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IMPLEMENTATION STATUS OF STEEL FRAMED COMMERCIAL BUILDNG IN KATHMANDU METROPOLITAN CITY

BY

SANGAM BHUJEL
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DECLARATION

I hereby declare that the thesis entitled "**Implementation Status of Steel Framed Commercial Building in Kathmandu Metropolitan City**", submitted to the Department of Civil Engineering in partial fulfillment of the requirements for the degree of Master of Science in Engineering in Construction Management, is a record of original work done under the guidance of Er. Subash Kumar Bhattarai and Assoc. Prof Nagendra Bahadur Amatya. This thesis contains only work completed by me except for the consulted material, which has been duly referenced and acknowledged.

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CERTIFICATE OF THESIS APPROVAL

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ABSTRACT

The Government of Nepal has established regulations to ensure safe building construction; however, effective enforcement remains a significant challenge, particularly at the local level where authorities are responsible for implementing the National Building Code and related provisions. This study examines the level of compliance with these regulations in the construction of steel-framed commercial buildings within Kathmandu Metropolitan City and identifies the key factors contributing to non-compliance, along with potential corrective measures. A mixed-method approach was adopted, incorporating field observations, questionnaire surveys, and Key Informant Interviews (KII), with the findings analyzed using the Relative Importance Index (RII) to rank both causes of non-compliance and corresponding control strategies. The results indicate that current construction practices are frequently inadequate despite the predominantly commercial use of such structures, with common deviations observed in member sizing, structural systems, connections, and welding practices. Although steel is favored for its rapid construction advantages, cost-driven design alterations often compromise structural integrity. Fabricators highlighted that client-induced modifications hinder adherence to approved designs, while a prevalent preference for welded over bolted connections—based on misconceptions regarding strength—can introduce additional safety concerns. The study further reveals that non-compliance is largely driven by limited awareness among owners, a tendency to rely on fabricators rather than qualified engineers, and insufficient regulatory oversight. To address these issues, the study recommends enhancing stakeholder awareness, providing targeted training for fabricators and engineers, and strengthening site inspection and monitoring mechanisms by municipal authorities to ensure safer and more compliant steel construction practices.

Keywords: *Steel-Framed Commercial Structures, Non-Compliance Factors, Steel Fabricators, Buildings Regulations, Construction Practices, Kathmandu Metropolitan City*

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LIST OF ABBREVIATIONS

CBS	Central Bureau of Statistics
CPS	Center for Post-Graduate Studies
DUDBC	Department of Urban Development and Building Construction
GESI	Global Earthquake Safety Initiative
IS	Indian Standard
KII	Key Informant Interview
KMC	Kathmandu Metropolitan City
LMC	Lalitpur Metropolitan City
LSMC	Lalitpur Sub-Metropolitan City
MPPW	Ministry of Physical Planning and Works
MRT	Mandatory Rules of Thumb
NBC	National Building Code
NBCDP	National Building Code Development Project
NBR	National Building Regulations
NNBC	Nepal National Building Code
OMRF	Ordinary Moment Resisting Frame
RCC	Reinforced Cement Concrete
RII	Relative Importance Index
SD	Standard Deviation
SMRF	Special Moment Resisting Frame
SPSS	Statistical Package for Social Science

1 INTRODUCTION

1.1 Background

Steel-framed structures have increasingly become a preferred choice in both global and Nepali construction practices due to their superior performance characteristics, including long-term durability, cost-effectiveness, and reduced maintenance requirements. Steel, being a structural alloy, exhibits high tensile strength, excellent ductility, and good resistance to environmental degradation, which makes it highly suitable for a wide range of applications in residential, commercial, and industrial buildings (Badal, Badal, & Shrestha, 2019).

Building codes play a crucial role in ensuring the safety and quality of construction. However, in countries like Nepal and Bangladesh, enforcement of these codes remains weak. A large portion of construction is informal, with over 80% of housing estimated to be non-compliant or only loosely guided by regulations (Bhattarai, 2017)

Nepal lies in a highly earthquake-prone region, and building collapses are the leading cause of earthquake-related deaths. Poor construction practices, rapid urbanization, and lack of preparedness have made cities like Kathmandu increasingly vulnerable (Chaulagain, 2015).The Global Earthquake Safety Initiative (GESI) found that nearly 85% of fatalities in Kathmandu during earthquakes were due to building collapses, underscoring the need for strict code enforcement (Guragain, 2019).

Nepal currently has 293 urban municipalities and 460 rural municipalities that are responsible for issuing building permits and managing urban planning activities. Despite this decentralized structure, effective enforcement remains limited due to shortages of qualified technical personnel and inadequate monitoring mechanisms. Achieving resilient construction requires not only the training of technicians but also increased awareness among all stakeholders, along with strengthening institutional frameworks to ensure better compliance. (Nepal. G. o., 2017)

1.2 Problem Statement

Although building codes for steel-framed structures were introduced in Nepal decades ago to enhance safety, effective implementation and enforcement remain limited (Ahmed, et al., 2019). While the Local Government Operation Act entrusts municipalities with the responsibility of enforcing these codes, in practice, compliance is weak and monitoring is insufficient (Rai, 2017). Typically, municipal engineers only inspect construction at the plinth level, with no follow-up during later stages (Maharjan, 2017).

The lack of specialized manpower, absence of dedicated enforcement sections, and weak institutional coordination have led to ineffective regulation (Bhattarai, 2017)Steel structures, although faster to build and more earthquake-resistant than RCC, are rarely monitored or approved according to proper procedures (Pangeni, 2021). Additionally, due to limited familiarity among local contractors and craftsmen, poor-quality materials and unskilled labor are often used (Lamichhane & Neupane, 2023).

Although numerous studies in Nepal have concentrated on reinforced concrete (RC) buildings, research on steel-framed structures—particularly regarding their compliance and implementation practices—remains limited. Existing literature shows that RC construction dominates the building sector in Nepal, indicating comparatively less academic attention toward alternative systems such as steel framing. (Bhusal, Pradhananga, Paudel, & Najam, 2024)

1.3 Research Objective

The primary objective of this research is to determine 'IMPLEMENTATION STATUS OF STEEL FRAMED COMMERCIAL BUILDNG IN KATHMANDU METROPOLITANCITY' whereas specific objectives are

- To assess the implementation status of steel-framed commercial building construction within Kathmandu Metropolitan City.
- To identify the key causes contributing to non-compliance with building codes in steel-framed commercial structures.
- To propose practical and effective measures for improving compliance in the construction of steel-framed commercial buildings.

1.4 Research Question

The Research question of the project is as follows:

- What is the current status of construction of steel-framed Commercial buildings in Kathmandu Metropolitan City?
- Which key factors contribute to non-compliance in steel-framed Commercial building construction in Kathmandu Metropolitan City?

- What strategies and interventions can be proposed to enhance building code compliance for steel-framed structures in Kathmandu Metropolitan City?

1.5 Significance Of Study

This study seeks to examine the level of adherence to registered drawings in steel-framed buildings and to explore the key factors contributing to construction non-compliance. It also aims to propose practical and effective strategies to improve compliance practices in such structures.

The significance of this research can be summarized as follows:

- The findings will support Kathmandu Metropolitan City in improving future planning, policy development, and regulatory implementation.
- The study will provide a clear picture of the existing compliance status of steel-framed buildings with approved drawings.
- The results can be used as a reference for other municipalities facing similar urban development challenges and construction practices.

Overall, the study emphasizes the importance of evaluating compliance with registered drawings in steel-framed commercial buildings within Kathmandu Metropolitan City, highlighting its role in improving construction quality, ensuring structural safety, and enhancing the effectiveness of regulatory systems.

1.6 Scope And Limitation of Study

1.6.1 Scope of the Study

The major scope of the study are as follows: -

- The study was carried out to check the compliance of the steel framed Commercial building on ongoing projects.
- The construction was compared to the registered drawing from the Kathmandu Metropolitan City to ensure compliance.

1.6.2 Limitations of the Study

- The study does not include an evaluation of quality assurance plans or quality control systems.
- The preparation of steel surfaces is beyond the scope of this research.
- A complete assessment of all compliance parameters during field investigations is not possible, as some buildings are either under construction or already completed.
- Residential steel structures are excluded from this study.

2 LITERATURE REVIEW

2.1 Background of the National Building Code (NBC)

The devastating 1988 earthquake in eastern Nepal caused extensive structural damage and s significant loss of life, exposing the weaknesses in the country's construction practices. This incident drew national attention to the urgent need for building safety and resilience. In response, the Government of Nepal sought technical assistance from the United Nations Development Programme (UNDP) and the United Nations Centre for Human Settlements (UNCHS/Habitat), initiating a three-year project titled *"Policy and Technical Support to the Urban Sector"*. Within this framework, the National Building Code Development Project (UNDP/UNCHS/Habitat Nep/88/054) was launched in 1992–1993 under the Department of Urban Development and Building Construction (DUDBC) (formerly the Department of Buildings), supported by international experts from New Zealand, Canada, and the USA (Sangachhe, 2009)

The National Building Code (NBC) was drafted in 1994 but lacked legal enforcement until the Building Act 1998 empowered the Ministry of Physical Planning and Works (MPPW) to implement it. A notable development occurred in 2006, when NBC implementation was officially mandated in all municipalities and selected Village Development Committees (VDCs) through a Gazette notification) (Subedi & Mishima, 2008).

Although the Nepal National Building Code is mandated at the national level, its implementation differs from one municipality to another. As the capital and largest urban center, Kathmandu Metropolitan City (KMC) plays a crucial role in enforcing and promoting building regulations. While Lalitpur Sub-Metropolitan City was the first to adopt the code in 2003, Kathmandu soon followed due to growing concerns over rapid urban growth and uncontrolled construction practices. In recent years, KMC has enhanced its regulatory measures through building permit approval processes, compliance monitoring, and awareness initiatives aimed at relevant stakeholders. Nevertheless, challenges such as limited resources, insufficient technical capacity, and weak institutional coordination still restrict the full and effective enforcement of the building code.

The development of the NBC also faced technical and contextual challenges, such as Nepal's complex soil conditions, diverse construction materials, and varying climatic zones. Given time and cost constraints, the NBC Development Team chose a pragmatic approach—adopting international best practices and adapting them to Nepal's specific context. A comprehensive management plan was also developed to address legal, institutional, and operational frameworks needed for effective code implementation (Bothara, Bothara, Parajuli, Arya, & Sharpe, 2000)

2.2 National Building Code

The National Building Code (NBC) is a comprehensive set of guidelines and standards that regulate building design and construction practices, including provisions for structural design, construction materials, fire safety, electrical systems, plumbing, and other essential components to ensure safe and resilient buildings, particularly in earthquake-prone regions (Nepal, 1994).

In Nepal, the National Building Code (NBC) was initially developed in 1994 and has undergone periodic revisions, with the most recent version being NBC 2019. Based on design parameters and construction methodologies, the Building Act 2007 (First Amendment) and NBC 2003 classify buildings into the following categories:

Table 2.1: Classification of NBC

S.N.	Type of building Code	Purpose
1	Category "A": International State-of-the-art Applicable code: NBC 000	Related to large and irregular structures. They need to be designed following international codes.
2	Category 'B": Professionally engineered buildings Applicable codes: NBC 101, NBC 102, NBC 103, NBC 104, NBC 105, NBC 106, NBC 107, NBC 108, NBC 109, NBC 110, NBC 111, NBC 112, NBC 113, NBC 114, NBC 206, NBC 207, NBC 208	Building with plinth area> 1000 sq. ft, No. of Storey >3, span >4.5 m, and irregular in shape. It must be designed and constructed under the direct supervision of engineers.
3	Category "C": Mandatory Rules of Thumb (MRT) Applicable codes: NBC 201, NBC 202, NBC 205	Buildings with plinth area< 1000 sq. ft, No. of Storey < 3, span < 4.5m and regular. These buildings can be designed and constructed by technicians.
4	Category "D": Guidelines for remote rural buildings (low–strength masonry / earthen buildings) Applicable codes: NBC 203, NBC 204	Structures are constructed by local masons in remote areas and are maximum 2 stories (plus the attic).

Source: (Subedi & Mishima, 2008)

2.2.1 International State-of-the-Art

This category includes structures that are designed using advanced engineering approaches and modern analytical methods, often derived from building codes used in developed countries. Engineers in Nepal, together with international consultants, are capable of applying such sophisticated design practices, even when they are different from the national code provisions. However, it is important that these buildings still meet Nepal-specific requirements, especially regarding minimum design loads, seismic safety provisions, and appropriate structural configurations (Kandel, Shrestha, & Dixit, 2008).

2.2.2 Professionally Engineered Structures

This category includes buildings that are designed in accordance with standard code provisions recognized by professionally qualified engineers. These structures must satisfy the minimum requirements specified in the National Building Code of Nepal. The design and construction of such buildings require the direct involvement and supervision of licensed engineers to ensure structural safety, serviceability, and compliance with regulatory standards (Kandel, Shrestha, & Dixit, 2008).

2.2.3 Mandatory Rules of Thumb

In the context of Nepal, it is often not feasible to require professional engineers for the design of all small-scale buildings due to limited financial resources and technical capacity. As a result, the Mandatory Rules of Thumb (MRT) have been introduced within the building code to provide a simplified design method for structures that fall within defined limits of height, storeys, and floor area.

The accompanying guidelines and explanatory materials are developed in a way that can be easily understood and applied by trained technicians or junior engineers. This system supports the preparation of design details during both the building permit approval and construction stages. It also helps ensure a reasonable level of structural safety while accommodating the practical constraints of small-scale construction projects (Kandel, Shrestha, & Dixit, 2008)

2.2.4 Guidelines for Remote Rural Buildings

This category provides guidelines for approximately twelve common building typologies identified through a building inventory conducted in 1993. The primary objective is to recommend improvements to traditional construction practices in order to enhance seismic resistance.

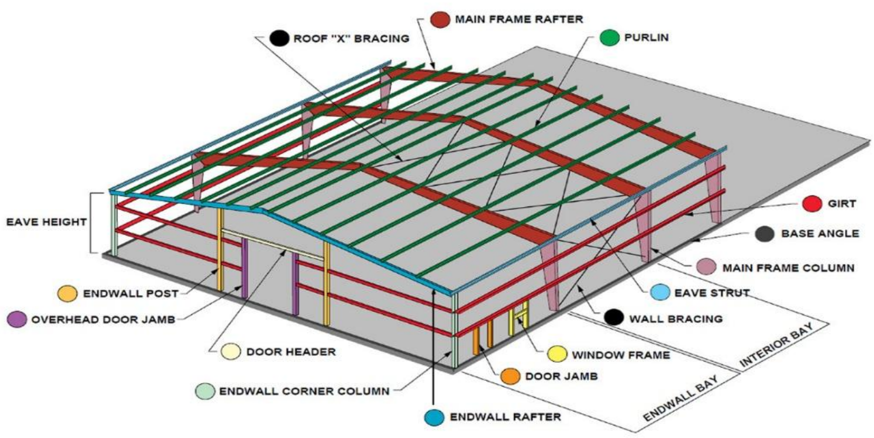
These buildings are typically constructed without modern engineering analysis or rational design methods and commonly use locally available materials such as unfired masonry, mud mortar, rubble stone, and dry stone. The guidelines focus on introducing simple yet effective modifications to improve the structural performance of these buildings under seismic loading, considering their inherent construction characteristics (Kandel, Shrestha, & Dixit, 2008)

Steel structures are comprised of structural steel parts that are connected to one another to support loads and offer complete stiffness. This construction is dependable and uses fewer raw materials than others like concrete structure and timber structure because of the high strength grade of steel. Structural steel is a type of steel that is manufactured with a particular shape and chemical make-up to meet the requirements of a project. The I-beam, HSS, Channels, Angles, and Plate are examples of common shapes (Saraogi, et al., 2018).

The choice of the right cross sections for the various parts of the structure being constructed is given the utmost importance during the design process. Instead of calling to produce a shape with unusual dimensions and qualities, this option will typically mean selecting a common, standard cross-sectional shape. Even if choosing a "off-the-shelf" item involves using a little bit more material, it will nearly always be the most cost-effective option (Segui, 2012).

2.3 Components of Steel Structures

Standard prefabricated steel buildings consist of various components that are engineered and manufactured at a steel fabrication shop before being transported to the construction site for assembly. Each component is designed by an in-house engineer and is prefabricated, meaning they are pre-cut, pre-welded, and pre-drilled, facilitating a streamlined and simplified assembly process. This approach ensures efficiency and ease of construction, as the components are specifically tailored to fit together seamlessly during on-site assembly (Swanton Welding Company, 2022).



Source: (Google Image, 2024)

Figure 2.1 : Components of Steel Structures

2.3.1 Primary Framing

The primary framing serves as the fundamental structural support of a steel building. It consists of various components that form the core framework of the structure. These components can be customized according to the specific budget and requirements of the building. This customization allows for flexibility in design and ensures that the primary framing meets the desired structural integrity while accommodating the unique needs of the structure. By tailoring the components to specific specifications, the primary framing provides a solid foundation for the overall steel building construction (Swanton Welding Company, 2022).

A) **Rigid Frames:** When constructing a building, it typically consists of two or more rigid frames, the exact number depending on the length of the building. These rigid frames play a critical role in providing structural support. In particular, the interior rigid frames are specifically designed to support half of each adjacent bay.

B) **Beams and Columns:** In the construction of each rigid frame, there are typically two columns, often constructed using I-beams. These columns can be either straight or tapered in shape.

C) **Rafters:** Each rigid frame in a building will feature two rafters. These rafters, along with the columns, form the fundamental shape of the structure. The rafters are typically sloped beams that extend from the top of one column to the top of the adjacent column. They play a crucial role in providing support for the roof and transferring the weight of the roof to the columns.

D) **Trusses and Girders:** Trusses, which consist of a latticework of bracing metal between the top and bottom chords, offer an alternate method of supporting the roof or higher floors. The girders are horizontal beams used to support floors.

E) **Lean-to/Single Slope:** These are a style of rigid frame to create the style of the primary framing.

2.3.2 Secondary Framing

The secondary framing elements of a building are custom-designed and engineered to suit the specific size, application, and load requirements of the structure. These elements are essential for providing structural stability and transferring loads to the main frame. In cases where there are extreme load requirements, larger gauge and depth may be necessary to ensure adequate strength and support. All the secondary framing elements are required for structural stability and will transfer load to the main frame. Pre-welded clips make attaching your secondary framing easy (Swanton Welding Company, 2022).

A) **Cold Formed Steel:** Cold-formed steel, which is available in the form of panels and sheets, undergoes a process where it is passed through rollers to create a final product that is strong and durable. This process is known as cold rolling or cold forming.

B) **Girts and Purlins:** Girts and purlins are integral components of the secondary framing system in a building. Girts are horizontal elements that run from column to column, encircling the building. They are designed to provide support for the wall panels of the structure. Girts help to stabilize the wall system, distribute loads, and enhance the overall structural integrity of the building. Purlins, on the other hand, are also horizontal elements that run from rafter to rafter in a similar manner to girt. They are specifically designed to support the roof system. Purlins play a crucial role in distributing the weight of the roof evenly across the rafters, providing structural support and stability to the roof assembly.

C) **Wall and Roof Braces:** There are three ways to brace your building: x-bracing, wind columns, and portal frames. Although X-bracing is the least expensive, it cannot be used to add windows or doors. You can keep the bay open by using portal frames and wind columns.

D) **Eave Struts:** Eave struts are components that are installed at the intersection point between the wall and roof of a building. They are positioned where the purlins, which support the roof system, begin, and the girts, which support the wall panels, terminate.

E) **Headers and Jambs:** Headers and jambs are essential components of the framework that surrounds openings in a building, such as doors, windows, or bays. Headers are horizontal elements placed above the opening. They provide structural support and help distribute the weight of the load above the opening to the surrounding walls or columns. Headers are designed to withstand the vertical loads imposed on them and ensure the stability and integrity of the opening. Jambs are vertical elements positioned on the sides of the opening. They provide vertical support and help frame the opening. Jambs play a crucial role in maintaining the structural stability of the opening and can be designed to accommodate various types of doors, windows, or other features.

2.3.3 Fasteners

Approved fasteners are essential for assembling both primary and secondary members in pre-fabricated steel structures. They are specifically chosen to maintain quality, uniformity, and overall structural performance. Common types of fasteners used in such systems include:

- **Bolts:** High-strength bolts are widely utilized to join steel elements. They provide firm and reliable connections, contributing significantly to the overall stability of the structure.

- **Nuts and Washers:** These components are used along with bolts to secure joints effectively. Washers help in distributing loads evenly, while nuts ensure that the connections remain tight and stable.
- **Screws:** Self-drilling or self-tapping screws are commonly applied for fixing secondary elements such as cladding sheets or interior components. They are capable of penetrating steel surfaces and holding materials securely in place.
- **Rivets:** Rivets are permanent fasteners installed in pre-drilled holes and then deformed to lock the connection. They offer strong and durable joints and are particularly useful where welding cannot be applied.

2.4 Building Construction Process

Figure 2.2 illustrates that the building construction process is predominantly carried out by individual owners. In rural regions, over 80% of structures are built by owners themselves, whereas in urban areas this proportion rises to more than 90%. Although contractor-led construction has been gradually increasing in suburban areas—largely due to improved efficiency and greater professional involvement—the overall construction practice remains largely owner-driven.

Even in urban settings, where technical expertise and resources are more readily available, a considerable number of buildings are still constructed without proper engineering input. This situation is mainly associated with low awareness and understanding of building codes and their effective application. Such a lack of awareness is not confined to homeowners and the general public; it is also evident among policymakers, construction practitioners, and even educated members of society.

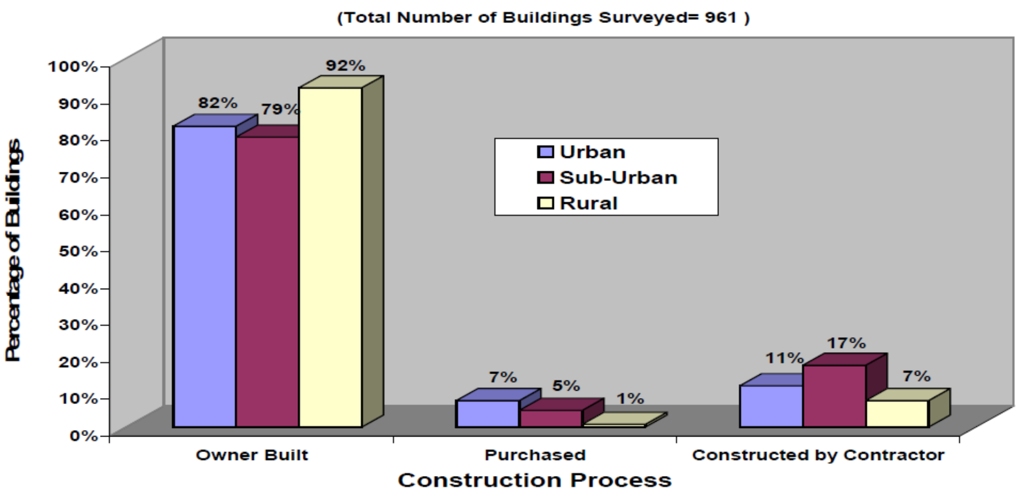


Figure 2.2: Building Construction Process

2.4.1 Engineered Constructions

Engineered constructions refer to buildings that are designed and constructed in accordance with established engineering principles and practices. These structures follow a formal process of obtaining building permits from the concerned municipal or regulatory authorities. The process requires the involvement of qualified architects and engineers during both the design and construction phases to ensure compliance with prevailing building codes, standards, and planning regulations. Such constructions are expected to incorporate considerations for structural safety, including seismic resistance, thereby enhancing the overall reliability and performance of the building (Dixit, 2009).

2.4.2 Non-Engineered Constructions

Non-engineered constructions refer to buildings that are built without formal engineering design and adequate professional supervision. These structures often bypass official building permit procedures or involve minimal input from qualified architects and engineers. Even where municipal regulations exist, such buildings typically lack detailed structural design, particularly in relation to seismic resistance. As a result, they are more prone to structural deficiencies and exhibit higher vulnerability in hazard-prone regions (Arya, 2000).

2.4.3 Owner-Built Buildings

Owner-built buildings are structures constructed directly by owners, often with assistance from local masons or carpenters who may not possess formal training in structural engineering or earthquake-resistant construction techniques. In many cases, these buildings are developed with minimal or no involvement of professional engineers and may not follow the formal design and approval process. Consequently, they frequently lack proper structural detailing and may not fully comply with the Nepal National Building Code provisions, particularly those related to seismic safety and construction standards (DUDBC, 2020)

2.5 Gaps in Stakeholders

In Nepal, many owner-built, non-engineered structures lack proper earthquake-resistant provisions. Even among engineered buildings, compliance with seismic design requirements is often inadequate. This is largely due to the limited involvement of engineers, which is frequently restricted to preparing architectural drawings rather than providing full supervision during construction. In many instances, engineers are either absent from the construction phase or their design specifications are not accurately followed on site. As a result, buildings may fail to achieve the intended level of seismic safety despite being professionally designed. Furthermore, driven by prevailing political and economic conditions, there has been rapid and often uncontrolled construction activity, leading to a significant number of structures that do not comply with building regulations and lack proper engineering oversight.

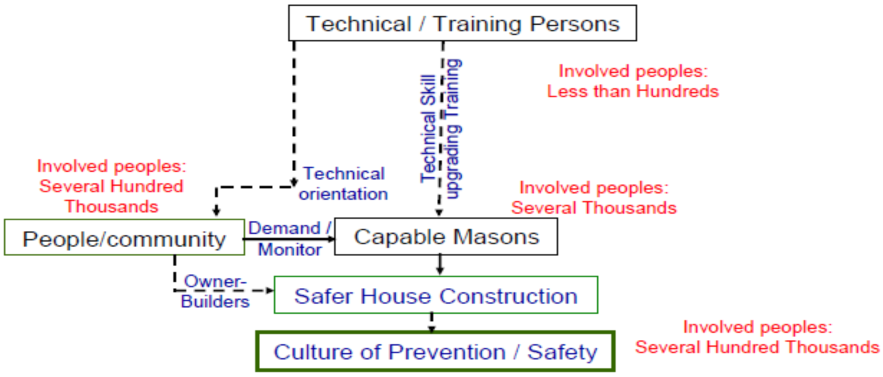


Figure 2.3 : Gaps in Stakeholders of Safe Housing Construction (Dixit, 2009)

2.6 Enforcement of Building Code: Compliance vs. Control

Intervention from a broad range of stakeholders, including the general public and policymakers, is necessary for the enforcement of building codes. Their roles are intertwined, and failure by any of the stakeholders to comply will seriously hinder the application of the building code. Reaching each stakeholder in the pyramid is crucial, even though the approach and key tools could differ (Figure 2.4). A sizable portion of the general population is at the bottom of the stakeholders' pyramid, and authorities, including municipal authorities and those who are in charge of developing tools and policies, are at the top of the pyramid. Although compliance is more effective at the bottom of the pyramid than enforcement via control, enfo rcement by control may be effective at the higher levels (Subedi J. K., 2009).

The most crucial aspect for achieving compliance is raising awareness, followed by the development of capacity and the use of policy tools. Control and compliance are interconnected and work best together. While the efficiency of control mainly depends on compliance, it can be improved and made effective through indirect control methods like home loans and insurance. Building code compliance is a viable and effective technique, but it needs to be supported by both direct and indirect control measures (Subedi J. K., 2009).

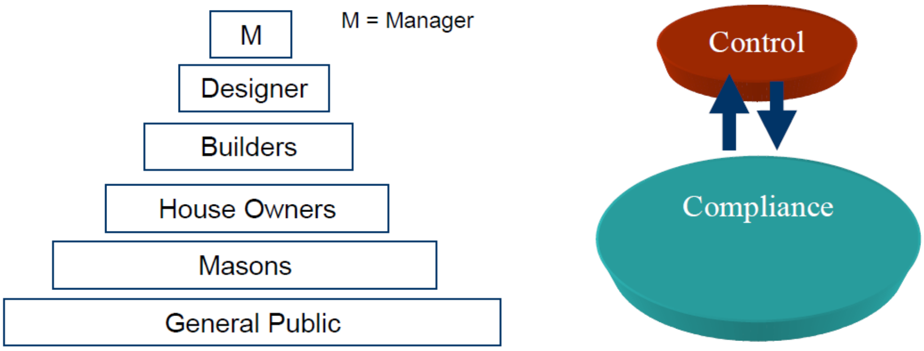


Figure 2.4 Compliance and Control for Effective Enforcement of Building Code (Subedi J. K., 2009)

2.7 Challenges in Implementation of Building Code

The Communist Party of Nepal declared war on Nepal on February 13, 1996, beginning a nearly 11-year civil war. The Comprehensive Peace Accord, signed on November 21, 2006, marked the end of the civil conflict. On May 28, 2008, Nepal proclaimed itself a Federal Democratic Republic, ending the monarchy less than two years later. Following that, the nation began work on a new constitution, which was eventually accepted on September 20, 2015. It is understandable that the NBC's implementation was not Nepal's top priority given the country's current unrest and ambiguity, as well as the unclear intentions of the administration (Arendt, et al., 2017).

The lack of knowledge among householders regarding safety, the NBC, and its compliance is one of the main problems. The NBC is challenging to execute in older portions of cities like Kathmandu where buildings were built decades ago in accordance with traditional designs when Nepal did not have building rules and frequently sit on narrow lots. The supply of transportation accessibility in these densely populated areas with limited lot sizes as needed by current codes would be impossible without the demolition of structures. There are large stockpiles of ancient buildings that were not built according to building codes and where rehabilitation is difficult. Due to financial limitations, construction is frequently not carried out under the supervision of experienced built environment specialists (engineers and architects). Particularly in metropolitan areas where projects like high-rise skyscrapers are being built, many of these specialists lack adequate design skills. There are insufficient institutional resources and political intervention at the government level (Ahmed, et al., 2019).

The primary barrier to the effective implementation of building regulations and bylaws is related to behavioral factors. Among these, lack of awareness among owners regarding building codes and bylaws ranks highest, followed by negligence and a preference for hiring local masons instead of qualified engineers for construction work. From a legal perspective, the absence of an effective system of incentives and penalties emerges as the second major constraint after behavioral issues. Additionally, institutional challenges within municipalities—such as delays in issuing construction management guidelines and a complex, time-consuming building permit process—also significantly hinder effective enforcement (Sharma, 2022).

Masons believe that the adaption of construction practices that breached the compliance of the code in construction as a result of instructions from the owner during construction is the primary cause of non-compliance with the building code. Additionally, it has been observed that masons modify the blueprints in order to facilitate building, which is against the compliance requirement (KC, 2023). The "failures in enforcement undermines' the effectiveness of building codes and present a challenge in figuring out how to bring about stronger implementation of code provisions." (Burby, May, Feeley, & Wood, 1999).

Some of the challenges in implementation of building code are as follows (Ahmed, et al., 2019):

- Large Informal Sector: In Nepal, there is an effort to use a "Mandatory Rule of Thumb (MRT)" approach to contextualize building standards for small buildings and those made of indigenous materials.
- Lack of awareness and knowledge: The ability to comprehend and use building codes is significantly lacking in both technical knowledge and awareness. Codes frequently focus on resistance to seismic or earthquake events, although they might not cover a larger variety of impacting hazards.
- Lack of capacity: Building capacity is necessary for all levels of stakeholders, from formally trained experts in the built environment to employees in the unregulated construction industry.
- Perception of extra cost: Building codes are perceived as costly and hence many building owners and developers may not see the benefits of investing in compliance with building code, and the perceived costs may exceed the perceived benefits.
- Corruption: Building approvals obtained through bribery, political connections, and political patronage can weaken the proper implementation of building code and comprise the safety and resilience of buildings.

2.8 Major Stakeholders for Building Code Implementation

The concept of stakeholders refers to any individual or group that can influence, or is influenced by, the achievement of an organization's objectives (Freeman, 1984). The fundamental premise is that stakeholders have an interest in the organization's activities and may either contribute to or be affected by its outcomes. They are considered both potential beneficiaries and risk bearers of the organization's operations, as they contribute voluntarily or involuntarily to its overall functioning (Post, Preston,,, & Sachs, 2002).Furthermore, stakeholders can be identified based on the potential benefits they receive or the risks they face as a result of the organization's actions or inactions (Donaldson & Preston, 1995)

In the context of building code implementation, several key stakeholders play a crucial role in ensuring compliance and effective enforcement. The four primary stakeholders influencing building code implementation are described as follows (Timsina et al., 2015) (Timsina, Maharjan, & Dixit, 2015) :

- **Houseowners:**

  House owners are the key decision-makers in building construction. For effective code implementation, their awareness of earthquake-resistant construction needs to be improved. Although most aim to build safe structures, financial constraints and the perception of higher costs often limit full compliance with building code requirements.

- **Engineer/Designer:**

  Engineers and designers are responsible for planning, designing, and supervising construction works. They prepare drawings in accordance with the Nepal National Building Code (NBC) to ensure safety and compliance. They also supervise site activities and coordinate with contractors to ensure construction follows approved designs and standards.

- **Contractor:**

  Contractors and masons handle the actual construction work. In Nepal, many lack formal training in modern and earthquake-resistant construction techniques, relying mainly on experience. Therefore, capacity building is important. They also manage materials, workmanship, and project execution, which directly affects construction quality and safety.

- **Municipality:**

  Municipal authorities enforce the National Building Code and related bylaws. Their responsibilities include approving designs, conducting inspections, issuing permits, and providing completion certificates after verifying compliance with approved drawings and safety standards.

Compliance Parameter

The compliance check parameters are developed using the checklist titled "Record of Inspection & Approval for Structural Steel Works," which was created by the Building and Construction Authority (BCA, 2023).

A) Member Size

- Correct member sizes and dimensions, verified all documents, thickness (Flange & Web)
- Materials are visually acceptable, no visual defects such as warping, twisting, distortion, damaged sections, pitting
- All plates and stiffener plate fit ups are as per drawings.

B) Structural System

- Grid spacing, orientation of members, shapes of the member's align with the drawings.

C) Bolt Connection

- Reconfirmed bolt grade & type, bolt dimension (Dia. x Length)
- Connection joints/splice joints constructed as per drawings
- Number of bolts and arrangement as per drawings.
- Bolt diameter as per drawings.

D) Welding Connection

- Size and length of weld according to approved plan and specifications

2.9 Factors Affecting the Performance of Steel Construction

The performance of steel structures is influenced by several interrelated factors that affect the quality, safety, durability, and overall effectiveness of construction (Rashid, 2016). These factors are described as follows:

- **Design:**
  Designing steel structures requires a strong grasp of both structural principles and practical construction methods such as fabrication and erection. The design must support safe, efficient, and economical construction while ensuring smooth execution without conflicts between design intent and field implementation.
- **Fabrication:**
  Fabrication consists of preparing steel components through cutting, drilling or punching holes,

joint preparation, and applying protective coatings when needed. Accurate fabrication is essential to achieve correct alignment and proper fitting during site erection.

- **Training:**
  Training of workers involved in steel construction is essential for improving both productivity and site safety. Regular skill development programs for skilled and unskilled workers engaged in fabrication and erection help enhance overall construction performance, particularly in private sector projects.
- **Material Handling:**
  Material handling includes storage, transportation, and management of steel elements on site. Proper procedures are necessary to prevent damage, distortion, or corrosion. Steel components should be stored using suitable supports to avoid unwanted stress and maintain material integrity.
- **Quality:**
  Quality in steel construction is maintained through effective quality assurance and quality control at every stage of fabrication and erection. Poor quality management can lead to construction defects, rework, increased costs, and reduced structural reliability.
- **Time and Weather:**
  Weather conditions such as rainfall, wind, temperature, and humidity have a direct impact on steel construction activities, especially during erection. Proper scheduling based on local climatic conditions is important to maintain safety and ensure efficient project progress.
- **Assembly Process:**
  The assembly process involves lifting, positioning, aligning, and connecting steel members in the correct sequence. Careful planning of these activities improves construction efficiency, reduces delays, and ensures the stability and integrity of the overall structure.

2.10 Major Projects

Several notable steel-structure projects illustrate current practice (see table below). Key examples include: auto showrooms (Kathmandu), a sports training hall (Kathmandu), modular offices (Kathmandu). Many of these leveraged prefabricated components for speed.

Table 2.2: Major Recent Steel-structure Buildings in Nepal.

Project	Location	Sector	Description	Year & Size
Kathmandu Airport Air Cargo Office	Kathmandu (TIA)	Institutional	Multi-storey office with large span; steel moment frame.	2023
National Sports Council Training Centre	Tripureshwor, KTM	Institutional	Indoor sports hall / training center in steel construction.	2024
Honda Motorcycle Showroom	Tripureshwor, KTM	Commercial	Multi-level steel-framed dealership building.	2024
Club Volcano Nightclub	Thamel, Kathmandu	Commercial	Multi-storey entertainment venue built as steel structures.	2023–24
WHO Modular Office	Singha Durbar, KTM	Institutional	Six-unit prefabricated office (steel modules) for Health Ministry.	2025

Source: Pro Eth Consultants Pvt.Ltd.

2.11 Trend of Building Permit Approvals and Structural System Distribution in Kathmandu Metropolitan City

The building permit data from Kathmandu Metropolitan City (2076/03/10–2082/03/16 B.S.) reveals a strong dominance of reinforced concrete structural systems, particularly Reinforced Concrete Special Moment Resisting Frame (RC-SMRF), across all building classes. Out of a total of 14,547 approved buildings, Class C buildings account for the largest share, followed by Class B, while Class A buildings remain minimal. Residential buildings significantly outnumber commercial and hotel structures, indicating a high demand for housing development within the metropolitan area. Notably, the adoption of steel structural systems is extremely limited, with only two steel-framed buildings recorded in the entire dataset. This trend highlights a clear preference for conventional reinforced concrete construction practices and underscores the need to further investigate the implementation status, challenges, and potential of steel-framed commercial buildings in Kathmandu Metropolitan City.

2.12 Relevant Past studies

Previous studies conducted in Nepal suggest that the enforcement of building bylaws and the National Building Code in urban areas such as the Kathmandu Valley remains weak, with a clear mismatch often observed between approved designs and actual on-site construction. Findings show that non-compliance is mainly influenced by low awareness among house owners, insufficient enforcement of regulations, and inadequate supervision during construction activities. In addition, institutional constraints such as a shortage of skilled personnel, weak coordination among relevant stakeholders, and complicated approval procedures further limit effective implementation, despite a general understanding among stakeholders of the importance of compliance.

In relation to steel-framed buildings, research carried out in Lalitpur Metropolitan City reported that overall compliance levels were below 35%, with comparatively better adherence in column elements but very poor compliance in truss components. One of the major concerns identified was the lack of inspection during the construction phase, as many structural elements become hidden before final verification. Behavioral issues also played a significant role, including the tendency of owners to rely on fabricators instead of engineers, cost-minimization practices, and limited understanding of code requirements. Furthermore, unethical practices and negligence among fabricators were found to contribute to deviations from approved structural designs. The study concluded that improving compliance requires stronger on-site monitoring, enhanced awareness programs, training for engineers and fabricators, and incentive-based strategies to encourage proper adherence to standards.

2.13 Comparison Of NBC Code and IS Code for Steel Structure Parameters

Table 2.3: Comparison Of NBC Code and IS Code for Steel Structure Parameters

Parameter	NBC 111	IS 800
Member Size (Base Plate)	NBC 111 adopts IS 800 designs	a. Base plates distribute column load. b. If base plate > needed size, equal projection beyond column face is allowed c. b. All bearing surfaces must be machined. If column is welded to base plate with full-penetration welds, consider effective base area.
Column Sections	a. Follows IS 800 section classification and slenderness limits but adds Nepal-specific rules: max fy=450 MPa b. Effective lengths per NBC 111 (unbraced) Connections: beams to columns design for 1.25× loads or K=4 rule with full-depth stiffeners.	a. Slenderness limits: L/r ≤ 200 (axial), ≤ 300 (beam); check KL/r to prevent buckling b. Apply correct effective length (K) and provide battens/lacing where required
Beam	Designed for bending, shear & deflection; seismic considerations from NBC 105	Plastic/elastic design with section classification (Class 1–4), LTB checks
Batten & Stiffener Plate	General guidance; not deeply specified	Detailed provisions for spacing, size, slenderness (IS 800 Cl. 7.6)

Truss Members	Designed based on axial forces & load combinations	Detailed tension/compression member design, slenderness limits & connection detailing
Structural Parts (Beam)	a. Follows IS 800 (sections 8.2–8.5). Frame beams assumed simply supported unless moment connections. b. Use bent-up sides/full end-plates (9.2.1) modified: end-plate connections must have full-depth butt welds on stiffeners. Practical: ensure flange bracing/stiffeners as per 8.6.1.	a. IS 800 8.6: restrict lateral buckling: provide flange bracing every **L**³/60 span or intermediate stiffeners. End connections: Table F-4 guidance. b. Beam slenderness (KL/r ≤ 300 about strong axis, ≤450 about weak axis). c. Use IS rolled sections or built-ups designed per 8.6.1. Provide ribs or stiffeners if needed.
Column	a. As per *IS 800 (Sec. 7)*; NBC 111 assumes K = 1.0 (unbraced frame) b. For tall frames, adopt K ≈ 1.25 for safer buckling design c. Use H/I or welded box sections with battens/lacing *(IS 800 Cl. 7.6/7.7)* d. Provide tie plates (Cl. 7.6.5) to ensure proper composite action	a. Design per *IS 800 (Cl. 7.3–7.7)* with KL/r limits for axial capacity b. Provide ≥ 3 battens, properly spaced with KL/r (segment) ≤ 50 c. End battens ≥ full depth; intermediate ≥ 0.75 depth
Truss	Load based design approach	Detailed member design + connection detailing rules
Bolted Connection (Number of Bolts)	Follow IS 800. NBC permits increasing allowable bolt stress by 25% for seismic/wind (Clause 3.9.2.1b)	a. Determine bolts from shear & tension capacity (IS 800 Cl. 10.3–10.4) b. Use minimum 2 bolts per joint, placed symmetrically c. Provide proper gauge, clearances (Cl. 10.2) and ensure pretension for HSFG bolts
Bolt Arrangement and Diameter	Selected based on practical use	Standardized (M16, M20, etc.) with capacity calculations
Welded Connection (Size of weld and Length of weld)	Follow IS 800 clauses	a. Use fillet or butt welds; min fillet size ≥ 3 mm (Table 21 governs) b. Effective throat ≤ 0.7t; provide end return ≥ 2× weld size c. Effective length = actual length + 2× weld size (min ≥ 4× size) d. Lap length ≥ 4t or 40 mm; increase size for deep penetration (+2.4 mm)

3 WORK METHODOLOGY

3.1 Research Design

The diagram illustrates a linear research flow from idea → questions → objectives → data collection using primary and secondary sources, followed by data compilation, analysis, and interpretation to produce results, conclusions, and recommendations, guided by literature review and supervisor consultation.

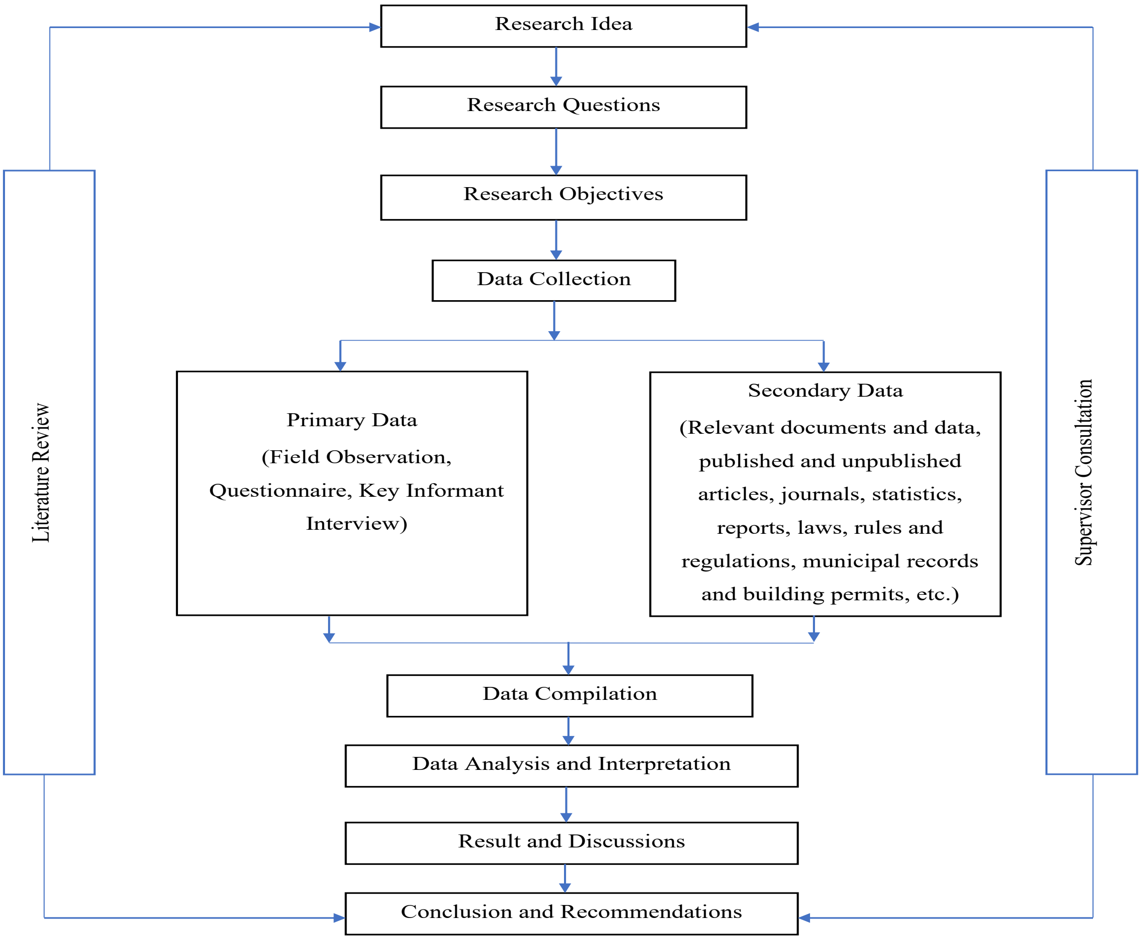


Figure 3.1:Research Process Flowchart

3.2 Research Approach

The study adopts a mixed-method research approach, integrating both quantitative and qualitative techniques to ensure comprehensive and reliable findings. The quantitative component involves a structured questionnaire survey based on a Likert scale administered to key stakeholders, including homeowners, contractors, engineers, and fabricators. The collected data are analyzed using statistical tools such as mean score, standard deviation, ranking, and reliability analysis

(Cronbach's α) to identify the major causes and levels of construction non-compliance, ensuring objectivity, generalizability, and measurable comparison of variables.

The qualitative component consists of field observations and Key Informant Interviews (KII) conducted with experts such as DUDBC officials and municipal engineers to explore underlying causes, institutional challenges, and practical insights that cannot be captured through quantitative methods alone. The findings from both approaches are then triangulated to enhance validity and consistency, where quantitative results provide measurable trends and qualitative insights help to explain and validate those findings, leading to a more robust interpretation and well-founded conclusions.

3.3 Study Of Project Area

Kathmandu Metropolitan City (KMC) lies in Kathmandu District of Bagmati Province and represents the most important urban core of Nepal, functioning as the country's administrative, economic, and cultural center. The city is divided into 32 wards and spans an area of about 49.45 km^2. As per the National Population and Housing Census 2021 conducted by the Central Bureau of Statistics, the total population of KMC is 862,400, including 438,256 males and 424,144 females (Nepal. C. B., 2021). Due to its limited land area combined with rapid urban growth, the city has one of the highest population densities in the country. It is closely connected with surrounding municipalities such as Nagarjun, Tokha, Gokarneshwor, Kirtipur, and Chandragiri, forming a continuous urban region within the Kathmandu Valley. Because it serves as the main hub for government, business, education, and services, KMC continues to face increasing population pressure and infrastructure demands, making it highly significant for urban development research. (City, 2020)

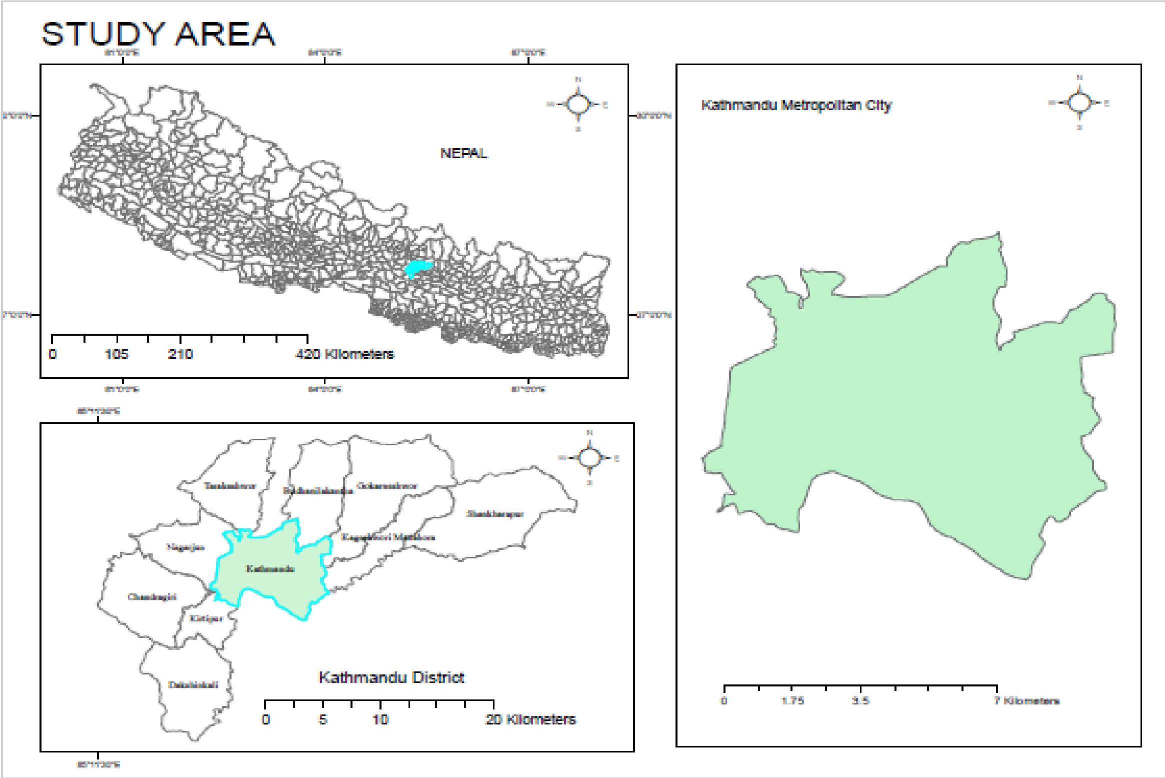


Figure 3.2:Study Area (Self-Generated)

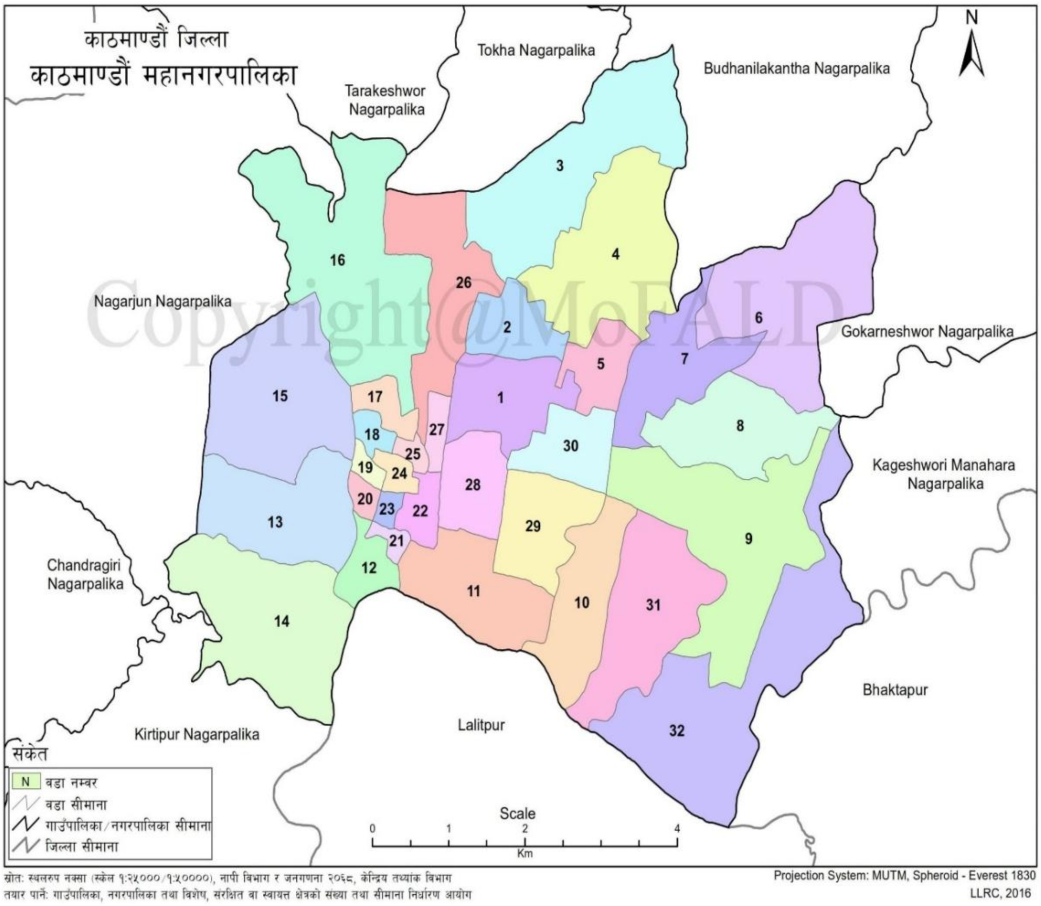


Figure 3.3: Kathmandu Metropolitan City Map

3.4 Study Population, Sampling Method and Sample Size

Building samples that were in the pre-construction stages, Construction stages and Post Construction stages after being registered in Kathmandu Metropolitan City were collected for verification.

The study population in this research refers to government engineers, consulting firms/designers/engineers, Contractor engineers and fabricator involved in the construction of steel-framed structure within the Kathmandu Metropolitan City.

To evaluate the progress of steel-framed commercial building construction in Kathmandu Metropolitan City, buildings registered with the municipality were selected for study. In the year (2081/82 to 2082/83), 20 houses were registered for Commercial purposes such as applications for superstructure permits, and completion. Out of these, only 20 houses in progress were included in the compliance check. The distribution of building purposes based on registration, with 4 buildings classified as Pre-Construction Stage, 9 buildings classified as construction phase and 7 buildings classified as Post-Construction Stage, making a grand total of 20 commercial buildings.

3.5 Method of Data Collection

The research was utilized both primary and secondary data.

A) Primary Data Collection

A) Field Verification: A site investigation was conducted on sampled buildings, and their compliance was assessed using a prepared checklist as mentioned in Appendix 1.

B) Questionnaires: A set of distinct questionnaires was prepared for homeowners and fabricators or contractors to understand their perspectives on compliance in construction and the root causes of non-compliance from grassroots stakeholders. Additionally, a list of causes of non-compliance and solutions for compliance in construction was compiled from the literature review, and the opinions of municipal engineers, Government engineers of DUDBC, designer/consultant engineers and Contractor engineers were gathered using the Likert Scale in the questionnaire

C) Key Informant Interview (KII): KII were conducted with the Deputy Director General (DDG) of the Department of Urban Development and Building Construction (DUDBC) and Structural Engineer of Kathmandu Metropolitan City (KMC).

B) Secondary Data Collection

To collect secondary data, municipal records, websites, and registered drawings and designs were utilized to identify the steel-framed buildings. This data was then used for the compliance check during the field investigation to ensure accuracy and gain valuable insights into steel-framed buildings practices.

3.6 Data Analysis

Compliance Analysis

The compliance analysis was conducted by assessing the level of conformity between approved structural drawings and actual field conditions of steel-framed buildings. Data collected through field observation checklists and questionnaire surveys were systematically compiled and analyzed using statistical techniques such as mean score, standard deviation, and ranking to identify the degree of compliance and non-compliance. The results were then interpreted to determine key areas of deviation from design standards, and the findings were further validated through Key Informant Interviews (KII), ensuring a comprehensive understanding of compliance status in relation.

Relative Importance Index (RII)

The RII is calculated using the following formula:

$$RII = \frac{\sum W}{A \times N} = \frac{1 \cdot N_1 + 2 \cdot N_2 + 3 \cdot N_3 + 4 \cdot N_4 + 5 \cdot N_5}{5 \times N}$$

Where:

- W= weighting assigned by respondents (ranging from 1 to 5)
- N_1, N_2, N_3, N_4, N_5= number of respondents corresponding to each level of importance (from "Not Important" to "Very Important")
- A= highest weight (5 in this study)
- N= total number of respondents

The application of the RII method enabled the identification and ranking of the most critical causes of non-compliance, as well as potential solutions. This prioritization supports informed decision-making and the development of effective strategies to improve construction compliance.

The analyzed data were further illustrated through charts, graphs, tables, and diagrams, enhancing the clarity and interpretability of the research outcomes. These visual tools played a vital role in effectively communicating complex findings and supporting the overall conclusions of the study.

Kruskal–Wallis Test

It evaluates whether the distribution of the dependent variable differs across groups by comparing the mean ranks.

The hypotheses for the Kruskal–Walli's test are defined as follows:

- **H_0 (Null Hypothesis):** The population medians of all groups are equal.
- **H_1 (Alternative Hypothesis):** At least one group has a median that differs from the others.

The test statistic, denoted as H, is calculated using the following formula:

$$H = \frac{12}{n(n+1)} \sum_{j=1}^{c} \frac{T_j^2}{n_j} - 3(n+1)$$

Where:

- n= total number of observations across all groups
- c= number of groups (samples)
- T_j= sum of ranks for the j^{th}group
- n_j= number of observations in the j^{th}group

The computed H-statistic is compared with the critical value from the chi-square (χ^2) distribution with $c - 1$degrees of freedom at a specified level of significance (commonly 0.05). If the calculated value of Hexceeds the critical value, the null hypothesis is rejected, indicating that there is a statistically significant difference among the groups.

3.7 Reliability and Validity

The field observation checklist and questionnaires were developed based on findings from various research papers and reports. Extensive consultation with the supervisor was conducted to ensure validity.

Cronbach's alpha was employed to assess the consistency of the questionnaire across municipal engineer, DUDBC Engineers and designer/consultant engineer. A higher alpha value indicates greater reliability of the questionnaire. Researchers have suggested that a reliability coefficient of 0.7 and above is considered acceptable. Below is the formula used to calculate Cronbach's alpha:

$$\boldsymbol{\alpha = \frac{K}{K-1} X \left[1 - \frac{\sum \sigma_k^2}{\sigma_{total}^2}\right]}$$

Were,

K is the number of items 20

$\sum \boldsymbol{\sigma_k^2}$ is the sum of the k item score variances

σ^2_{total} is the variance of scores on the total measurement

It is interpreted based on the level of reliability as follows (Zeller, 2005):

0 to 0.5 = unacceptable

0.5 to 0.6 = poor

0.6 to 0.7 = questionable

0.7 to 0.8 = acceptable

0.8 to 0.9 = good

0.9 to 1.0= excellent

Separate questionnaires were designed for engineers to assess the causes of non-compliance and measures for construction compliance in steel-framed structures. The questionnaire's reliability was evaluated using Cronbach's alpha.

Table 3.1: Cronbach's Alpha Test of Reliability for Causes of Non-Compliance in Steel-Framed Buildings

S.N.	Variables	Description	Value
1	α	Cronbach’s Alpha	0.876
2	α (standardized)	Cronbach’s Alpha Based on Standardized Items	0.883
3	K	Number of items	20

The reliability analysis shows a Cronbach’s Alpha value of 0.876, which indicates a high level of internal consistency among the 20 items used in the study. The standardized Cronbach’s Alpha (0.883) also confirms strong reliability of the scale. Since both values are above the acceptable threshold of 0.70, the instrument is considered reliable for further statistical analysis.

Table 3.2 :Cronbach's Alpha Test of Reliability for Construction Compliance in Steel-Framed Buildings

S.N.	Variables	Description	Value
1	α	Cronbach’s Alpha	0.887
2	α (standardized)	Cronbach’s Alpha Based on Standardized Items	0.888
3	K	Number of items	11

The reliability analysis shows a Cronbach’s Alpha value of 0.887, which indicates a high level of internal consistency among the 11 items. Since the value is greater than 0.7, the instrument is considered highly reliable for further analysis.

3.8 Research Matrix

Table 3.5: Research Matrix

OBJECTIVES	DATA REQUIRED	SOURCES OF DATA	TOOLS	OUTCOMES
To assess the implementation status of steel-framed Commercial building construction in buildings in Kathmandu Metropolitan City.	The data of different parameters of construction compliance as per the prepared checklist in steel-framed buildings.	Field observation and measurement, checklist, registered drawings	Descriptive statistics such as percentage, charts.	Compliance status of individual parameters.
To identify the key causes of non-compliance with building codes in steel-framed Commercial structures.	Stakeholders' opinion on causes of non-compliance in steel-frames buildings.	Questionnaire Survey, Key Informant Interview (KII) Relative	Relative Importance Index (RII), Kruskal Wallis Test,	Ratings of different causes of non-compliance, Perception of house-owners and fabricator/ contractor
To suggest measures for construction compliance in steel-framed commercial buildings.	Stakeholders' opinion on potential recommendations for construction compliance	Questionnaire survey, Key Informant Interview (KII)	Relative Importance Index (RII), Kruskal Wallis Test.	Ratings of different potentials recommendation

4 RESULTS AND DISCUSSION

4.1 Implementation Status of Building Code in Construction of Steel-Framed Buildings in Kathmandu Metropolitan City

This section addresses the first objective, which focuses on assessing the implementation status of the building code in steel-framed buildings through field observation and registration data analysis.

4.1.1 Field Observation of Building Use

Samples taken from the field were grouped according to the building purpose as per registration and building purpose as per field.

Figure 4.1 illustrated the distribution of building purposes based on registration, with 4 buildings classified as Pre-Construction Stage, 9 buildings classified as construction phase and 7 buildings classified as Post-Construction Stage, making a grand total of 20 commercial buildings.

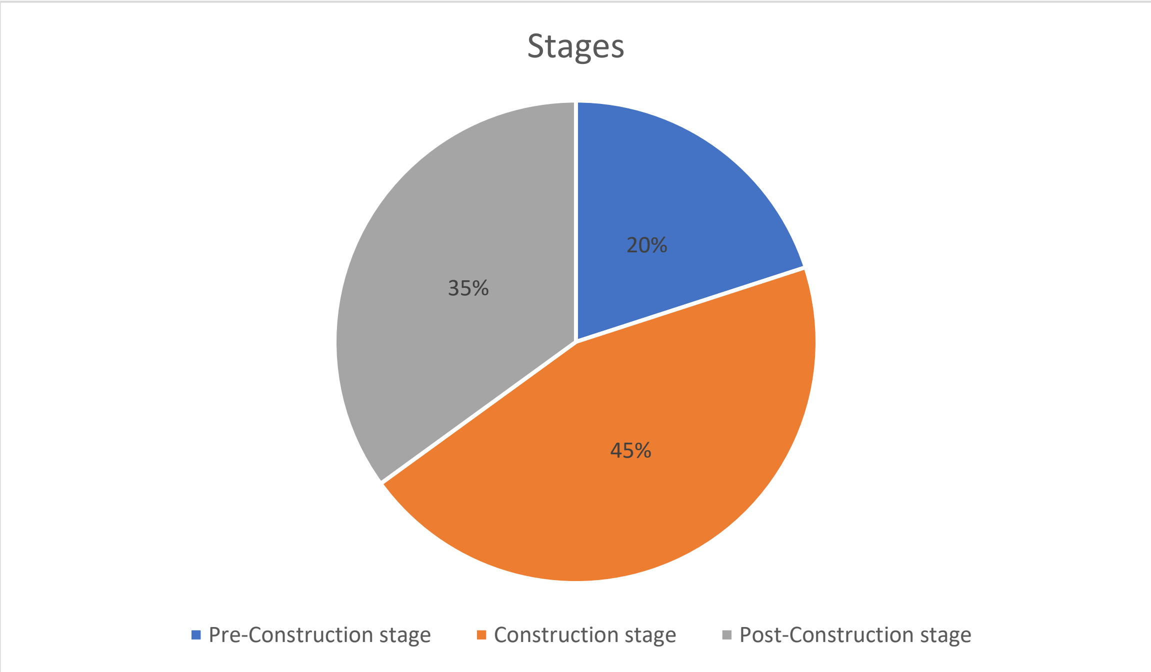


Figure 4.1 : Field Observation of Building Use

4.1.2 Compliance Status of Steel-Framed Buildings during Construction

The compliance status of steel-framed structures was assessed by comparing the actual construction practices with the detailed drawings provided by the designer. This process involved a thorough inspection and verification of various elements and parameters to ensure that the construction adhered to the registered drawings.

The compliance status of steel-framed buildings was assessed by carefully examining various parameters. Due to some buildings being incomplete and certain sections of finished buildings being hidden, not all parameters were checked during field observations. This thorough evaluation helped identify any discrepancies or non-compliance issues and provided insights into current practices in steel-framed building construction.

A) Member Size

Member size of base plate, column, beam, batten plate, stiffener plate, and truss members were observed.

A. Base Plate

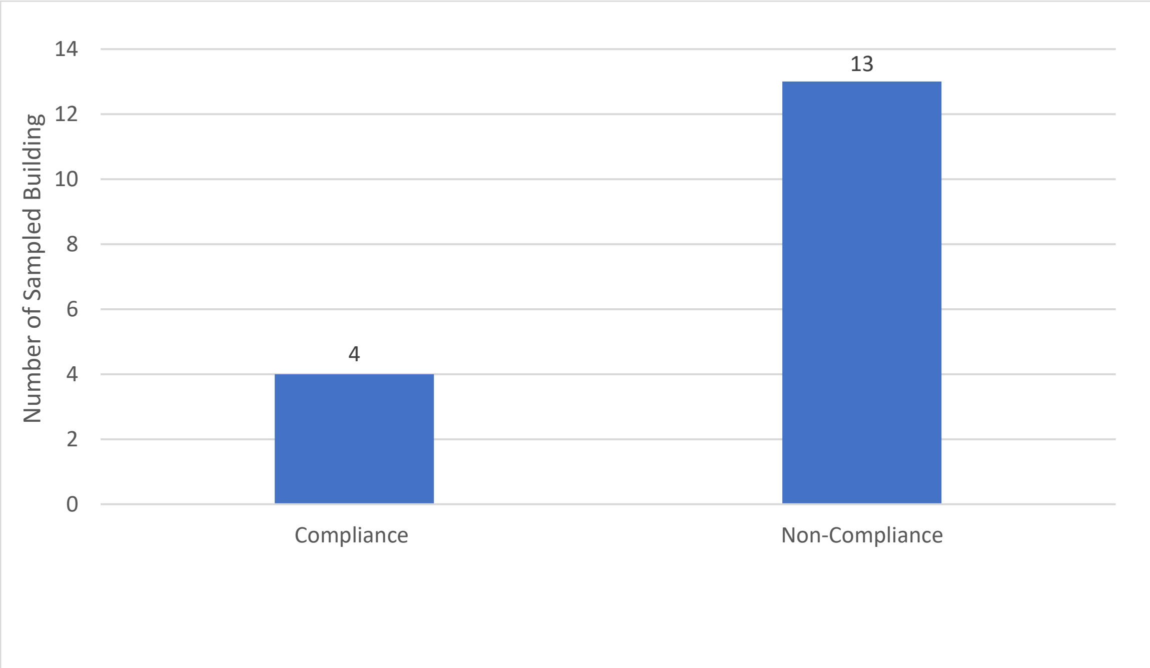


Figure 4.2: Member Size-Base Plate

Figure 4.2 presented the results of a compliance check on base plate dimensions. According to the data, base plate compliance was observed in 4buildings, while non-compliance was noted in 13 buildings. The non-compliance issues were attributed to changes in the size of the base plate, specifically its length, breadth, and thickness, and in some cases, the absence of the base plate. It was found that, to reduce costs, house owners opted to use smaller sizes for the base plate, and in some cases, it was omitted altogether on-site. These practices reflect a lack of awareness among house owners about earthquake-resistant building standards.

B. Column

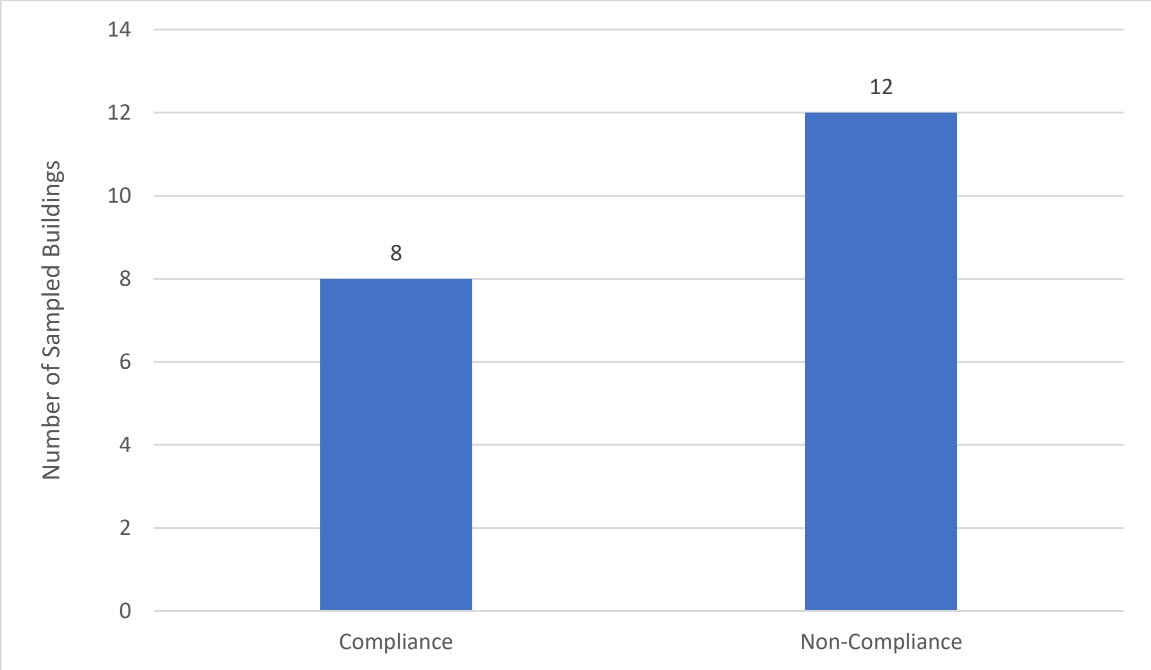


Figure 4.3: Member Size-Column

Figure 4.3 illustrated the outcomes of a compliance assessment conducted on base plate dimensions. The data indicated that 8 buildings met the specifications for column size, while 12 buildings did not comply. The non-compliance issues were attributed to changes in the size of the columns, specifically their length, breadth, and thickness. In some cases, the steel sections were entirely replaced. It was found that, to reduce costs, house owners opted to use smaller sizes for the columns, and in some cases, replaced them with smaller, lighter sections. Additionally, a lack of understanding of the drawings by fabricators led to changes in the steel sections. These findings highlight the need for increased awareness among house owners and emphasize the importance of training for fabricators.

C. Beam

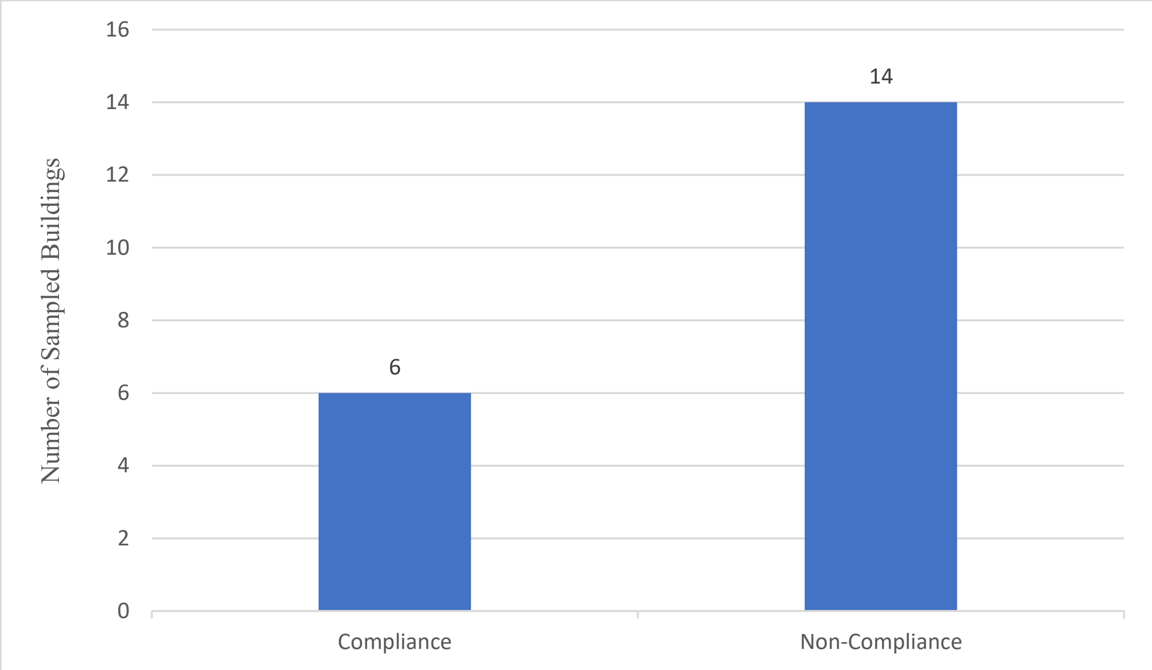


Figure 4.4 :Member Size-Beam

Figure 4.4 illustrates the findings of the compliance check on beam dimensions. Compliance with beam specifications was confirmed in 6 buildings, while 14 buildings were found to be non-compliant. The non-compliance issues were attributed to changes in the size of the beams, specifically their length, breadth, and thickness. It was found that, to reduce costs, house owners opted to use smaller sizes for the beams. These findings highlight the need for increased awareness among house owners.

A) Batten and Stiffener Plate

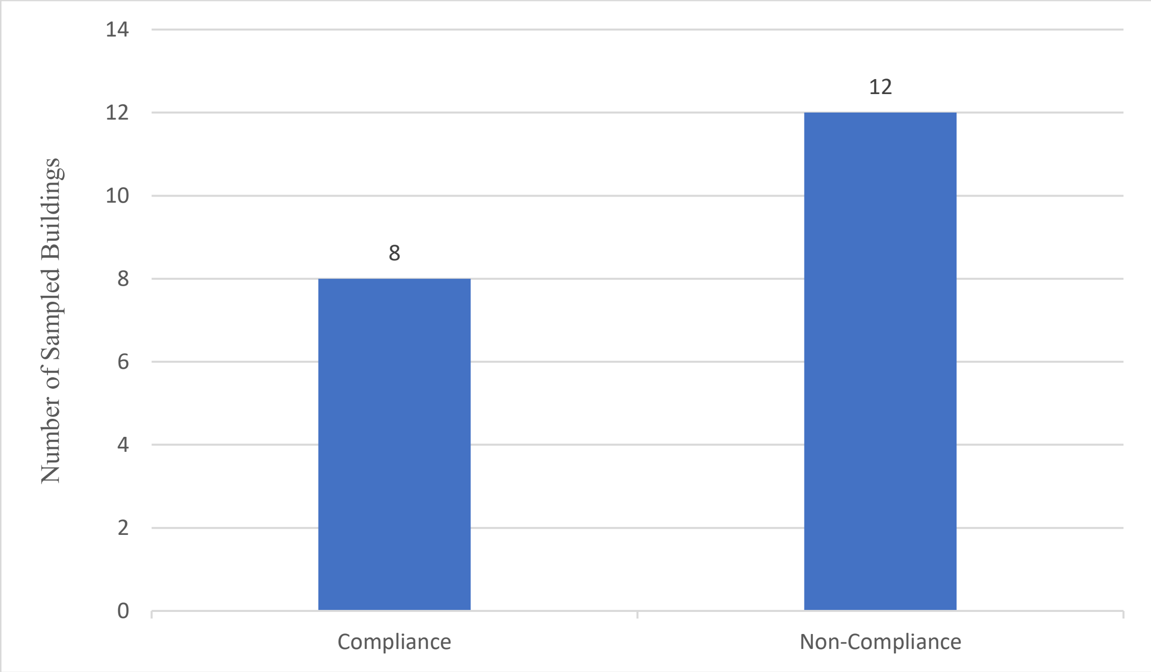


Figure 4.5: Member Size-Batten Plate

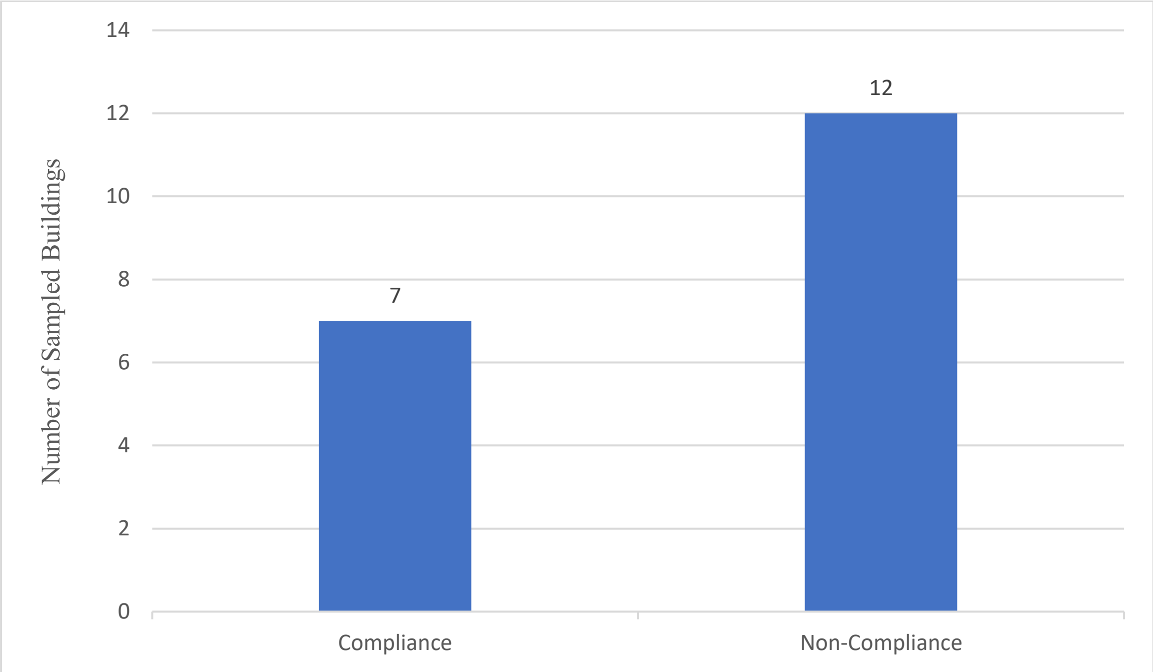


Figure 4.6: Member Size-Stiffener Plate

Figures 4.4and 4.6 illustrate the findings of the compliance check on batten plate and stiffener plate dimensions in buildings. Compliance with batten plate specifications was confirmed in 8 buildings, while 12 buildings were found to be non-compliant. Regarding stiffener plates, compliance was observed in 7 buildings, whereas 12 buildings were noted as non-compliant. Non-compliance issues with both the batten plate and stiffener plate in these buildings primarily arose from discrepancies in their dimensions, the reduction in the number of batten plates, and the omission of the stiffener plate. It was determined that the discrepancies resulted from cost reduction measures adopted by house owners. These findings underscored the necessity for greater awareness among house owners.

A) Truss Members

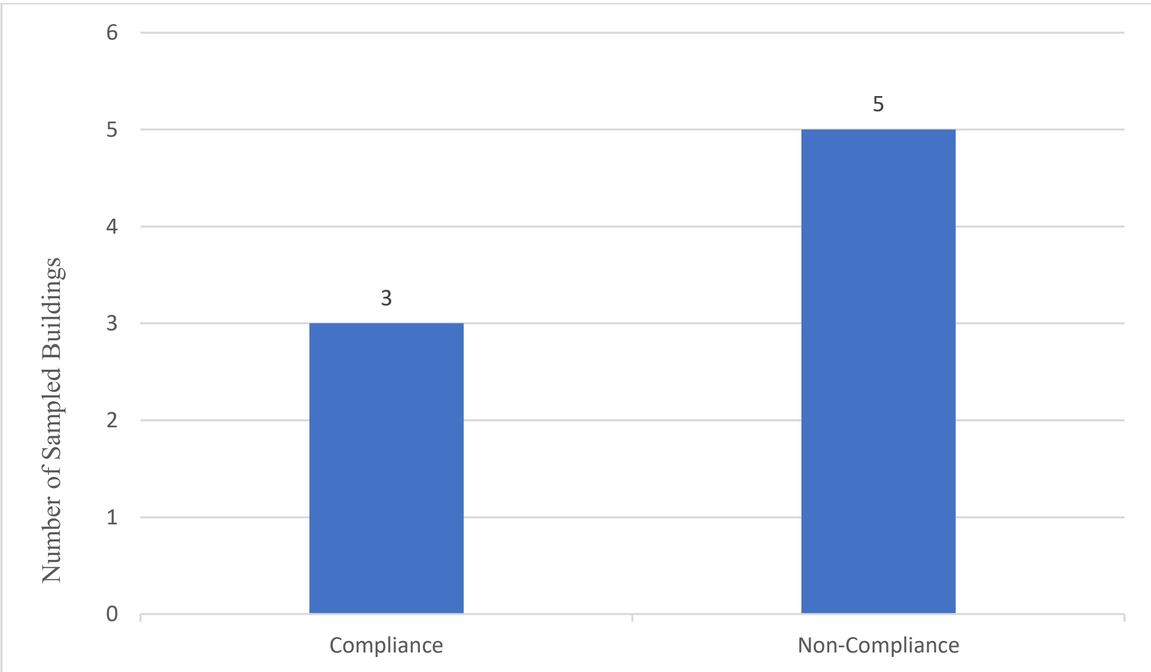


Figure 4.7: Member Size-Truss Member

Figure 4.7 illustrates the findings of the compliance check on truss member dimensions. Compliance with truss member specifications was confirmed in 3 building, while 5 buildings were found to be non-compliant. The non-compliance issues primarily included a reduction in the number of purlins and struts, as well as the use of smaller section sizes. It was found that the reason for non-compliance was mainly due to cost reduction measures adopted by house owners.

B) Structural System

The structural system encompasses parameters such as grid spacing, orientation, and the number of members in column, beam, and trusses.

A) Column

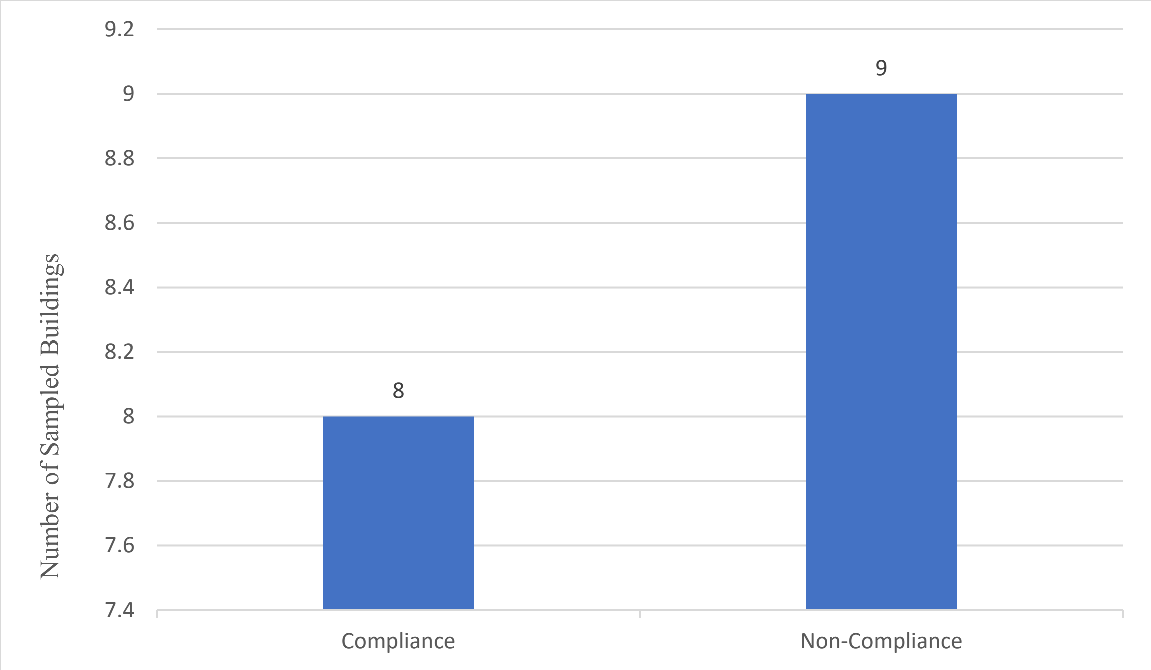


Figure 4.8: Structural System-Column

Figure 4.8 illustrates the findings of the compliance check on column structural system. Compliance with column specifications was confirmed in 8 building, while 9 buildings were found to be non-compliant. It was found that non-compliance was primarily due to changes in grid spacing, alterations in section properties such as transitioning from C-channel to I-section, and also the omission of columns. These deviations were primarily due to the lack of awareness among house owners and a perception that significant cost reductions could be achieved.

A) Beam

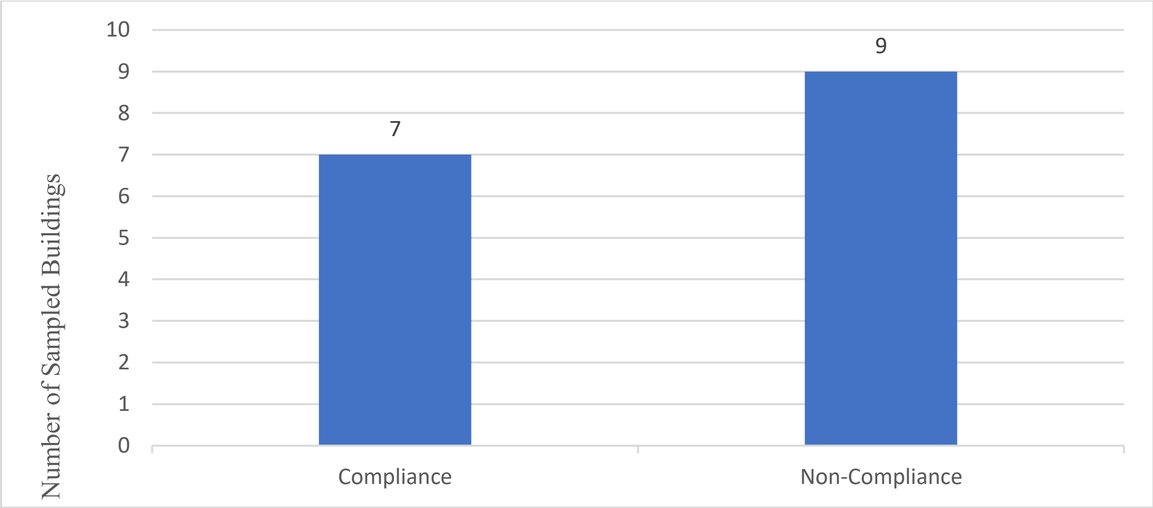


Figure 4.9: Structural System-Beam

Figure 4.9 illustrates the findings of the compliance check on beam structural systems. Compliance with beam specifications was confirmed in 7 buildings, while 9 buildings were found to be non-compliant. It was discovered that the non-compliance was primarily due to changes in grid spacing and alterations in section properties. These deviations were primarily due to the lack of awareness among house owners and a perception that significant cost reductions could be achieved.

A) Truss Member

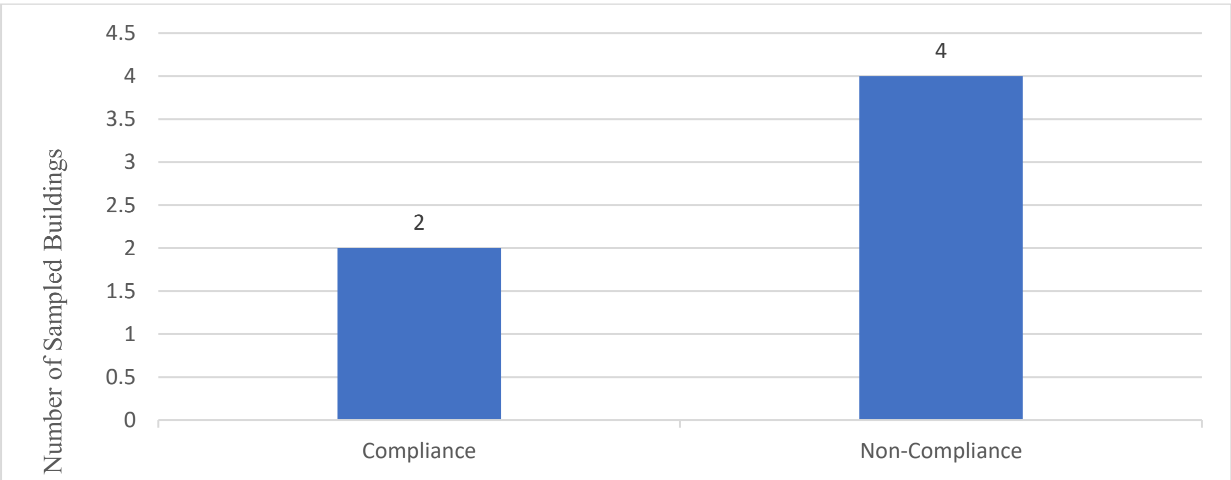


Figure 4.10: Structural System-Truss Member

Figure 4.10 presents the results of the compliance assessment for truss member dimensions. Compliance with truss member specifications was verified in 2 buildings, while 4 buildings did not meet the requirements. It was discovered that the spacing of purlins and vertical struts was increased beyond the recommendations in the drawings, as a cost-saving measure by house owners.

C) Bolted Connection

Bolted connections are primarily used in the base-plate to column connection and the beam to column connection.

A) Baseplate to Column

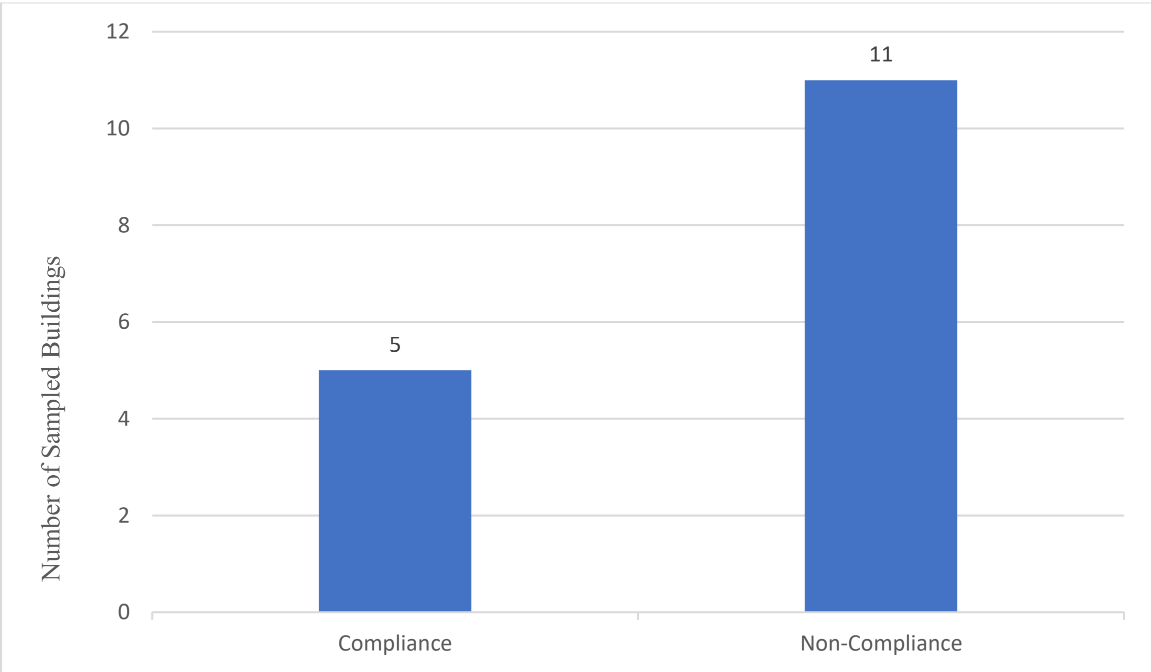


Figure 4.11: Base Plate-Column Connection

Figure 4.11 presents the results of the compliance assessment for base-plate to column connections. Compliance with specifications was verified in 5 buildings, while 11 buildings did not meet the requirements. It was discovered that the number of bolts was fewer than specified in the drawings, and in some cases, nut bolts were omitted entirely and replaced with direct welding. Additionally, the arrangement of bolts was altered, and base plates were missing in certain instances. These issues arise from malpractice and the use of traditional construction methods by the fabricator. There was also negligence on the part of the fabricator, who believed that casting the column directly into the foundation makes it stronger than using a baseplate.

A) Beam-Column Connection

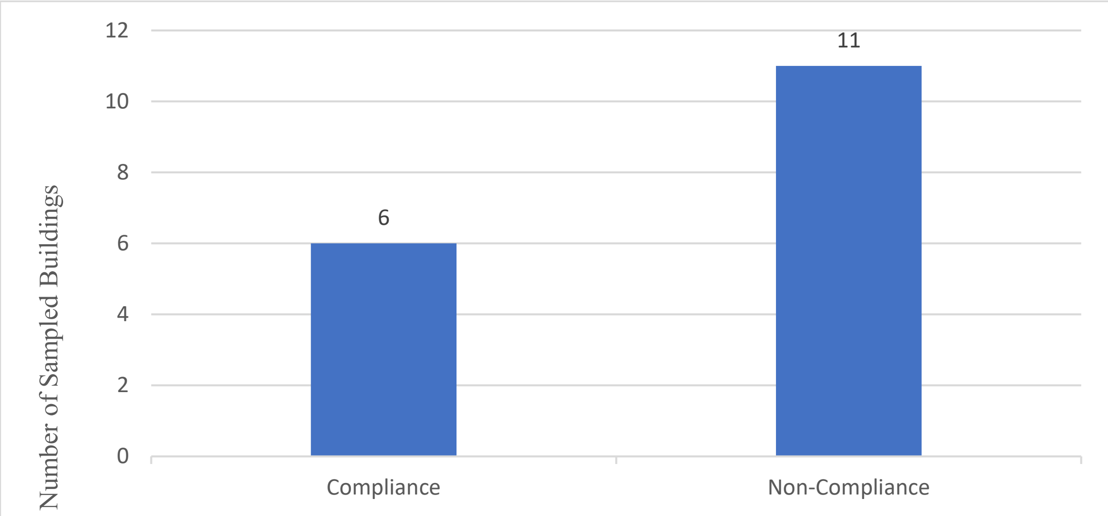


Figure 4.12: Beam-Column Connection

Figure 4.12 presents the results of the compliance assessment for beam to column connections. Compliance with specifications was verified in 6 buildings, while 11 buildings did not meet the requirements. It was discovered that in most cases, all connections were welded rather than bolted. This issue arose due to malpractice and a lack of knowledge on the part of the fabricator, coupled with the perception that welded connections are stronger than bolted connections.

A) Welded Connection

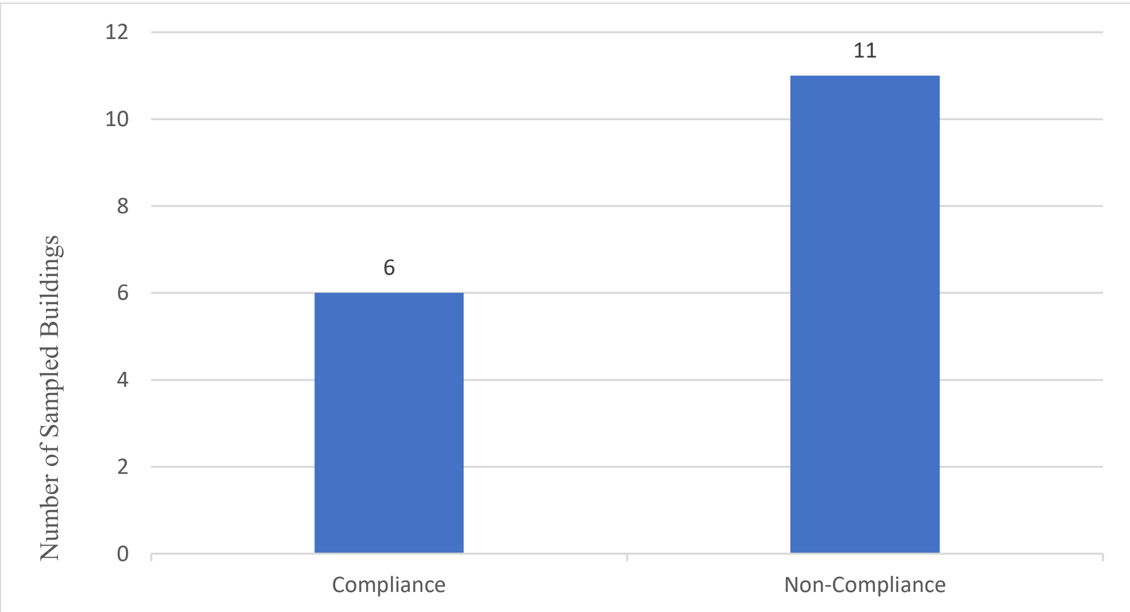


Figure 4.13: Welded Connection

Welded connections must meet specific size and length requirements to ensure strong and reliable structural integrity. Figure 4.13 outlines the compliance assessment findings for welded connections. Among the buildings assessed, compliance with specifications was confirmed in 6 buildings, while 11 buildings did not meet the requirements. It was found that welding was only partially completed, with no full-length welds in some cases, and intermittent small patches of welding in others. This issue arose due to malpractice and a lack of knowledge on the part of the fabricator, who mistakenly believed that their welding practices were sufficient.

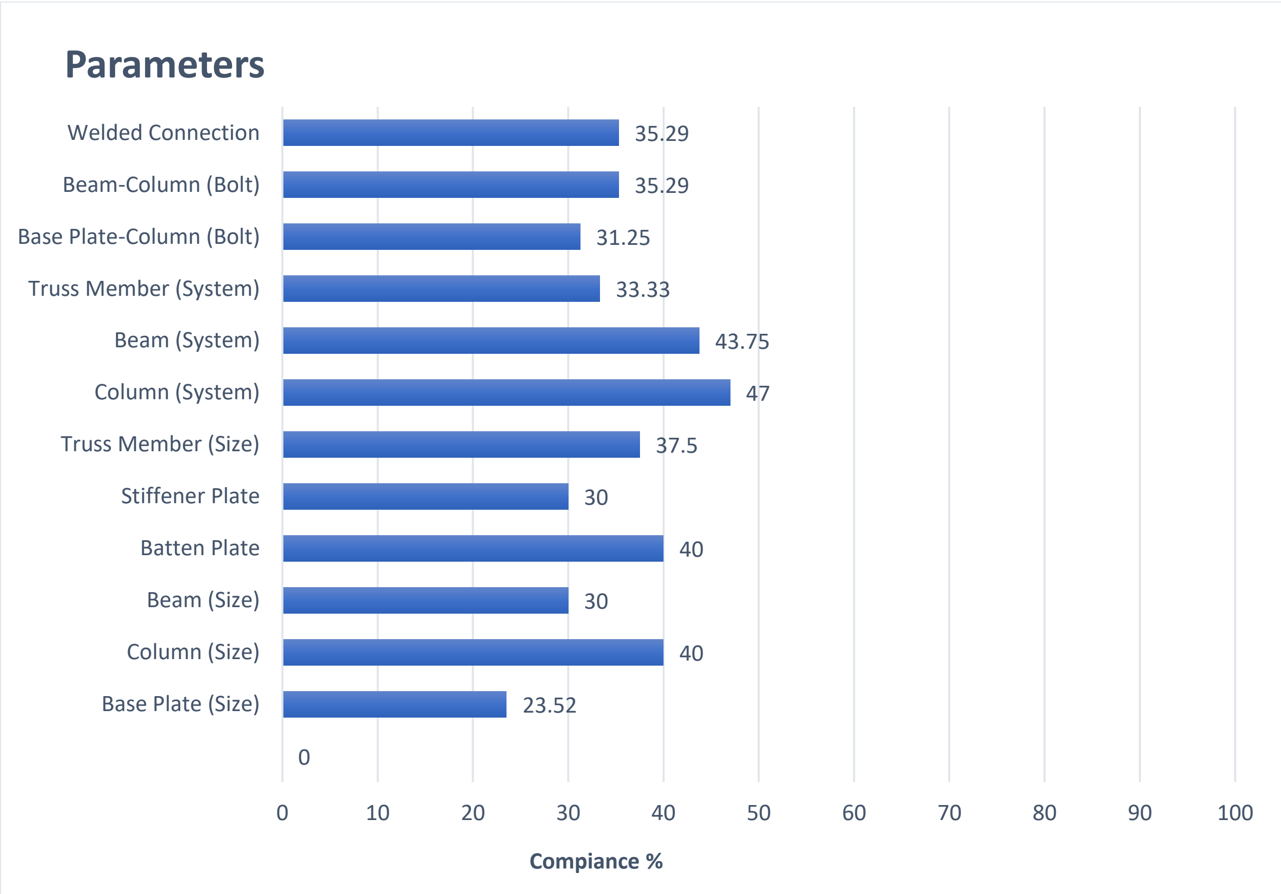


Figure 4.14: Bar Chart showing the Compliance of Parameters

The bar chart illustrates the compliance levels of various structural parameters in steel-framed buildings. It is evident that the highest compliance is observed in column (system) with a value of 47%, followed by beam (system) at 43.75%. Similarly, column (size) and batten plate show moderate compliance levels of 40%, indicating relatively better adherence to design specifications in primary structural members. This trend suggests that elements perceived as critical to structural stability receive more attention during construction and inspection.

In contrast, lower compliance levels are observed in parameters such as base plate (size) at 23.52%, stiffener plate and beam (size) both at 30%, and base plate–column (bolt) at 31.25%. These results indicate that secondary components and connection details are often neglected or improperly executed. The compliance for truss member (system) (33.33%) and truss member (size) (37.5%) is also relatively low, highlighting insufficient monitoring and possible alterations during construction.

Additionally, welded connections and beam-column (bolt) connections both show equal compliance values of 35.29%, reflecting moderate adherence but also indicating gaps in proper connection practices. These deficiencies may be attributed to limited technical knowledge among fabricators, misconceptions regarding connection strength, and lack of strict inspection mechanisms.

Overall, the figure demonstrates that while primary structural elements such as columns and beams exhibit comparatively higher compliance, significant non-compliance persists in connection details and secondary components. This imbalance highlights the need for improved technical awareness, stricter inspection procedures, and better enforcement of structural design standards in steel-framed construction.

4.2 Causes of Non-Compliance in Steel-Framed Commercial Buildings

4.2.1 House Owner Perception Toward Steel-Framed Building Construction

House owners' perception of steel-framed construction plays an important role in determining construction quality and compliance with building codes and standards. When owners have adequate knowledge and a positive attitude toward such systems, they are more likely to follow proper design procedures, use certified construction materials, and hire qualified professionals, which ultimately improves compliance with technical and regulatory requirements.

On the other hand, limited understanding or incorrect assumptions about steel structures often lead to decisions driven mainly by cost considerations. This can result in unauthorized changes to designs, use of low-quality materials, and deviation from approved construction specifications. Such practices increase the risk of non-compliance and can negatively affect structural safety, durability, and service performance.

1. **Reason for Steel-Framed Building Construction**

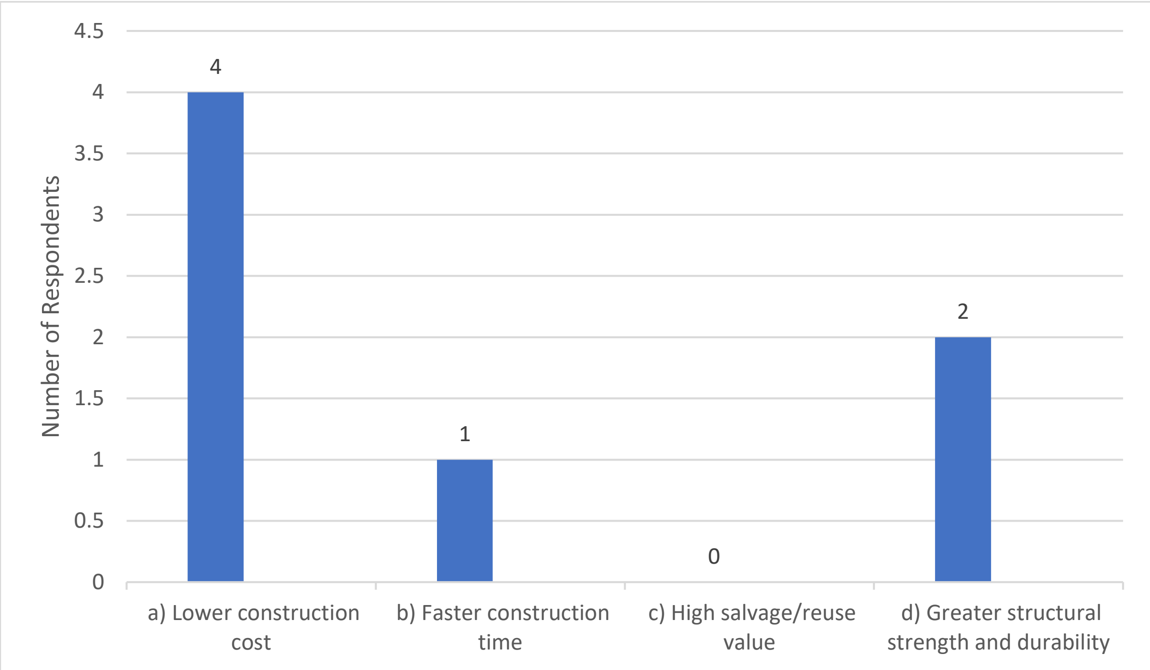


Figure 4.15: House Owner Reasons for Selecting Steel-Framed Building

Figure 4.15 shows that most people think lower construction cost is the reason for choosing steel-framed construction. Four people said it is the factor. This means that most people care about the cost. On the hand only one person said that faster construction time is important. Steel is good for construction because it can be made beforehand. Two people also said that structural strength and durability are important. This shows that they know about the things steel can do. Interestingly nobody thought about the reuse value of steel. This means that people do not think much about sustainability and long-term benefits. Overall, the study finds that people mainly choose steel-framed construction because it is cost-efficient. Other benefits, like speed, durability and sustainability are not considered much.

2. **Reason for Modifications in Steel-Framed Building Construction**

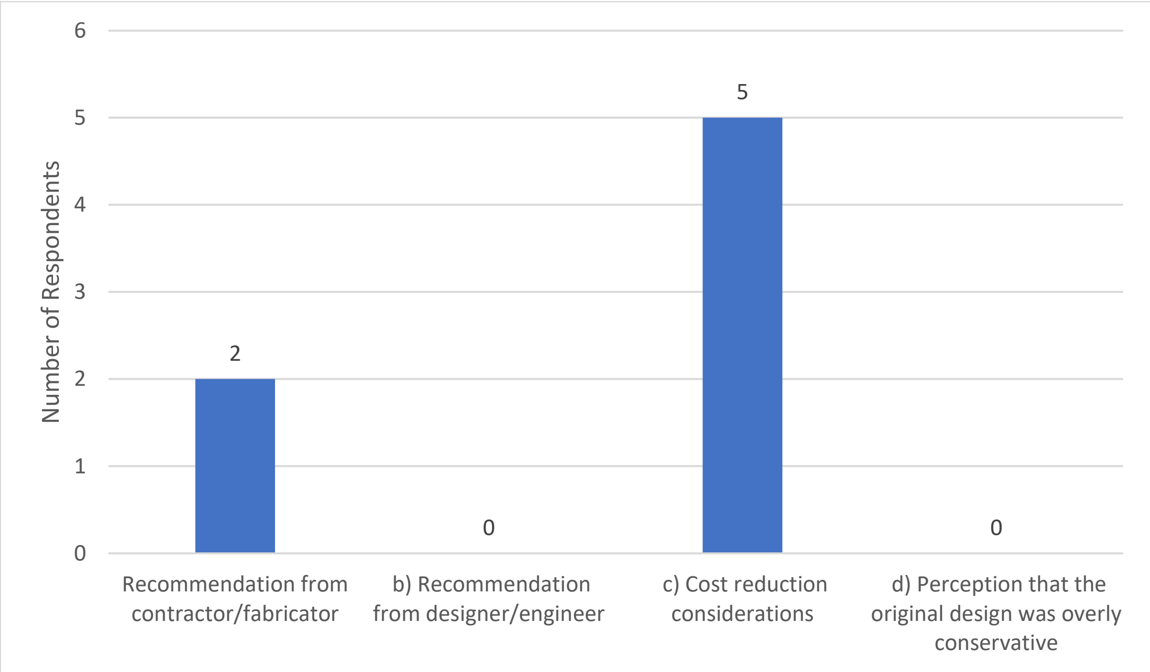


Figure 4.16 : Reason for Modifications in Steel-Framed Building Construction

Figure 4.16 presents the primary reasons for changes made to steel structural systems or member sizes during construction. The most dominant factor identified is cost reduction considerations, reported by the majority of respondents (5), clearly indicating that financial pressure plays a decisive role in on-site decision-making. This reflects a practical reality where budget constraints often lead fabricators and contractors to modify original designs to achieve immediate cost savings. Additionally, two respondents indicated that such changes were made based on recommendations from contractors or fabricators, suggesting that field experience and constructability considerations also influence design alterations.

Interestingly, none of the respondents attributed these changes to recommendations from designers/engineers or to the perception that the original design was overly conservative. This highlights a noticeable disconnect between design professionals and site-level execution, where modifications are largely driven by economic and practical factors rather than formal engineering review. In human terms, it shows that decisions on-site are often shaped more by "what works within budget and conditions" rather than strictly following design intent. Overall, the findings emphasize the need for stronger coordination between designers and fabricators, as well as stricter control mechanisms to ensure that cost-driven changes do not compromise structural safety and compliance.

4.2.2 Fabricator Perception Toward Steel-Framed Building Construction

Responses from fabricators (Appendix 3) indicate that non-compliance in steel-framed construction is largely driven by cost-related pressures, weak supervision, and insufficient technical capacity. They reported that modifications to steel members during construction are frequently requested on-site, mainly due to clients attempting to minimize overall costs. Problems such as poor welding practices and incorrect interpretation of design drawings were also identified. Although fabricators are generally familiar with the Nepal National Building Code (NBC), its implementation is often only partial, and quality control practices tend to be informal. This reflects a significant gap between design specifications and actual construction practices, primarily influenced by organizational and behavioral issues.

To overcome these challenges, stronger coordination among designers, engineers, and fabricators is required to ensure clear understanding and proper execution of design intentions. Unauthorized site modifications should be strictly controlled, supported by enhanced supervision mechanisms. Providing targeted training for welders and fabrication workers is also essential to improve workmanship quality. Furthermore, establishing a systematic QA/QC framework with regular inspections is necessary to ensure compliance with approved drawings and building code provisions, thereby improving the safety and reliability of steel-framed structures.

4.2.3 Ranking of Causes of Non-Compliance

The questionnaire results were analyzed to calculate the relative importance index, which was then used to rank various causes of non-compliance in steel-framed Commercial buildings in Kathmandu Metropolitan City.

Table 4.1: Ranking of Causes of Non-Compliance

S.N.	Aspect	Item	Municipal/DUDBC Engineer		Consultant / Designer		Contractor	
			RII	Rank	RII	Rank	RII	Rank
1	Legal	Ineffective system for enforcing rewards and punishments.	0.708	17	0.693	13	0.747	4
2		Lack of effective enforcement of building codes and regulations contributes to non-compliance in steel-framed commercial buildings.	0.744	11	0.696	11	0.747	4
3	Organizational	Lack of sufficient technical manpower in municipality	0.736	15	0.7	9	0.747	4
4		Delays caused by an overly complex building approval process	0.752	6	0.743	3	0.667	17
5		Lack of public dissemination of information about listed engineers and trained fabricators.	0.792	1	0.726	6	0.76	2
6		Insufficient construction management guidelines	0.752	6	0.7	9	0.68	15
7	Market	The quality of construction materials used in steel-framed buildings is often below the required standards.	0.664	20	0.623	20	0.613	20
8		There is an inadequate number of professional engineers with expertise in steel structure construction.	0.742	14	0.689	14	0.72	11
9	Functional	Steel-framed construction projects often lack adequate on-site supervision by qualified engineers	0.768	3	0.721	7	0.64	19

10		Ineffective coordination between owners and designers leads to non-compliance in steel-framed buildings	0.704	18	0.643	18	0.68	15
11		Drawings approved by designers or the municipality are often incomplete or insufficient for proper construction.	0.72	16	0.65	17	0.693	13
12		Frequent changes to design drawings during construction contribute to non-compliance issues	0.768	3	0.764	1	0.733	8
13		Engineers involved in steel-framed construction often lack sufficient practical field experience	0.768	3	0.686	15	0.733	8
14	**Behavioral**	Ethical practices among stakeholders are insufficient to ensure compliance in steel-framed construction.	0.744	11	0.657	16	0.76	2
15		Negligent behavior by stakeholders negatively affects compliance with approved designs and codes.	0.748	10	0.696	11	0.72	11
16		Owners tend to prioritize selecting fabricators over engaging qualified engineers, leading to non-compliance	0.752	6	0.743	3	0.747	4
17		The perception that steel-framed construction is costly discourages full compliance with standards	0.696	19	0.643	18	0.653	18
18		Owners generally have limited knowledge of applicable building codes for steel-framed structures	0.752	6	0.743	3	0.693	13
19		Contractors or fabricators may compromise compliance to remain competitive in the construction market.	0.775	2	0.707	8	0.733	8
20		Owners have limited awareness of the potential risks associated with non-compliance.	0.744	11	0.764	1	0.773	1

4.2.4 Ranking of Aspects by Mean for Causes of Non-Compliance

Table 4.2: Ranking of Aspects by Mean for Causes of Non-Compliance

S.N.	Aspect	N	Mean	Standard Deviation
1	Organizational	69	3.66	0.682
2	Behavioral	69	3.64	0.698
3	Legal	69	3.61	0.824
4	Functional	69	3.57	0.765
5	Market	69	3.32	0.891

Table 4.2, the average response for each aspect was determined by considering the opinions of municipal engineers, consultant/designers, and contractors. The data indicated that the organizational aspect had the highest mean score among the five aspects.

This suggests that respondents perceived organizational issues such as lack of technical manpower, delays in approval processes, poor dissemination of technical information, and insufficient management guidelines as the most critical causes of non-compliance in steel-framed commercial buildings.

The behavioral aspect ranked second, indicating that negligence, unethical practices, lack of awareness, and cost-driven decisions by owners and stakeholders significantly contribute to non-compliance. The legal aspect ranked third, highlighting the role of weak enforcement systems and inadequate regulatory mechanisms.

The functional aspect ranked fourth, reflecting issues related to supervision, drawing changes, coordination, and practical field experience. The market aspect ranked fifth, though still important, indicating comparatively lower concern regarding material quality and shortage of specialized professionals.

4.2.5 Kruskal-Wallis Test for Difference Among Cause Aspects

The Kruskal-Walli's test was employed to examine significant differences in mean values across various aspects.

Null Hypothesis	Test	Sig.	Decision
The distribution of the mean is the same across different categories of cause aspects.	Independent Samples Kruskal-Wallis Test	0.406	Retain the null hypothesis

Since the p-value is greater than 0.05, there is insufficient evidence to conclude that the mean values differ significantly across the five aspects. Therefore, respondents showed broadly similar perceptions regarding all causes of non-compliance.

However, the organizational aspect emerged as the most significant cause of non-compliance in steel-framed commercial buildings in Kathmandu Metropolitan City.

Although no statistically significant difference was found among the five aspects ($p > 0.05$), the organizational aspect recorded the highest mean score (3.66), indicating it as the most influential cause of non-compliance.

Table 4.3 Triangulation of KII Findings with Cause aspects of Construction Non-Compliance

S.N.	Cause Aspect	Survey Result (Mean Score)	KII Perspective	Triangulated Interpretation
1	Organizational	3.66	Weak inspection and monitoring capacity	Institutional weakness in supervision
2	Legal	3.61	Poor enforcement and weak regulation	Weak enforcement system leads to non-compliance
3	Functional	3.57	Lack of technical guidelines and coordination	Technical and coordination gaps in implementation
4	Behavioral	3.64	Negligence and cost-driven decisions	Low awareness and unethical practices
5	Market	3.32	Shortage of skilled workforce	Lack of skilled manpower in construction sector

4.3 Measures for Effective Implementation of Construction Compliance in Steel-Framed Buildings

4.3.1 Ranking of Measures for Construction Compliance

The questionnaire results were analyzed to calculate the relative importance index, which was then used to rank various measures for effective implementation of construction compliance in steel-framed buildings in Lalitpur Metropolitan City

Table 4.4: Ranking of Measures for Construction Compliance

S.N.	Aspect	Item	Municipal/DUDBC Engineer		Consultant / Designer		Contractor	
			RII	Rank	RII	Rank	RII	Rank
1	Legal	An effective reward and punishment system improves compliance	0.744	11	0.763	8	0.8	7
		Strengthening enforcement of building codes and regulations	0.872	3	0.844	3	0.862	3
2		Incentives encourage owners to follow building codes	0.824	6	0.756	10	0.754	11
3	Organizational	Regular inspection and monitoring during different construction stages	0.88	2	0.885	1	0.892	1
4		Mandatory orientation or briefing programs for house owners before construction	0.808	8	0.807	6	0.831	5
5		Public access to listed consultants and contractors improves accountability	0.8	9	0.8	7	0.754	11
6		Better coordination among stakeholders (municipality, consultants, contractors, and owners)	0.864	4	0.859	2	0.831	5
9		Digitalization of building permit and monitoring systems	0.824	6	0.815	5	0.785	9
10		Improved coordination between design approval and site inspection authorities	0.848	5	0.83	4	0.877	2
7	Behavioral	Awareness programs should be conducted for public	0.8	9	0.756	10	0.769	10
11		Increasing awareness among building owners about building codes and safety standards	0.888	1	0.756	10	0.846	4

4.3.2 Ranking of Aspects by Mean for Measures for Construction Compliance

Table 4.5 :Ranking of Aspects by Mean for Measures for Construction Compliance

S.N.	Aspect	N	Mean	Standard Deviation
1	Organizational	69	4.21	0.782
2	Behavioral	69	4.08	0.841
3	Legal	69	3.93	0.848

In Table 4.4, the average response for each aspect was determined by considering the opinions of municipal engineers, consultant/designers, and contractors. The data revealed that the organizational aspect had the highest mean score among the three aspects. This indicates that respondents considered organizational measures such as regular inspection, coordination among stakeholders, orientation programs, and digital monitoring systems as the most effective recommendations for improving compliance in steel-framed commercial buildings.

The behavioral aspect ranked second, highlighting the importance of public awareness and increasing owners' understanding of building codes and safety standards. The legal aspect ranked third, though it also obtained a high mean value, indicating strong agreement regarding enforcement systems, incentives, and regulatory mechanisms.

4.3.3 Kruskal-Wallis Test for Difference Among Recommendation Aspects

The Kruskal-Walli's test was employed to examine whether significant differences existed in mean values across the three recommendation aspects.

Null Hypothesis	**Test**	**Sig.**	**Decision**
The distribution of the mean is the same across different categories of recommendation aspects.	Independent Samples Kruskal-Wallis Test	0.318	Retain the null hypothesis

Since the p-value is greater than 0.05, there is insufficient evidence to conclude that the mean values differ significantly across the three aspects. Therefore, respondents generally showed similar levels of agreement toward all recommendation aspects. However, the organizational aspect emerged as the most influential recommendation area for enhancing compliance in steel-framed commercial buildings in Kathmandu Metropolitan City.

Table 4.6 Triangulation of KII Findings with Recommendation aspects of Construction Non-Compliance

S.N.	Recommendation Aspect	Survey Result (Mean Score)	KII Perspective (Qualitative Evidence)	Triangulated Interpretation
1	Organizational	4.21 (Highest)	Strong emphasis on inspection capacity, coordination, and digital monitoring	Institutional strengthening is the most critical measure for compliance improvement
2	Behavioral	4.08	Highlighted need for awareness among owners, contractors, and consultants	Awareness and ethical practices are essential for reducing non-compliance
3	Legal	3.93	Focus on enforcement, penalties, and regulatory control mechanisms	Enforcement is necessary but less effective without institutional and behavioral support

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study evaluated the compliance status of steel-framed commercial buildings in Kathmandu Metropolitan City using field observations, questionnaire surveys, and key informant interviews. The findings indicate that the overall compliance level is below 50%**,** reflecting a significant gap between approved design standards and actual construction practices.

Component-wise analysis shows relatively higher compliance in primary structural elements such as columns and beams, whereas critical connection elements—including base plates, stiffeners, and member sizing—exhibit notably low compliance. This suggests that less visible structural components are often neglected, increasing potential structural risks.

The Relative Importance Index (RII) analysis identified key causes of non-compliance, with organizational factors ranking highest (Mean = 3.648)**,** followed closely by behavioral and legal aspects. Major issues include weak enforcement mechanisms, inadequate technical manpower, poor dissemination of technical information, cost-driven decisions by owners, and frequent design changes during construction. The Kruskal–Walli's test ($p > 0.05$) indicates that stakeholders share similar perceptions regarding these causes, highlighting that non-compliance is a systemic issue.

Furthermore, recommended measures emphasize strengthening organizational systems, particularly through regular inspection, improved coordination, and increased awareness among building owners. Overall, the study concludes that improving compliance requires integrated efforts addressing institutional inefficiencies, stakeholder behavior, and regulatory enforcement to ensure safer and more reliable steel-framed construction practices.

5.2 Recommendations from study

- **Strengthening Field Monitoring:**
  Municipal authorities should implement strict stage-wise inspection systems and ensure the involvement of supervision engineers throughout construction to maintain proper control and compliance.
- **Standardized Guidelines:**
  Clear and consistent guidelines for steel construction, aligned with the Nepal National

Building Code, should be developed to ensure uniform understanding and application across projects.

- **Awareness of Owners:**
  House owners should be made more aware of building code requirements and associated safety risks so that they can make informed and responsible construction decisions.
- **Licensing of Fabricators:**
  Fabricators should be registered and licensed based on proper training and certification to enhance accountability and minimize poor practices or malpractice in construction.
- **Capacity Building of Professionals:**
  Regular and continuous training programs should be provided to engineers and contractors to strengthen technical skills and improve compliance with design and construction standards.

5.3 Recommendation for further study

- Conduct similar research in other major cities of Nepal with a larger sample size.
- Compare steel-framed and RCC buildings in cost, time, and compliance.
- Study the seismic performance and structural safety of steel-framed buildings.

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APPENDICES

APPENDIX 1: Field Observation Checklist

FIELD CHECKLIST			
HOUSE OWNER NAME:		FORM NO:	
		NO. OF STOREY:	
ADDRESS:		BUILDING PURPOSE	
		DATE OF INSPECTION:	
BUILT-UP AREA:		GPS COORDINATES:	

S.N.	ITEM DESCRIPTION	YES	NO	N/A	REMARK
A) Size of Member					
1	Base Plate	☐	☐	☐	
2	Column	☐	☐	☐	
3	Beam	☐	☐	☐	
4	Batten Plate	☐	☐	☐	
5	Stiffner Plate	☐	☐	☐	
6	Truss Member				
	i) Rafter	☐	☐	☐	
	ii) Purlin	☐	☐	☐	
	iii) Post	☐	☐	☐	
	iv) Vertical Strut	☐	☐	☐	
	v) Inclined Strut	☐	☐	☐	
	vi)Tie Beam	☐	☐	☐	
B) Structural System					
1	Column	☐	☐	☐	
2	Beam	☐	☐	☐	
3	Truss Member				
	i) Rafter	☐	☐	☐	
	ii) Purlin	☐	☐	☐	
	iii) Post	☐	☐	☐	
	iv) Vertical Strut	☐	☐	☐	
	v) Inclined Strut	☐	☐	☐	
C) Bolted Connection					
1	Base Plate-Column Connection				
	i) Number of Bolt	☐	☐	☐	
	ii) Bolts Arrangement	☐	☐	☐	
	iii) Bolt Diameter	☐	☐	☐	
2	Beam-Column Connection	☐	☐	☐	
	i) Number of Bolt	☐	☐	☐	
	ii) Bolts Arrangement	☐	☐	☐	
	iii) Bolt Diameter				
D) Welded Connection					
1	Size and Length of Weld	☐	☐	☐	

APPENDIX 2: Questionnaire Survey for Building Owners

Title of Study: Implementation Status of Steel Framed Commercial Buildings in Kathmandu Metropolitan City

I would like to request your consent to participate in this questionnaire survey conducted for academic purposes. The information provided will be kept confidential and used only for research.

General Information

Name of Respondent: ____ Date of Survey:

Address: ____

Gender: ____

Survey Questions

1) What is the primary reason for selecting a steel structure for your building?

a) Lower construction cost
b) Faster construction time
c) High salvage/reuse value
d) Greater structural strength and durability
e) Other (please specify): ____

2) Are you aware of any modifications made to the original steel structural design or member sizes during construction?

a) Yes b) No

3) If yes, what was the main reason for these modifications?

a) Recommendation from contractor/fabricator
b) Recommendation from designer/engineer
c) Cost reduction considerations
d) Perception that the original design was overly conservative
e) Other (please specify): ____

4) Were you informed or consulted before making changes to the structural design or member sizes?

a) Yes, fully informed
b) Partially informed
c) Not informed

5) Do you believe that all construction practices followed the approved building code and design specifications?

a) Yes b) No c) Not sure

Thank you for your valuable time and cooperation.

APPENDIX 3: Questionnaire Survey for Fabricators

Title of Study: Implementation Status of Steel Framed Commercial Buildings in Kathmandu Metropolitan City
I would like to request your consent to participate in this questionnaire survey conducted for academic purposes. The information provided will be kept confidential and used only for research.

General Information
Name of Respondent: ____ Date of Survey:
Site Address: ____
Gender: ____

Survey Questions

1) Are you aware of any changes made to the steel structural system or member sizes during construction?
a) Yes b) No

2) If yes, what is the primary reason for such changes?
a) Recommendation from designer/engineer
b) Client pressure for cost reduction
c) Perception that the original design was overly conservative
d) Other (please specify): _______________________________________

3) What are the main reasons for insufficient or improper welding in steel members?
a) Inadequate detailing in drawings
b) Shortage of skilled welders
c) Lack of proper inspection or supervision
d) Assumption that the provided weld is sufficient e) Other (please specify): _______________________________________

4) What factors lead to the use of welded connections instead of bolted connections in certain members?
a) Misinterpretation or lack of clarity in drawings
b) Inadequate supervision or inspection
c) Belief that welded connections are stronger than bolted ones
d) Other (please specify): _______________________________________

5) Do you prepare and strictly follow approved shop drawings and design specifications during fabrication and erection?
a) Yes, always followed
b) Followed with minor deviations
c) Sometimes not followed
d) Not followed

6) What level of inspection and quality control is carried out during welding and connection works?

a) Regular inspection by engineer/supervisor
b) Occasional inspection
c) Rare inspection
d) No proper inspection

7) Are you familiar with Nepal Building Code (NBC) provisions related to steel structures?

a) Fully familiar and applied
b) Partially familiar
c) Heard of it but not applied
d) Not familiar

Thank you for your valuable time and cooperation.

APPENDIX 4: Questionnaire for Municipal Engineer, DUDBC Engineer, Consultant & Contractor

Questionnaire for Municipal Engineer, DUDBC Engineer, Consultant & Contractor

Respondent's Information:
Name of Respondents:
Enter a date:
Gender:
Organization Type:
Experience in Construction:

What are the causes of non-compliance in steel-framed commercial buildings in Kathmandu Metropolitan City?

Use a scale of 1-5 where
1= Strongly Disagree, 2= Disagree, 3=Neutral, 4=Agree, and 5= Strongly agree

S.N.	Aspect	Item	1	2	3	4	5
1	Legal	Ineffective system for enforcing rewards and punishments.					
2		Lack of effective enforcement of building codes and regulations contributes to non-compliance in steel-framed commercial buildings.					
3	Organizational	Lack of sufficient technical manpower in municipality					
4		Delays caused by an overly complex building approval process					
5		Lack of public dissemination of information about listed engineers and trained fabricators.					
6		Insufficient construction management guidelines					
7	Market	The quality of construction materials used in steel-framed buildings is often below the required standards.					
8		There is an inadequate number of professional engineers with expertise in steel structure construction.					
9	Functional	Steel-framed construction projects often lack adequate on-site supervision by qualified engineers					
10		Ineffective coordination between owners and designers leads to non-compliance in steel-framed buildings					
11		Drawings approved by designers or the municipality are often incomplete or insufficient for proper construction.					
12		Frequent changes to design drawings during construction contribute to non-compliance issues					
13		Engineers involved in steel-framed construction often lack sufficient practical field experience					
14	Behavioral	Ethical practices among stakeholders are insufficient to ensure compliance in steel-framed construction.					

15		Negligent behavior by stakeholders negatively affects compliance with approved designs and codes.					
16		Owners tend to prioritize selecting fabricators over engaging qualified engineers, leading to non-compliance					
17		The perception that steel-framed construction is costly discourages full compliance with standards					
18		Owners generally have limited knowledge of applicable building codes for steel-framed structures					
19		Contractors or fabricators may compromise compliance to remain competitive in the construction market.					
20		Owners have limited awareness of the potential risks associated with non-compliance.					

In your opinion, what are the causes of non-compliance in steel framed commercial buildings in Kathmandu metropolitan city? (if other)

……………………………………………………………………………………………………

What are the suggestions for construction compliance in steel framed commercial buildings in Kathmandu metropolitan city?

Use a scale of 1-5 where
1= Strongly Disagree, 2= Disagree, 3=Neutral, 4=Agree, and 5= Strongly agree

S.N.	**Aspect**	**Item**	1	2	3	4	5
1	**Legal**	An effective reward and punishment system improves compliance					
		Strengthening enforcement of building codes and regulations					
2		Incentives encourage owners to follow building codes					
3	**Organizational**	Regular inspection and monitoring during different construction stages					
4		Mandatory orientation or briefing programs for house owners before construction					
5		Public access to listed consultants and contractors improves accountability					
6		Better coordination among stakeholders (municipality, consultants, contractors, and owners)					
9		Digitalization of building permit and monitoring systems					
10		Improved coordination between design approval and site inspection authorities					
7	**Behavioral**	Awareness programs should be conducted for public					

11		Increasing awareness among building owners about building codes and safety standards					

In your opinion what are the suggestions for construction compliance in steel-framed commercial buildings in Kathmandu metropolitan city? (if other)

…..

APPENDIX 5: Result of Field Observation

S. N	Build -Up Area (Sq.ft.)	Purpose of Building	Changed Building Purposed
1	18101.73	Commercial	Commercial
2	4368.88	Commercial	Commercial
3	7028	Commercial	Commercial
4	6759	Commercial	Commercial
5	5422.8	Commercial	Commercial
6	6774.14	Commercial	Commercial
7	5905	Commercial	Commercial
8	2051	Commercial	Commercial
9	13020	Commercial	Commercial
10	10784	Commercial	Commercial
11	5051.37	Commercial	Commercial
12	7257	Commercial	Commercial
13	7589	Commercial	Commercial
14	4668	Commercial	Commercial
15	4262.51	Commercial	Commercial
16	4415	Commercial	Commercial
17	6017	Commercial	Commercial
18	5673.6	Commercial	Commercial
19	7782	Commercial	Commercial
20	4071	Commercial	Commercial

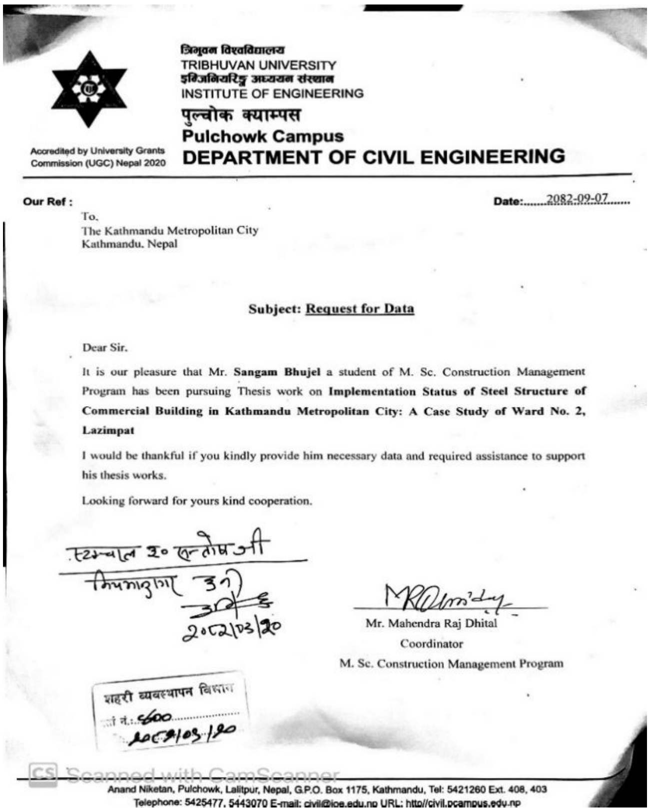
Table 1: Compliance of Various Parameters

S.N.	Items	Sub-Items	Compliance %
1	Member Size	Base Plate	23.52
2		Column	40
3		Beam	30
4		Batten Plate	40
5		Stiffener Plate	30
6		Truss Member	37.5
7	Structural System	Column	47
8		Beam	43.75
9		Truss Member	33.33
10	Bolted Connection	Base Plate-Column	31.25
11		Beam-Column	35.29
12	Welded Connection		35.29

Compliance Check

S.N.	Stage	Member size						Structural system			Bolted connection		Welded connection
		Base plate	Column	Beam	Batten Plate	Stiffener plate	Truss member	Column	Beam	Truss member	Base Plate -Column	Beam-Column	
1	Pre-Construction stage	N/A	0	0	0	0	0	N/A	N/A	N/A	0	0	N/A
2		0	0	0	0	0	0	0	0	0	0	0	0
3		N/A	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4		0	0	0	0	0	N/A	0	0	N/A	N/A	N/A	N/A
5	Construction stage	0	0	0	0	0	N/A	0	0	0	0	0	0
6		0	1	1	1	1	0	1	1	N/A	N/A	0	0
7		0	0	0	0	0	N/A	0	0	N/A	0	0	1
8		0	0	0	1	1	N/A	1	1	0	1	1	1
9		1	1	0	1	0	1	1	0	N/A	N/A	0	0
10		0	1	0	0	0	0	0	N/A	N/A	0	0	0
11		N/A	1	1	1	1	N/A	1	1	1	1	1	0
12		0	0	0	0	0	N/A	0	0	N/A	0	0	0
13		1	1	1	1	1	N/A	1	1	N/A	1	1	1
14		0	0	0	0	0	N/A	0	0	N/A	0	0	0
15	Post-construction stage	0	0	0	0	0	N/A	0	0	N/A	0	0	0
16		0	0	0	0	0	0	N/A	N/A	N/A	0	N/A	0
17		1	1	1	1	1	1	1	1	N/A	0	1	1
18		1	1	1	1	1	1	1	1	N/A	1	1	1
19		0	0	0	0	0	0	0	0	0	0	0	0
20		0	1	1	1	1	N/A	1	1	1	1	1	1
	C%	23.52	40	30	40	36.84	37.5	47	43.75	33.33	31.25	35.29	35.29

APPENDIX 6: Photographs



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To,
The Kathmandu Metropolitan City
Kathmandu, Nepal

Subject: Request for Data

Dear Sir,

It is our pleasure that Mr. **Sangam Bhujel** a student of M. Sc. Construction Management Program has been pursuing Thesis work on **Implementation Status of Steel Structure of Commercial Building in Kathmandu Metropolitan City: A Case Study of Ward No. 2, Lazimpat**

I would be thankful if you kindly provide him necessary data and required assistance to support his thesis works.

Looking forward for yours kind cooperation.

२०८२/०९/२०

Mr. Mahendra Raj Dhital
Coordinator
M. Sc. Construction Management Program

शहरी व्यवस्थापन विभाग

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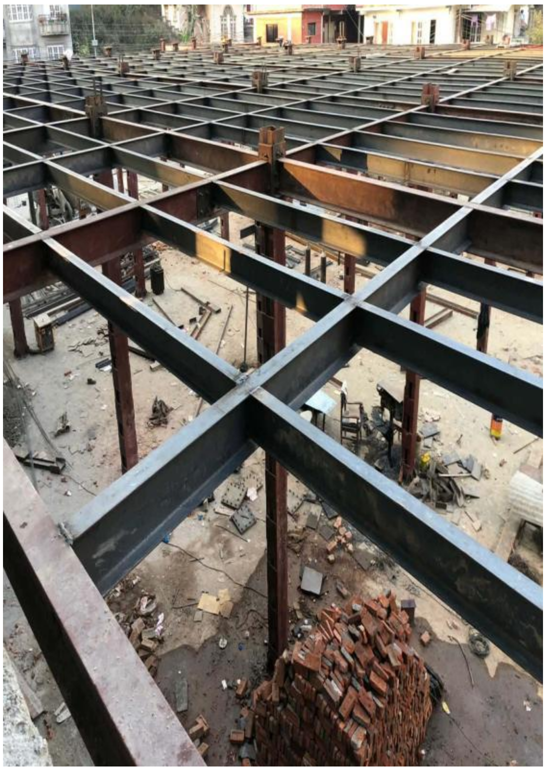

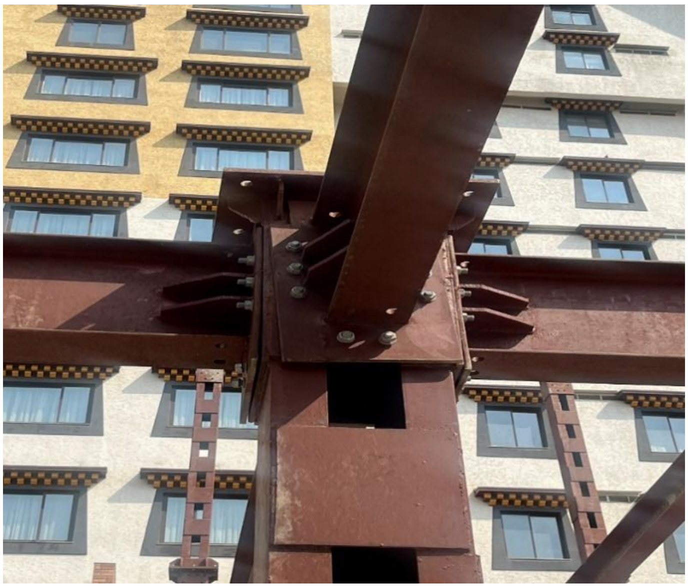




APPENDIX 7: Validity Source for Causes

Legal Aspects	Adapted from
Ineffective system for enforcing rewards and punishments.	Maharjan, R., Bhattarai, S. K., & Arayal, S. (2025)
Lack of effective enforcement of building codes and regulations contributes to non-compliance in steel-framed commercial buildings.	Shrestha, A., et al. (2025). *Building permit process and compliance challenges in Nepal*
Organizational Aspects	**Adapted from**
Lack of sufficient technical manpower in municipality	Lalitpur Metropolitan City. (2019
Delays caused by an overly complex building approval process	Shrestha, A., et al. (2025)..
Lack of public dissemination of information about listed engineers and trained fabricators.	Nepal Engineering Council. (2025)
Insufficient construction management guidelines	Maharjan, R., et al. (2025). *Assessing compliance with Nepal's building code and bylaws*.
Market	**Adapted from**
The quality of construction materials used in steel-framed buildings is often below the required standards.	Center for Investigative Journalism Nepal (CIJ-Nepal). (2021)
There is an inadequate number of professional engineers with expertise in steel structure construction.	Sharma, P., et al. (2020). *Steel structure implementation challenges in Nepal*
Functional	**Adapted from**
Steel-framed construction projects often lack adequate on-site supervision by qualified engineers	Lalitpur Metropolitan City. (2019). *Building construction supervision guidelines*
Ineffective coordination between owners and designers leads to non-compliance in steel-framed buildings.	Center for Investigative Journalism Nepal (CIJ-Nepal). (2021).
Drawings approved by designers or the municipality are often incomplete or insufficient for proper construction.	Center for Investigative Journalism Nepal (CIJ-Nepal). (2021).
Frequent changes to design drawings during construction contribute to non-compliance issues	Maharjan, R., et al. (2025). *Assessing compliance with Nepal's building code and bylaws*.
Engineers involved in steel-framed construction often lack sufficient practical field experience	Pant, S., & Subedi, R. (2025)..
Behavioral	**Adapted from**
Ethical practices among stakeholders are insufficient to ensure compliance in steel-framed construction.	Transparency International Nepal. (2022)
Negligent behavior by stakeholders negatively affects compliance with approved designs and codes.	Center for Investigative Journalism Nepal (CIJ-Nepal). (2021).
Owners tend to prioritize selecting fabricators over engaging qualified engineers, leading to non-compliance	Pangeni, B. (2021). *Steel construction practices in Nepal*.

The perception that steel-framed construction is costly discourages full compliance with standards	Pangeni, B. (2021). *Advantages of steel-framed construction in Nepal*
Owners generally have limited knowledge of applicable building codes for steel-framed structures	Pant, S., & Subedi, R. (2025)
Contractors or fabricators may compromise compliance to remain competitive in the construction market	Center for Investigative Journalism Nepal (CIJ-Nepal). (2021).
Owners have limited awareness of the potential risks associated with non-compliance.	Maharjan, R., et al. (2025).

APPENDIX 8: Validity Source for Recommendations

Legal	Adapted from
An effective reward and punishment system improves compliance	World Bank (2018). *Building Regulation for Resilience*
Strengthening enforcement of building codes and regulations	World Bank (2018). *Building Regulation for Resilience*
Organizational	Adapted from
Regular inspection and monitoring during different construction stages	Nepal National Building Code (NBC 105: Site Supervision and Quality Control)
Mandatory orientation or briefing programs for house owners before construction	DUDBC (Nepal) training manuals and awareness programs
Public access to listed consultants and contractors improves accountability.	Nepal Engineers' Association (NEA) registration guidelines
Better coordination among stakeholders (municipality, consultants, contractors, and owners	ADB (2017)
Digitalization of building permit and monitoring systems	ADB (2021)
Improved coordination between design approval and site inspection authorities	OECD (2017). *Regulatory Policy and Governance*
Behavioral	Adapted from
Awareness programs should be conducted for public	DUDBC Nepal awareness campaigns on earthquake-resistant construction
Increasing awareness among building owners about building codes and safety standards	DUDBC, Nepal – National Building Code implementation manuals

APPENDIX 9: Acceptance Letter For 18th Ioe Graduate Conference

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Dr. Pradeep Shrestha <ioegc17@gmail.com> Mon, Apr 27, 9:4
to me

Sangam Bhujel:

We have reached a decision regarding your submission to 18th IOE Graduate Conference, "Implementation Status of Steel-Framed Commercial Building in Kath

Our decision is to: Accept Submission

With Warm Regards,
IOEGC-18 Editorial Team

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APPENDIX 10: Plagiarism Check for Originality

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SANGAM BHUJEL

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