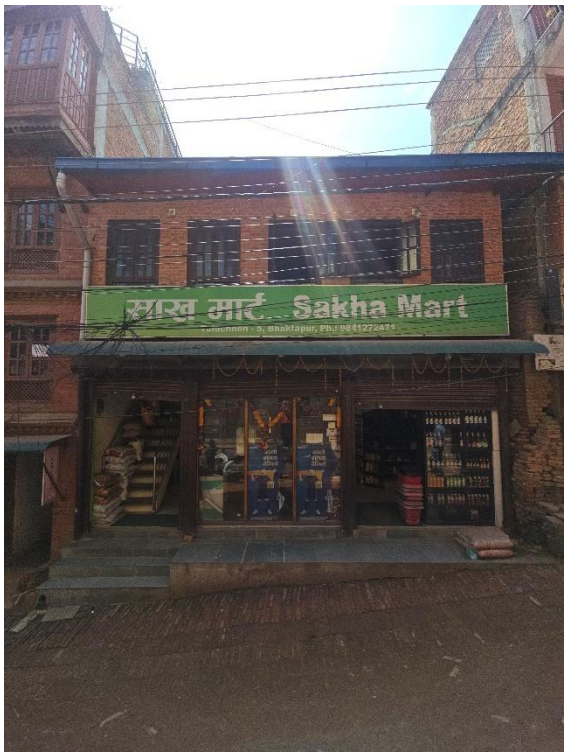
APPENDIX E: Field Photographs of Sampled Buildings

E.1 Bhaktapur (BKT-01 to BKT-40)

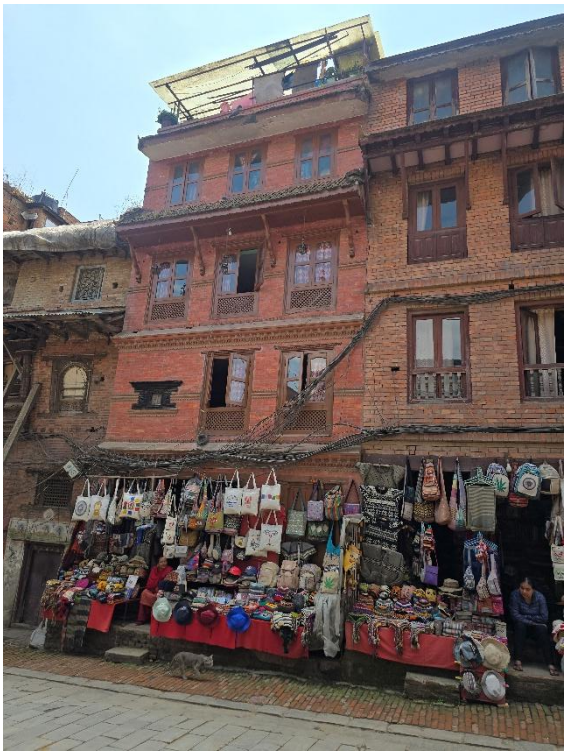


BKT-01 Ward No 9, Gachhen

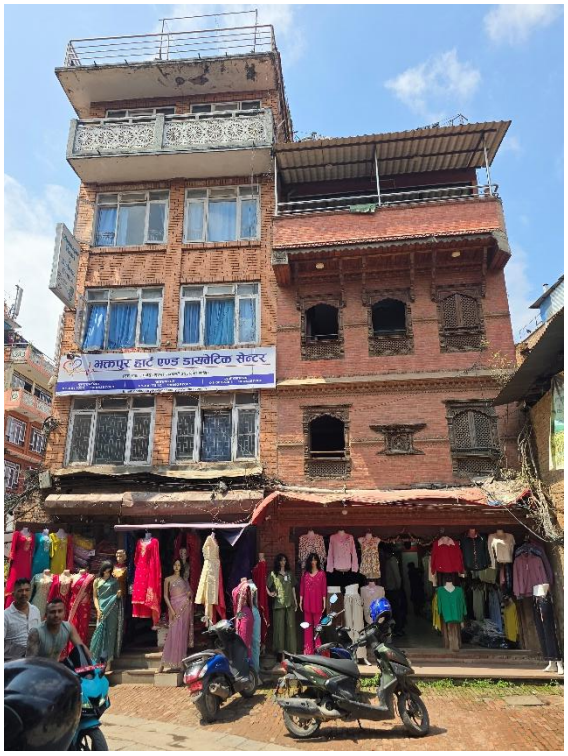
BKT-02 Ward No 5, Chasukhel



BKT-03 Sakotha-5

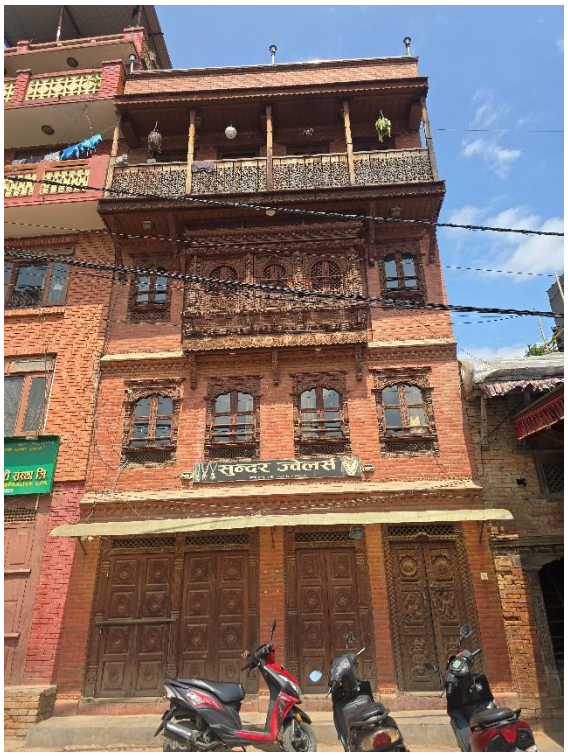


BKT-04 Tulachhen-5



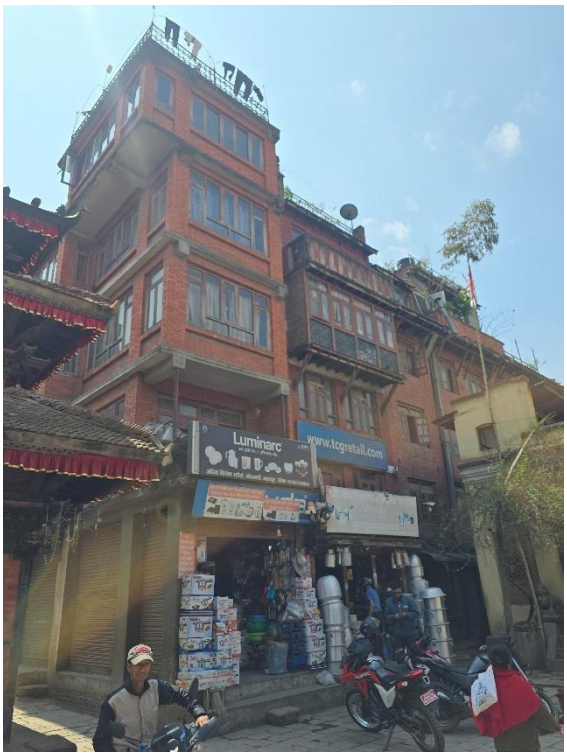
BKT-05 Sakotha-5

BKT-06 Sukuldhoka-5 (Left)



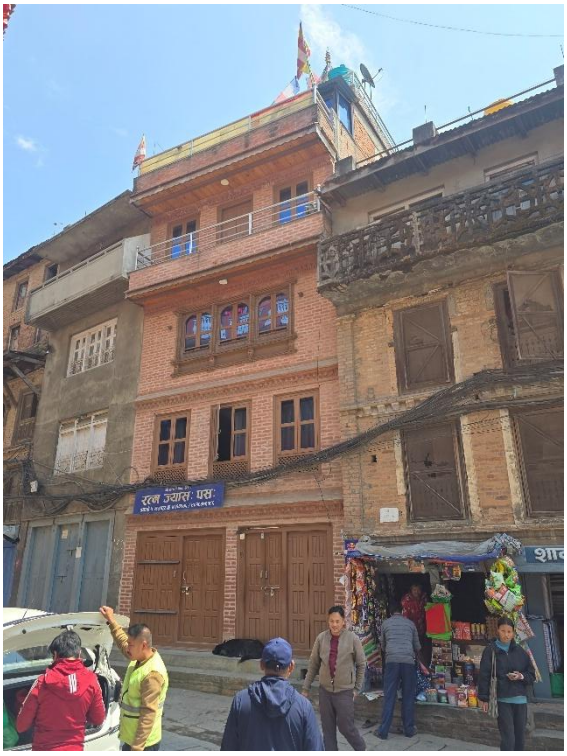
BKT-07 Sukuldhoka-5 (Right)

BKT-08 Ward No 5, Tulachhen

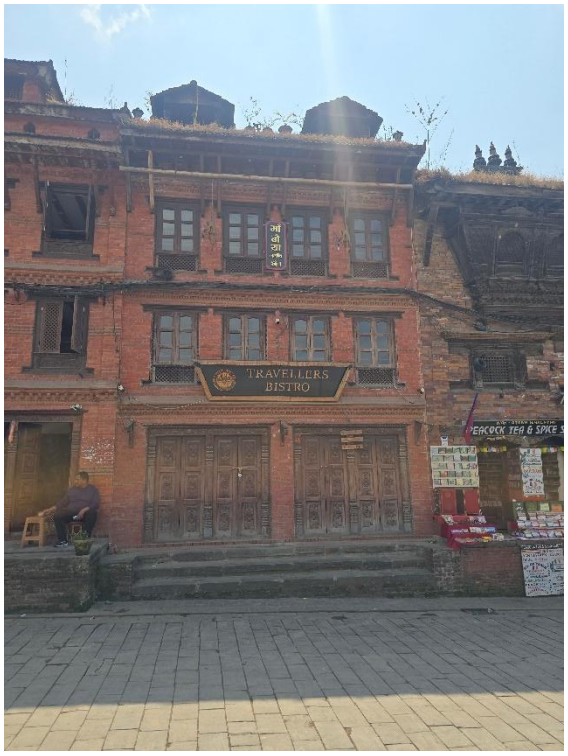


BKT-09 Golmadi

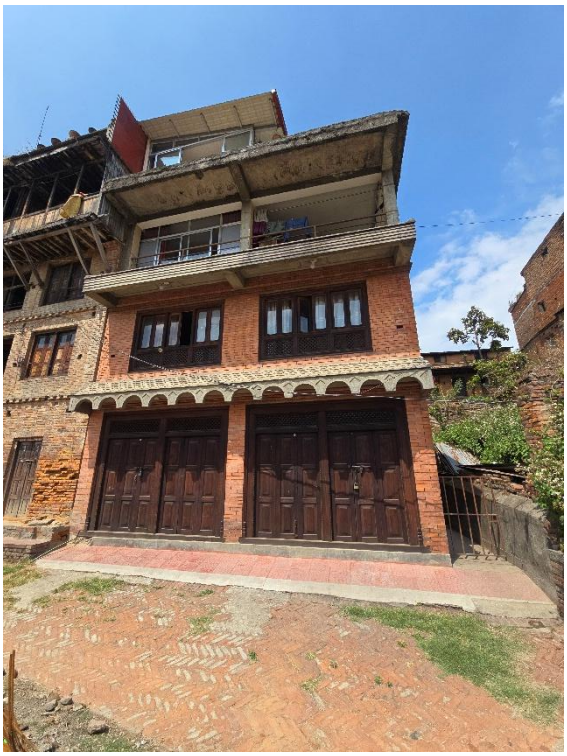
BKT-10 Golmadi-7



BKT-11 Inacho-7

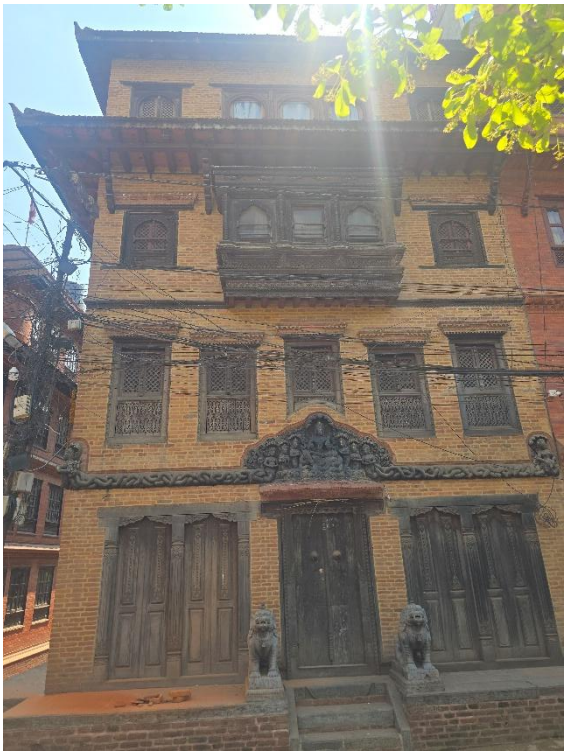


BKT-12 Dattatreya Square



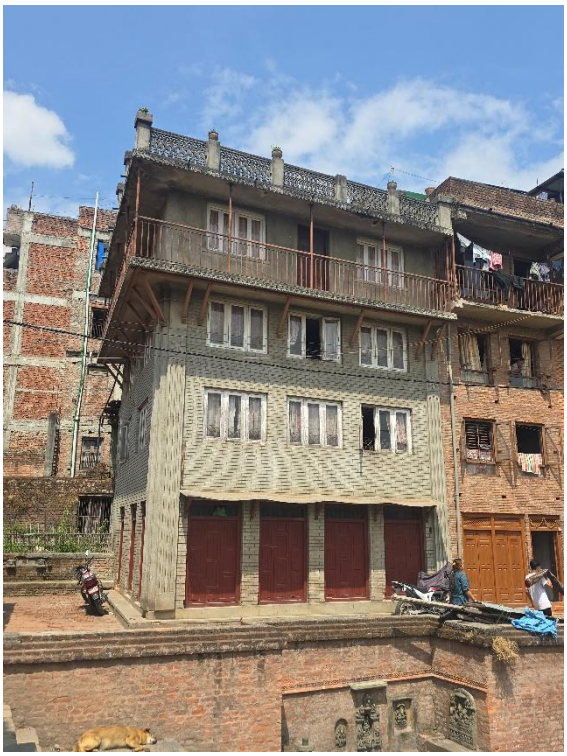
BKT-13 Ward No 9

BKT-14 Tachapaal-3



BKT-15 Nagpokhari

BKT-16 Nagpokhari



BKT-17 Nagpokhari

BKT-18 Thalachhen-10

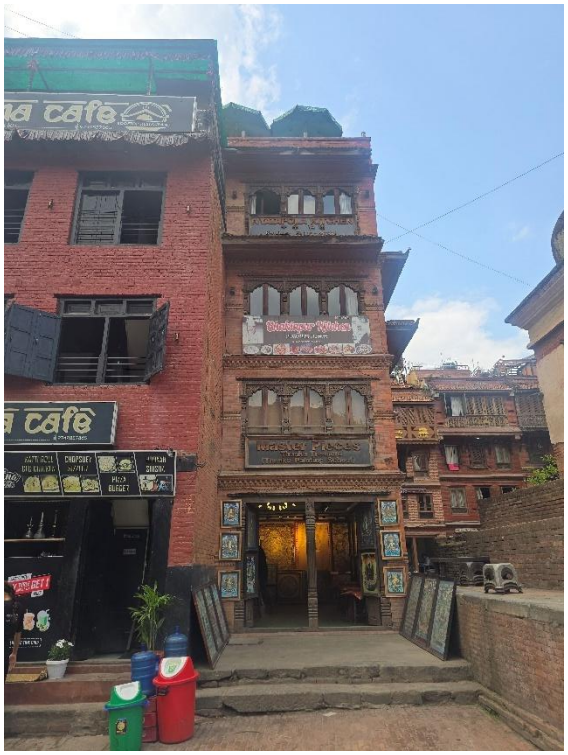
BKT-19 Bholachhen

BKT-20 Bholachhen

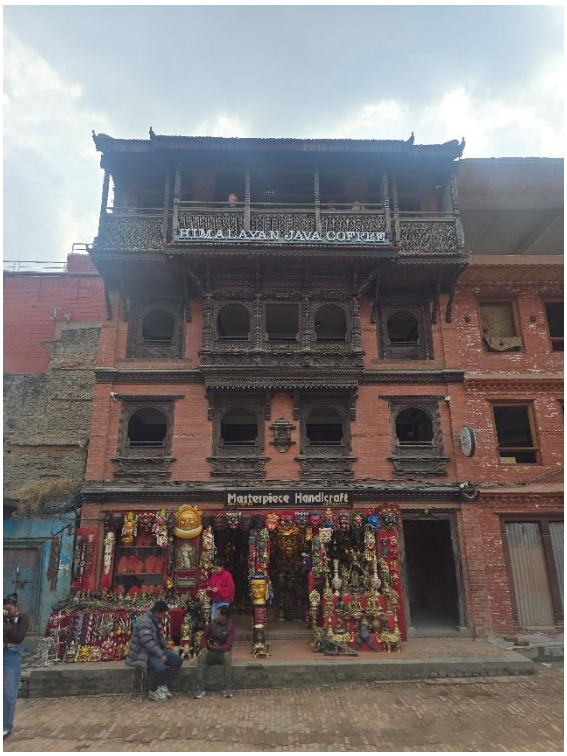
BKT-21 Bholachhen-6

BKT-22 Nasamana-3

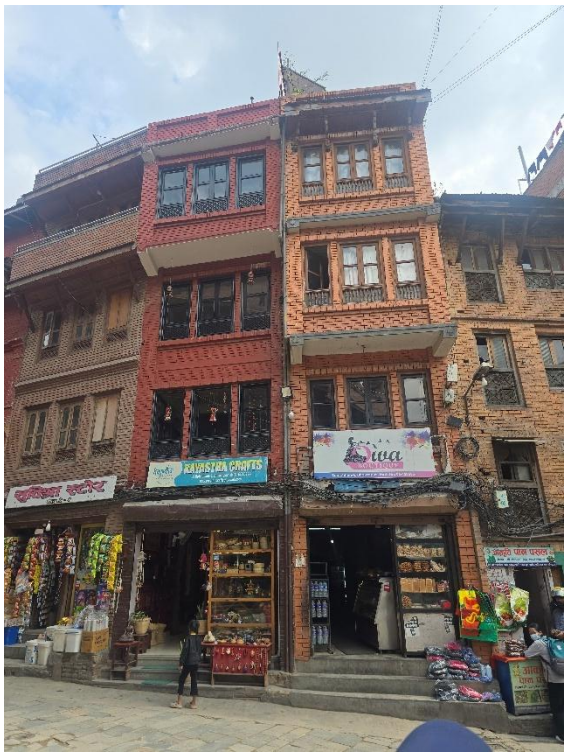
BKT-23 Nasamana-3



BKT-24 Taumadi



BKT-25 Taumadi

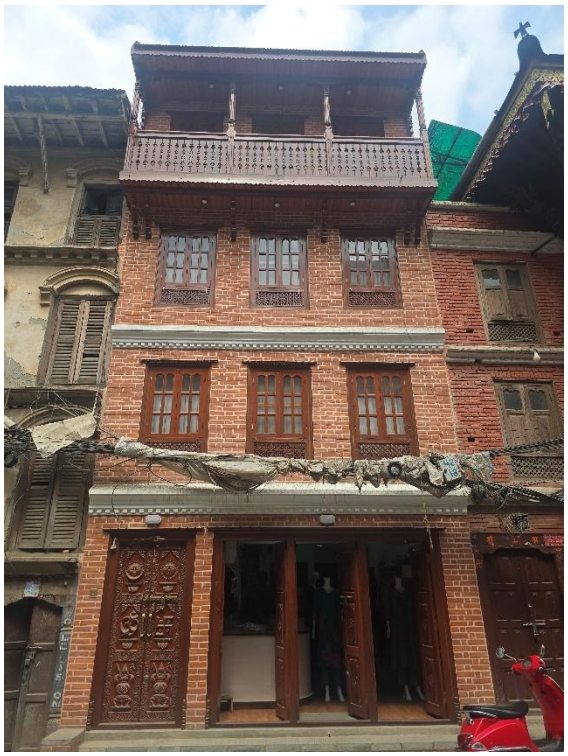


BKT-26 Bolachhen-4 (Red Color)

BKT-27 Taumadi

BKT-28 Nasamana

BKT-29 Nasamana



BKT-30 Bangshgopal-3

BKT-31 Bangshagopal-3

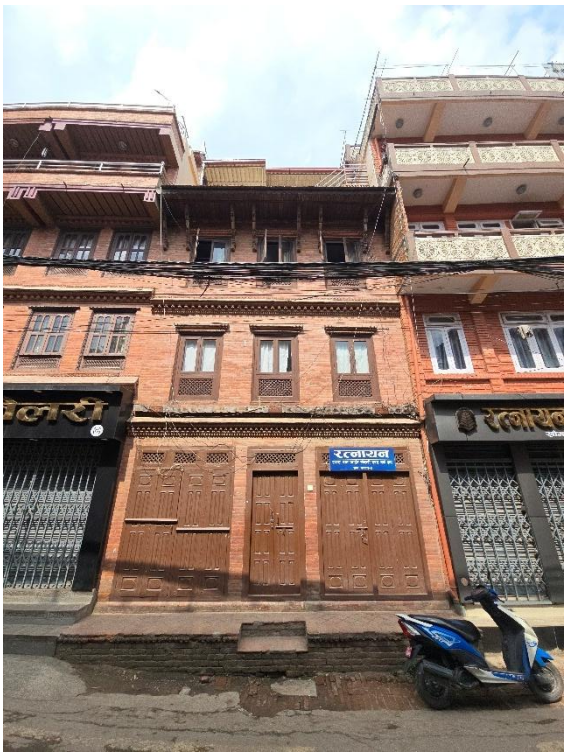
BKT-32 Tekhapukhu

BKT-33 Tekhapukhu

BKT-34 Tekhapukhu

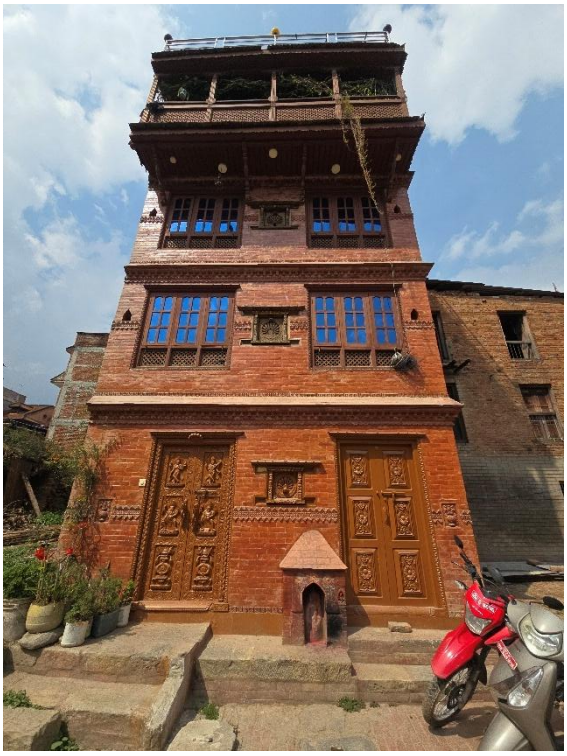
BKT-35 Tekhapukhu

BKT-36 Ittachhen

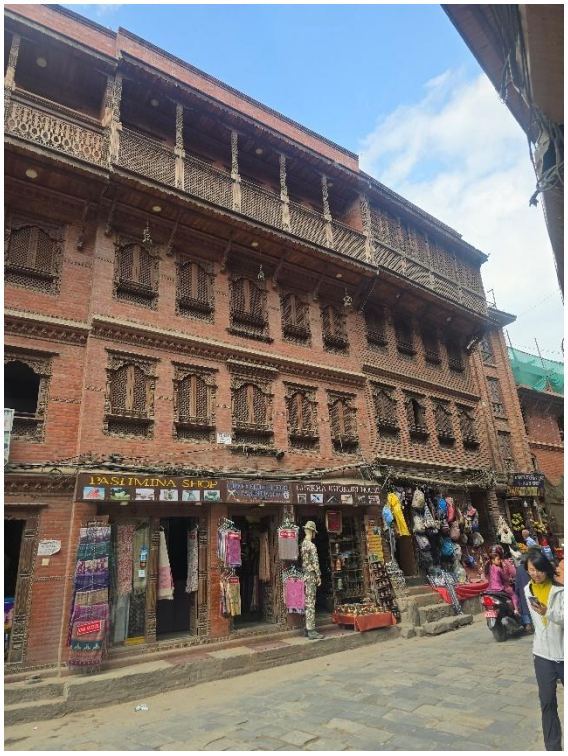


BKT-37 Khama-2

BKT-38 Khama (Red Color)

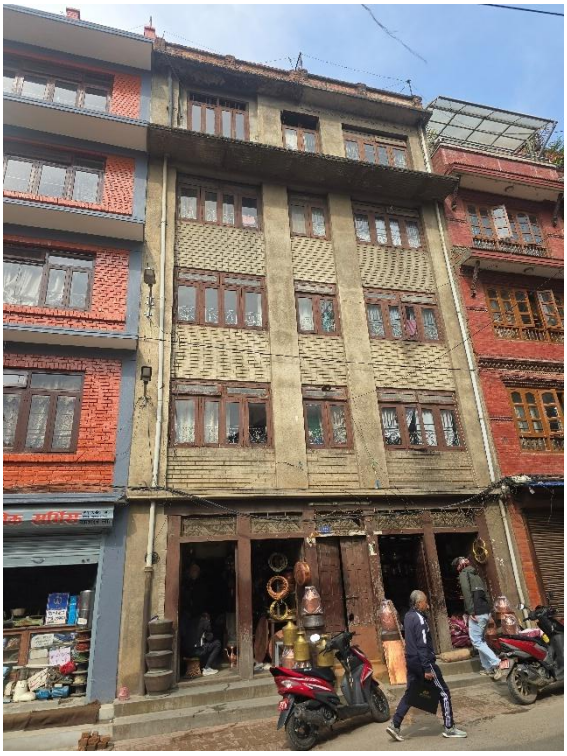


BKT-39 Khauma



BKT-40 Bolachhen

E.2 Patan (PTN-01 to PTN-40)

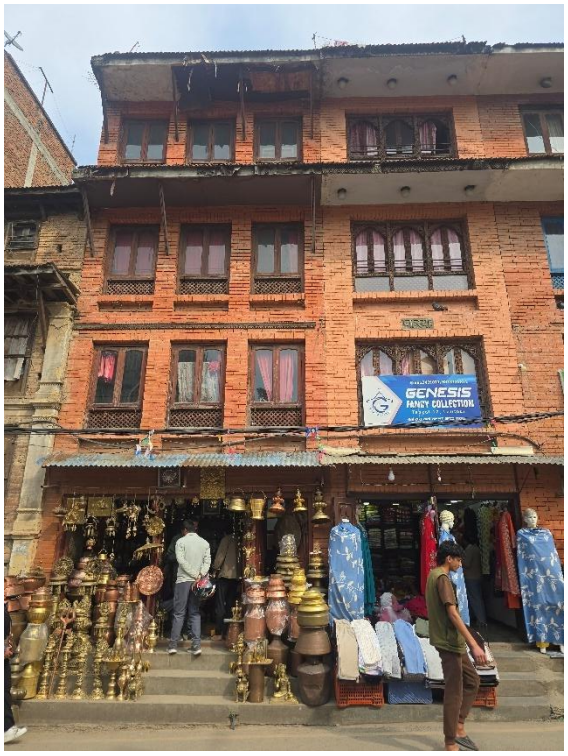


PTN-01 Chakrabahil

PTN-02 Chakrabahil

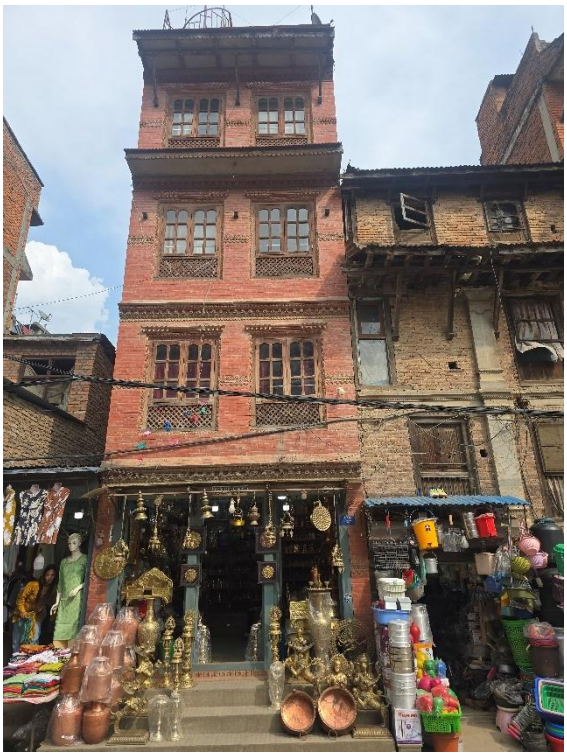
PTN-03 Nakabahe

PTN-04 Tichhu Galli



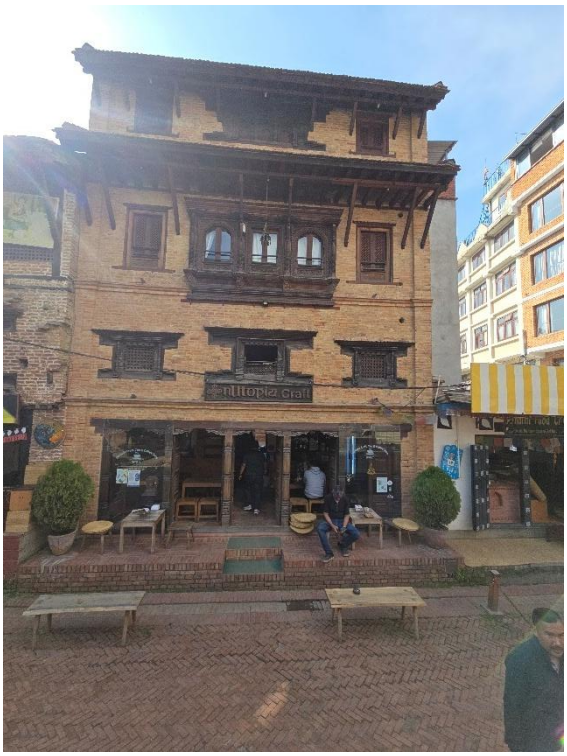
PTN-05 Tichhu Galli

PTN-06 Tangal



PTN-07 Tangal

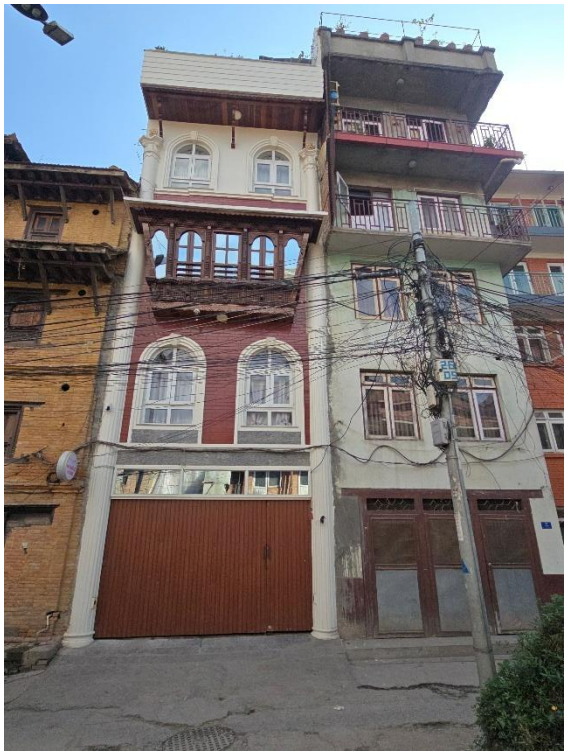
PTN-08 Kwalakhu Nhoolan Marg



PTN-09 Swotha

PTN-10 Swotha

PTN-11 Bangalamukhi

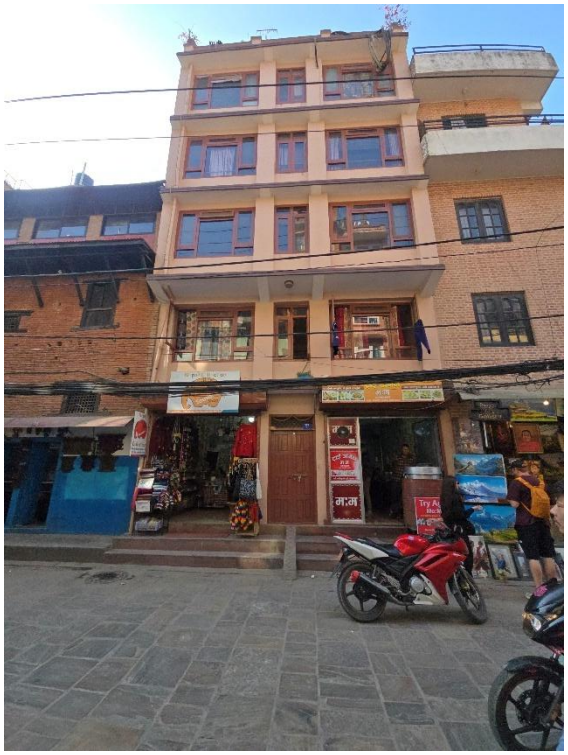


PTN-12 Thalachhen

PTN-13 Tunthi Marg

PTN-14 Tunthi Marg

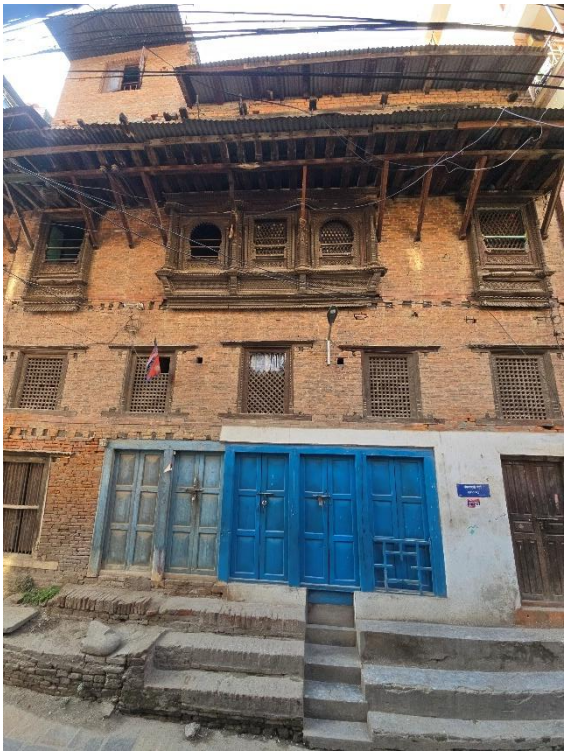
PTN-15 Vindhyolachhi



PTN-16 Swotha

PTN-17 Bangalamukhi

PTN-18 Bangalamukhi



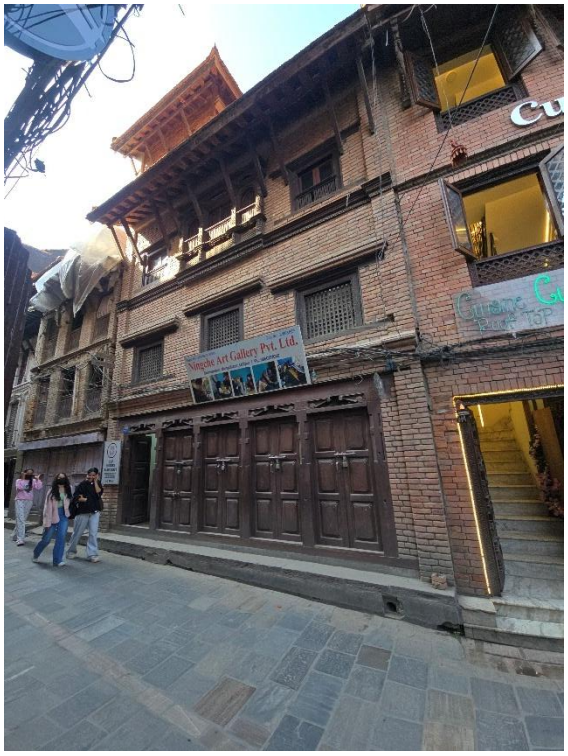
PTN-19 Bangalamukhi

PTN-20 Tichhu Galli

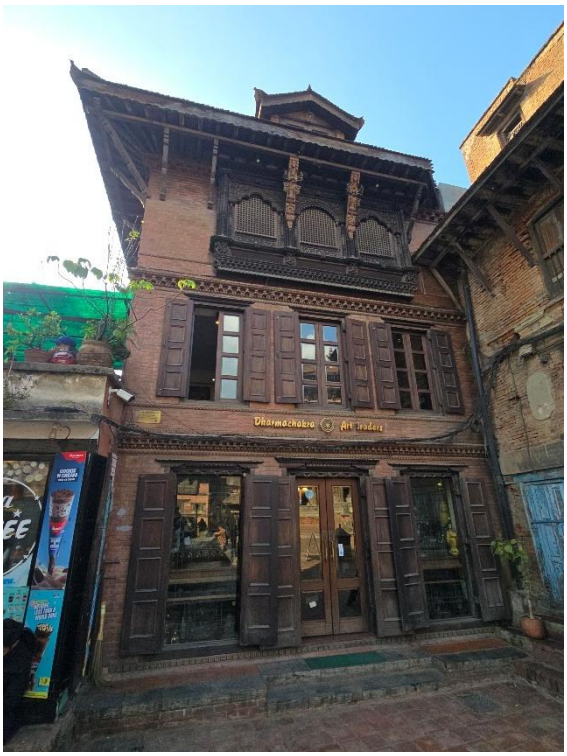
PTN-21 Kwalakhu

PTN-22 Kwalakhu

PTN-23 Kwalakhu



PTN-24 Bhimsenthan

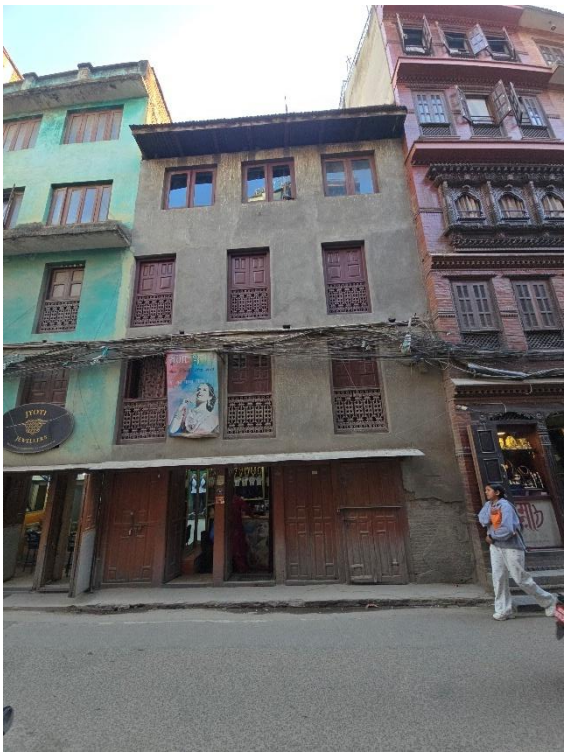


PTN-25 Durbar Square

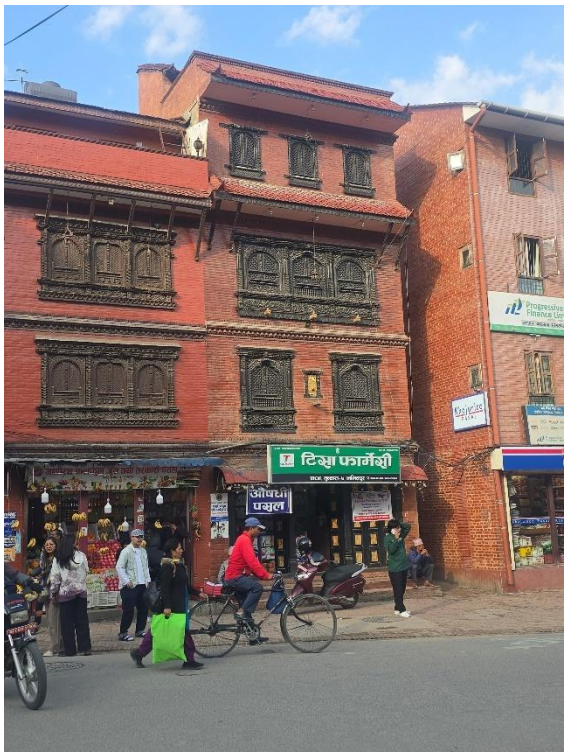
PTN-26 Hakha

PTN-27 Hakha

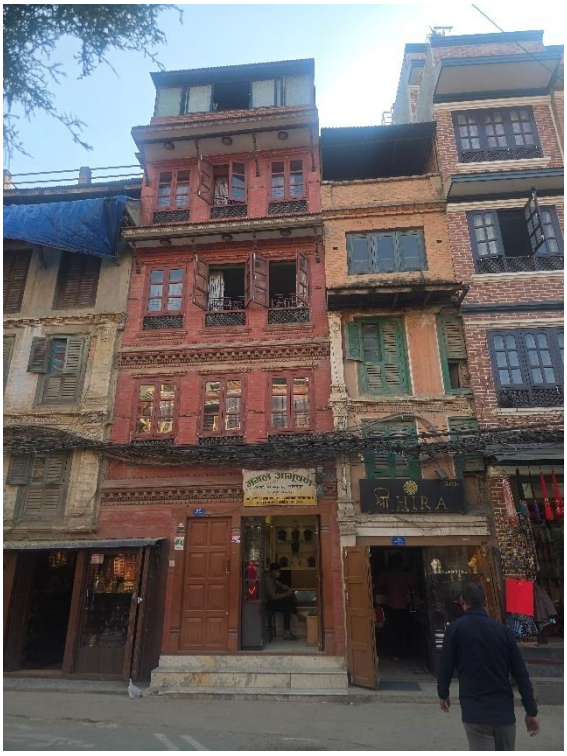
PTN-28 Hakha



PTN-29 Hakha



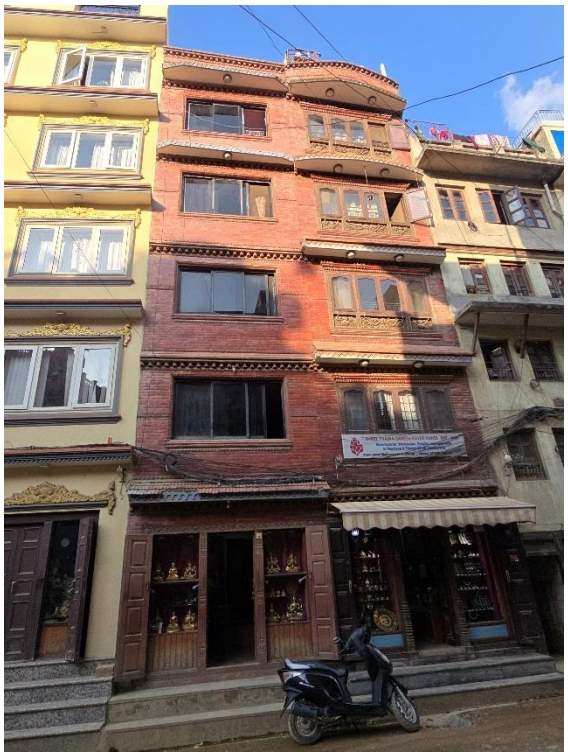
PTN-30 Sundhara



PTN-31 Hakha

PTN-32 Mahabaudhha

PTN-33 Thapahiti

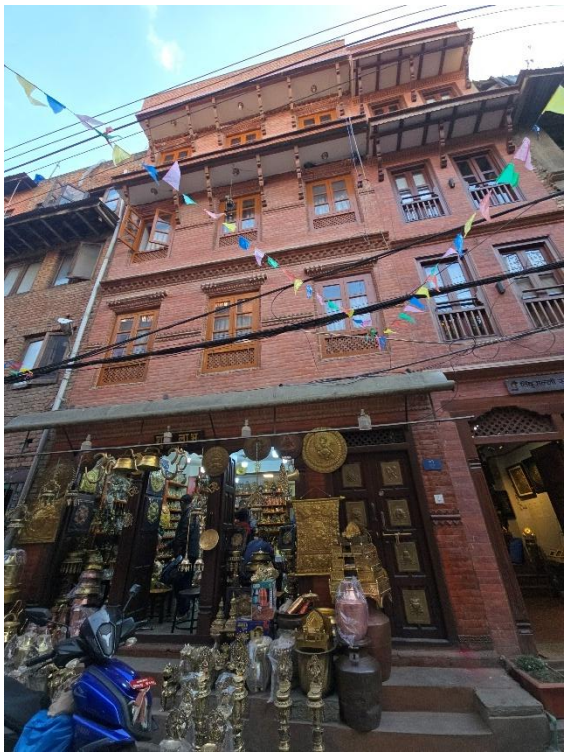


PTN-34 Yela

PTN-35 Mahapal

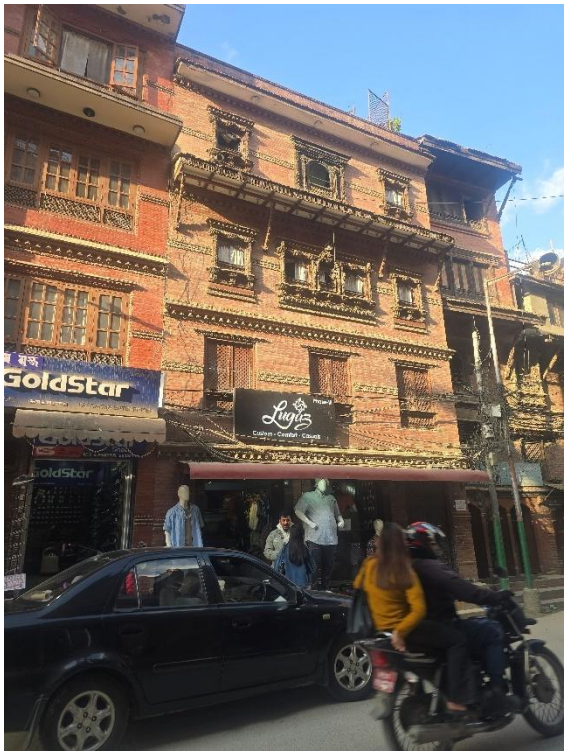
PTN-36 Mikhabahal

PTN-37 Mahabauddha



PTN-38 Tichhu Galli

PTN-39 Jhatapol



PTN-40 Gabahal

APPENDIX F: GPS Coordinates of Sampled Buildings

Table F.1 and Table F.2 present the GPS coordinates recorded via Kobo Toolbox for all 80 sampled buildings, together with their compliance score. Coordinates are in decimal degrees (WGS 84).

F.1 Bhaktapur (BKT-01 to BKT-40)

ID	Neighborhood	Latitude	Longitude	Score (/21)	Compliance (%)
BKT-01	Gachhen-9	27.674750	85.436140	20	95.2
BKT-02	Chasukhel-5	27.670720	85.431500	20	95.2
BKT-03	Sakotha-5	27.671730	85.430023	14	66.7
BKT-04	Tulachhen-5	27.672680	85.430790	11	52.4
BKT-05	Sakotha-5	27.671900	85.429620	19	90.5
BKT-06	Sukuldhoka-5	27.672100	85.430500	11	52.4
BKT-07	Sukuldhoka-5	27.672100	85.432000	18	85.7
BKT-08	Tulachhen-5	27.672750	85.430360	21	100.0
BKT-09	Golmadi	27.672510	85.432600	10	47.6
BKT-10	Golmadi-7	27.672500	85.433460	11	52.4
BKT-11	Inacho-7	27.672530	85.434220	15	71.4
BKT-12	DattareyaSquare	27.673340	85.435170	20	95.2
BKT-13	ward no 9	27.673980	85.434790	11	52.4
BKT-14	Tachapaal-3	27.673910	85.433890	17	81.0
BKT-15	Nagpokhari	27.674000	85.433450	21	100.0
BKT-16	Nagpokhari	27.674040	85.433380	18	85.7
BKT-17	Nagpokhari	27.674330	85.433220	15	71.4
BKT-18	Thalachhen-10	27.675920	85.433490	15	71.4

BKT-19	Bholachhen	27.675370	85.432340	21	100.0
BKT-20	Bholachhen	27.675440	85.432500	16	76.2
BKT-21	Bholachhen-6	27.675060	85.431810	11	52.4
BKT-22	Nasamana-3	27.670620	85.427230	18	85.7
BKT-23	Nasamana-3	27.670610	85.427070	14	66.7
BKT-24	Taumadi	27.671400	85.429930	20	95.2
BKT-25	Taumadi	27.670910	85.429250	21	100.0
BKT-26	Bolachhen-4	27.670390	85.428580	14	66.7
BKT-27	Taumadi	27.670900	85.429560	21	100.0
BKT-28	Nasamana	27.670580	85.426530	15	71.4
BKT-29	Nasamana	27.670560	85.426580	13	61.9
BKT-30	Bangshgopal-3	27.670890	85.425860	20	95.2
BKT-31	Bangshagopal-3	27.671150	85.425280	14	66.7
BKT-32	Tekhapukhu	27.671310	85.425120	21	100.0
BKT-33	Tekhapukhu	27.671320	85.425100	14	66.7
BKT-34	Tekhapukhu	27.671140	85.424570	21	100.0
BKT-35	Tekhapukhu	27.671550	85.424300	14	66.7
BKT-36	Ittachhen	27.672660	85.425000	13	61.9
BKT-37	Khama-2	27.672720	85.426470	20	95.2
BKT-38	Khama	27.672780	85.426700	14	66.7
BKT-39	Khauma	27.672140	85.426410	21	100.0
BKT-40	Bolachhen	27.670490	85.428650	20	95.2

F.2 Patan (PTN-01 to PTN-40)

ID	Neighborhood	Latitude	Longitude	Score (/21)	Compliance (%)
PTN-01	Chakrabahil	27.670698	85.325277	13	61.9
PTN-02	Chakrabahil	27.670635	85.325302	17	81.0
PTN-03	Nakabahe	27.670355	85.324982	20	95.2
PTN-04	Tichhu galli	27.671087	85.324932	19	90.5
PTN-05	Tichhu galli	27.671087	85.324932	20	95.2
PTN-06	Tangal	27.671485	85.324512	21	100.0
PTN-07	Tangal	27.671485	85.324512	21	100.0
PTN-08	Kwalakhu Nhoolan Marg	27.674696	85.325510	21	100.0
PTN-09	Swotha	27.675025	85.325470	21	100.0
PTN-10	Swotha	27.675010	85.325528	12	57.1
PTN-11	Bangalamukhi	27.675212	85.325993	17	81.0
PTN-12	Thalachhen	27.675458	85.325848	15	71.4
PTN-13	Tunthi Marg	27.674508	85.326398	20	95.2
PTN-14	Tunthi Marg	27.674435	85.326286	20	95.2
PTN-15	Vindhyolachhi	27.674151	85.327393	20	95.2
PTN-16	Swotha	27.675275	85.325941	13	61.9
PTN-17	Bangalamukhi	27.675532	85.326314	20	95.2
PTN-18	Bangalamukhi	27.676177	85.326111	18	85.7
PTN-19	Bangalamukhi	27.676041	85.325361	20	95.2
PTN-20	TIchhu galli	27.671960	85.324900	10	47.6

PTN-21	Kwalakhu	27.674984	85.324680	21	100.0
PTN-22	Kwalakhu	27.674866	85.324820	19	90.5
PTN-23	Kwalakhu	27.674890	85.324823	20	95.2
PTN-24	Bhimsenthan	27.674021	85.325061	20	95.2
PTN-25	Durbar Square	27.673741	85.324971	21	100.0
PTN-26	Hakha	27.672055	85.325586	21	100.0
PTN-27	Hakha	27.672068	85.325571	12	57.1
PTN-28	Hakha	27.671920	85.325712	18	85.7
PTN-29	Hakha	27.671340	85.326217	14	66.7
PTN-30	Sundhara	27.669822	85.328006	21	100.0
PTN-31	Hakha	27.671920	85.325712	20	95.2
PTN-32	Mahabaudhha	27.668718	85.327129	13	61.9
PTN-33	Thapahiti	27.669317	85.326579	21	100.0
PTN-34	Yela	27.669768	85.326263	13	61.9
PTN-35	Mahapal	27.673793	85.323344	14	66.7
PTN-36	Mikhabahal	27.676635	85.321411	13	61.9
PTN-37	Mahabauddha	27.668934	85.326870	13	61.9
PTN-38	Tichhu galli	27.672218	85.323922	20	95.2
PTN-39	Jhatapol	27.675820	85.325156	19	90.5
PTN-40	Gabahal	27.673869	85.322432	20	95.2

APPENDIX G: Chi-Square Test Calculations

G.1 Chi-Square Calculation: Facade Physical Condition

Mathematical Calculation

Expected frequency:

E = (Row Total × Column Total) / Grand Total = (40 × 50) / 80 = 25.0 (for Good); (40 × 24) / 80 = 12.0 (for Moderate); (40 × 6) / 80 = 3.0 (for Poor)

Chi-square formula:

$$\chi^2 = \Sigma (O - E)^2 / E$$

Substituting values:

$\chi^2 = (22-25)^2/25 + (14-12)^2/12 + (4-3)^2/3 + (28-25)^2/25 + (10-12)^2/12 + (2-3)^2/3$

$= (-3)^2/25 + (2)^2/12 + (1)^2/3 + (3)^2/25 + (-2)^2/12 + (-1)^2/3$

$= 9/25 + 4/12 + 1/3 + 9/25 + 4/12 + 1/3$

$= 0.360 + 0.333 + 0.333 + 0.360 + 0.333 + 0.333$

$= \mathbf{2.053}$

Degrees of freedom:

df = (r − 1) × (c − 1) = (2 − 1) × (3 − 1) = 1 × 2 = **2**

Result

The calculated value is:

$\chi^2 = 2.053$, df = 2, p-value = 0.358

G.2 Chi-Square Calculation: No Visible Rolling Shutters

Mathematical Calculation

Expected frequency:

E (Compliant) = (40 × 36) / 80 = 18.0

E (Non-Compliant) = (40 × 44) / 80 = 22.0

Chi-square formula:

$\chi^2 = \Sigma (O - E)^2 / E$

Substituting values:

$\chi^2 = (16-18)^2/18 + (24-22)^2/22 + (20-18)^2/18 + (20-22)^2/22$

$= (-2)^2/18 + (2)^2/22 + (2)^2/18 + (-2)^2/22$

$= 4/18 + 4/22 + 4/18 + 4/22$

$= 0.222 + 0.182 + 0.222 + 0.182 = 0.808$

Degrees of freedom:

df = (2 − 1) × (2 − 1) = **1**

Result

The calculated value is:

$\chi^2 = 0.808$, df = 1, p-value = 0.369

G.3 Chi-Square Calculation: Traditional Sloped Tile Roof

Mathematical Calculation

Expected frequency:

E (Compliant) = (40 × 43) / 80 = 21.5

E (Non-Compliant) = (40 × 37) / 80 = 18.5

Chi-square formula:

$\chi^2 = \Sigma (O - E)^2 / E$

Substituting values:

$\chi^2 = (18-21.5)^2/21.5 + (22-18.5)^2/18.5 + (25-21.5)^2/21.5 + (15-18.5)^2/18.5$

$= (-3.5)^2/21.5 + (3.5)^2/18.5 + (3.5)^2/21.5 + (-3.5)^2/18.5$

$= 12.25/21.5 + 12.25/18.5 + 12.25/21.5 + 12.25/18.5$

$= 0.570 + 0.662 + 0.570 + 0.662 = 2.464$

Degrees of freedom:

df = (2 − 1) × (2 − 1) = **1**

Result

The calculated value is:

$\chi^2 = 2.464$, df = 1, p-value = 0.117

G.4 Chi-Square Calculation: Storey Count Compliance

Mathematical Calculation

Expected frequency:

E (Compliant) = (40 × 51) / 80 = 25.5

E (Non-Compliant) = (40 × 29) / 80 = 14.5

Chi-square formula:

$\chi^2 = \Sigma (O - E)^2 / E$

Substituting values:

$\chi^2 = (22-25.5)^2/25.5 + (18-14.5)^2/14.5 + (29-25.5)^2/25.5 + (11-14.5)^2/14.5$

$= (-3.5)^2/25.5 + (3.5)^2/14.5 + (3.5)^2/25.5 + (-3.5)^2/14.5$

$= 12.25/25.5 + 12.25/14.5 + 12.25/25.5 + 12.25/14.5$

$= 0.480 + 0.845 + 0.480 + 0.845 = 2.650$

Degrees of freedom:

df = (2 − 1) × (2 − 1) = **1**

Result

The calculated value is:

$\chi^2 = 2.650$, df = 1, p-value = 0.104

APPENDIX H: Acceptance Letter - IOE Graduate Conference

Pulchowk Campus
Institute of Engineering
Tribhuvan University

AASHISH KOIRALA <080mscom001.aashish@pcampus.edu.np>

[IOEGC18] Editor Decision

1 message

Dr. Pradeep Shrestha <ioegc17@gmail.com> Tue, Apr 28, 2026 at 8:24 AM
To: Aashish Koirala <080mscom001.aashish@pcampus.edu.np>, Subash Kumar Bhattarai <subashkbhattarai@gmail.com>, Nagendra Bahadur <nbamatya@ioe.edu.np>

Aashish Koirala, Subash Kumar Bhattarai, Nagendra Bahadur:

We have reached a decision regarding your submission to 18th IOE Graduate Conference, "Facade Guideline Compliance in Heritage Residential Buildings: A Comparative Assessment of Bhaktapur and Patan".

Our decision is to: Accept Submission

With Warm Regards,
IOEGC-18 Editorial Team

APPENDIX I: Plagiarism Check for Originality

iThenticate

Similarity Report ID: oid:3117:584554674

PAPER NAME

A Comparative Study of Facade Guideline Compliance and Construction Management Issues in Residential Buildings within Heritage Zones of Bhaktapur and Patan

AUTHOR

Aashish Koirala

WORD COUNT

13436 Words

CHARACTER COUNT

83082 Characters

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60 Pages

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