TRIBHUWAN UNIVERSITY

INSTITUTE OF ENGINEERING

PULCHOWK CAMPUS

THESIS NO.: 080/MSCoM/009

Analysis of Quality and Cost of Major Construction Materials in Kathmandu Valley

By

Biraj Aryal

A THESIS

SUBMITTED TO THE DEPARTMENT OF CIVIL ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE IN CONSTRUCTION MANAGEMENT

DEPARTMENT OF CIVIL ENGINEERING

LALITPUR, NEPAL

APRIL, 2026

COPYRIGHT

The author has agreed that the library, Department of Civil Engineering, Pulchowk Campus, Institute of Engineering may make this thesis freely available for inspection. Moreover, the author has agreed that permission for extensive copying of this thesis for scholarly purpose may be granted by the Professor, who supervised the project work recorded herein or, in their absence, by the Head of the Department or concerning MSc. Program Coordinator or dean of the Institute in which this thesis was done. It is understood that the recognition will be given to the author of this thesis and to the Department of Civil Engineering, Pulchowk Campus, Institute of Engineering, in any use of the material of this thesis. Copying or publication or the other use of this thesis for financial gain without approval of the Department of Civil Engineering, Pulchowk Campus, Institute of Engineering and author's written permission is prohibited.

Request for permission to copy or to make any other use of the material in this thesis in whole or in part should be addressed to:

....

Head of Department of Civil Engineering

Pulchowk Campus, Institute of Engineering

Pulchowk, Lalitpur

Nepal

DECLARATION

I hereby declare that the thesis entitled "Analysis of Quality and Cost of Selected Construction Materials in Kathmandu Valley", submitted to the Department of Civil Engineering in partial fulfillment of the requirement for the degree of Master of Science in Engineering in Construction Management, is a record of an original work done under the guidance of Asst. Prof. Mahendra Raj Dhital. This thesis contains only work completed by me except for the consulted material, which has been duly referenced and acknowledged.

....

Biraj Aryal

080/MSCoM/009

TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

PULCHOWK CAMPUS

DEPARTMENT OF CIVIL ENGINEERING

CERTIFICATE OF THESIS APPROVAL

The undersigned certify that we have read and recommended to the Institute of Engineering for acceptance, a thesis entitled "**Analysis of Quality and Cost of Selected Construction Materials in Kathmandu Valley**" submitted by Biraj Aryal in partial fulfillment of the requirements for the degree of Master of Science in Construction Management.

....

Supervisor,

Asst. Prof. Mahendra Raj Dhital

Assistant Professor

Department of Civil Engineering, IOE, Pulchowk Campus

....

External Examiner,

Er. Subash Kumar Bhattarai

Visiting Faculty

Construction Management

Center for Post Graduate Studies

Nepal Engineering College (nec-CPS)

....

Program Coordinator,

Asst. Prof. Mahendra Raj Dhital

M.Sc. in Construction Management

Department of Civil Engineering, IOE, Pulchowk Campus

....

Date: April, 2026

Tribhuvan University
Institute of Engineering
Department of Civil Engineering
Pulchowk Campus

ABSTRACT

Rapid urbanization in Kathmandu Valley has intensified the demand for cement, rebar, and brick -the three materials that dominate structural cost and determine safety in building projects. Procurement decisions, however, are often made without a consolidated evidence base that links laboratory compliance, market price, and stakeholder preference. This study was undertaken to address that gap.

The research adopted a mixed-method design. Laboratory testing was conducted on 11 cement brands (OPC 43 grade, OPC 53 grade, and PPC), 8 rebar brands (including RB2) across diameters from 8 mm to 32 mm, and 9 brick brands, following NS 49, NS 104, NS 191, IS 1786, and IS 1077 protocols. A structured market-price survey was carried out among 30 hardware suppliers in Kathmandu, Lalitpur, and Bhaktapur. A questionnaire survey was administered face-to-face to 32 clients and 30 contractors/engineers; the instrument was pre-tested with 6 respondents and the internal consistency of Likert items returned Cronbach's $\alpha = 0.81$.

Quality testing showed 100% compliance for all 11 cement brands against the 28-day compressive-strength benchmark of 43 MPa (OPC 43), 53 MPa (OPC 53, reported at 28 days as a practical proxy for the 28-day codal value), and 33 MPa (PPC). For OPC 43 grade, CB1 recorded the highest mean strength at 54.50 MPa and CB4 the lowest at 45.33 MPa. For OPC 53 grade, CB1 again led at 70.88 MPa and CB9 returned the lowest at 46.98 MPa. For PPC, CB9 recorded the highest at 45.71 MPa and CB6 the lowest at 33.09 MPa. Six of seven deformed-bar brands (RB1, RB3, RB4, RB7, RB5, RB6, plus the 'RB8' category) met the Fe500 yield-strength requirement of 500 MPa, while RB2 failed with an average yield of only 385 MPa. All brands satisfied the minimum elongation of 12%. Among bricks, 3 of 9 brands (BB7 14.84 MPa, BB2 11.56 MPa, BB5 10.66 MPa) reached 1st-class classification (≥ 10 MPa), while the remaining six met 2nd class (≥ 7.5 MPa); BB9 brick showed high water absorption (22.7%) and is recommended only for plastered masonry.

Cost analysis showed a clear price premium on CB5 cement (NPR 934/bag for OPC 43, about 12% above the market average) that was not matched by proportionally higher strength. Rebar prices were highly uniform across brands (NPR 109–115.5/kg by diameter), indicating that quality compliance, not price, should drive rebar selection. Comparison of retail-survey prices against the Government of Nepal District Rate showed a systematic retailer-side premium of about 30–35% on cement, 8–9% on rebar, and material-type-specific premia on brick (chimney-made matches the District Rate almost exactly; machine-made carries a ~15% premium). Brick prices ranged from NPR 11 to NPR 19 per piece, with BB7 emerging as a strong value option. Stakeholder results indicated that 63% of clients prioritized quality, 25% prioritized cost, and 13% weighted both equally. Contractor/engineer selection was driven mainly by availability, workability, and brand familiarity: CB1 (27%) and CB8 (20%) led cement choices, RB1 (30%) and RB7 (23%) led steel, and BB7 (27%) and BB5 (23%) led brick.

The findings demonstrate that better procurement decisions are achieved when standards-based quality assessment, multi-supplier cost benchmarking, and practical stakeholder considerations are integrated into a single decision framework. The study contributes a local, data-driven reference for construction managers, clients, and contractors working in Kathmandu Valley.

Keywords: Construction materials, Quality testing, Cost analysis, Cement, Rebar, Brick, Stakeholder survey, Kathmandu Valley

ACKNOWLEDGEMENTS

First of all, I would like to express my sincere gratitude to my thesis supervisor Asst. Prof. Mahendra Raj Dhital for the constant guidance, supervision, comments, and encouragement throughout the research. Their patient reviews and critical insights shaped every chapter of this thesis.

I would also like to express my heartfelt gratitude to Asst. Prof. Santosh Kumar Shrestha, Pulchowk Campus, IOE, Tribhuvan University, for his continuous support and invaluable guidance. From the very beginning of this project, he provided one-to-one mentorship, insightful ideas, and consistent encouragement, which played a crucial role in the successful completion of this research.

I am deeply thankful to Asst. Prof. Mahendra Raj Dhital, Program Coordinator of the M.Sc. in Construction Management Program, Department of Civil Engineering, Pulchowk Campus, Tribhuvan University, for his continuous encouragement and for providing the academic environment necessary to complete this work.

I acknowledge with gratitude the staff of the CMTL Laboratory, Pulchowk Campus, where the cement, rebar, and brick specimens were tested. Their technical assistance and rigor in following NS and IS protocols were indispensable to the quality testing component of this study.

I extend my thanks to the thirty hardware suppliers across Kathmandu, Lalitpur, and Bhaktapur who participated in the market-price survey, and to the thirty-two clients and thirty contractors and engineers who took the time to respond to the questionnaire and share their field experience.

Finally, I thank my family and friends for their continuous support and patience during the long months of laboratory work, site visits, and writing that this research demanded.

Biraj Aryal

080/MSCoM/009

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviation	**Full Form**
AIT	Asian Institute of Technology
BIS	Bureau of Indian Standards
CBS	Central Bureau of Statistics
DUDBC	Department of Urban Development and Building Construction
Fe500	Grade 500 deformed reinforcement bar
Fe500D	Grade 500 deformed reinforcement bar -ductile
FNCCI	Federation of Nepalese Chambers of Commerce and Industry
IS	Indian Standard
KV	Kathmandu Valley
MPa	Mega Pascal
NBSM	Nepal Bureau of Standards and Metrology
NPR	Nepalese Rupees
NS	Nepal Standard
OPC	Ordinary Portland Cement
PPC	Pozzolana Portland Cement
RCC	Reinforced Cement Concrete
SD	Standard Deviation

1. INTRODUCTION

1.1 Background

Construction activity in Nepal has accelerated sharply over the past two decades, driven by rising urban population, post-2015 earthquake reconstruction, and large public-infrastructure programs. Kathmandu Valley -which comprises the three districts of Kathmandu, Lalitpur, and Bhaktapur -is the centre of this building boom and absorbs the largest share of residential, commercial, and public construction in the country (Central Bureau of Statistics, 2020; Shrestha & Manandhar, 2021). Of the many inputs that a construction project consumes, three materials -cement, reinforcement steel (rebar), and burnt-clay brick -stand out because they together account for the majority of structural material expenditure and, more importantly, determine the safety, durability, and serviceability of the finished structure (Acharya & Sharma, 2020) (Pradhan & Thapa, 2021).

The Nepalese market for these three materials has matured rapidly but unevenly. For cement, more than a dozen local brands operate across Ordinary Portland Cement (OPC) grade 43, OPC grade 53, and Pozzolana Portland Cement (PPC) categories, governed principally by Nepal Standard NS 49 and NS 104 (Nepal Bureau of Standards and Metrology, 2014). For rebar, deformed bars of grade Fe500 and Fe500D dominate the seismic-design market and are governed by NS 191 and the widely adopted Indian Standards IS 1786 and IS 1139 (Bureau of Indian Standards, 1966). For bricks, IS 1077 remains the reference specification, and both BB2 and traditional kiln-fired bricks are widely available (Bureau of Indian Standards, 2007).

Notwithstanding this regulatory coverage, actual procurement on construction sites is rarely decided by code compliance alone. Field experience and earlier surveys in Nepal and other South-Asian markets consistently show that material choice is shaped by a mixture of technical performance, price, supplier relationship, perceived brand legacy, and project-level operational factors such as availability and delivery reliability (Bista & Karki, 2023; Thapa & Dahal, 2023; Joshi & Bajracharya, 2022). Construction managers therefore work at the intersection of laboratory evidence, cost reality, and stakeholder judgement, and the quality of the decisions they make depends on how well these three dimensions are integrated.

This research was motivated by the observation that, in the context of Kathmandu Valley, each of these three dimensions has been studied in isolation but seldom together. Laboratory studies document strength variation across cement brands or brick kilns; market studies document price dispersion; social-science studies document stakeholder preferences. What is missing is a single evidence base that a practicing engineer or project manager can consult to compare brands on compliance, cost, and operational acceptance simultaneously. The present work attempts to build that evidence base by testing, surveying, and interviewing within a common analytical frame.

1.2 Problem Statement

Construction projects in Kathmandu Valley routinely experience cost overruns, quality non-conformities, and disputes that can be traced back, at least in part, to material-procurement decisions. Three recurring problems are observed. First, although most local cement brands are tested before being placed in the market, practitioners have no consolidated public record of brand-wise strength at the standard ages, and so premium-priced brands are often purchased on brand reputation alone without independent verification of proportional performance (Paudel & Subedi, 2022; Pradhan & Thapa, 2021). Second, plain mild-steel rod continues to appear on sites in seismically active areas even though it does not meet Fe500 requirements, mainly because it is cheaper and widely stocked (Shrestha & Manandhar, 2021; Risal & Ghimire, 2021). Third, brick procurement is often made on visual inspection and supplier familiarity rather than on class-based strength testing, leading to mismatches between the structural demand of the wall and the class of brick actually placed (Acharya & Sharma, 2020).

These problems are exacerbated by the fragmentation of existing evidence. Laboratory results, market prices, and stakeholder preferences are usually reported in different documents, at different times, and for different subsets of brands. The construction manager who must select a cement, rebar, and brick package for a new project therefore has no single reference that reports all three dimensions on the same brand list, in the same geographical market, within the same survey window. The absence of such an integrated reference is the central gap that this study addresses. Without it, procurement decisions remain vulnerable to the very factors -price minimization, brand familiarity, supplier convenience - that the literature identifies as predictive of downstream quality failures (Tuladhar & Rajbhandari, 2019; Maharjan & Shakya, 2023).

1.3 Research Questions

This study is organized around four research questions that together cover the technical, economic, and behavioral dimensions of material selection.

1. RQ1: What are the current quality characteristics, relative to Nepal Standard and Indian Standard benchmarks, of the cement, rebar, and brick brands in active use in Kathmandu Valley?
2. RQ2: How do the market prices of these materials vary across suppliers, brands, and product types within the valley?
3. RQ3: What factors - technical, economic, or operational - most strongly influence the selection of these materials by clients and by contractors/engineers?
4. RQ4: How can the evidence from quality testing, cost analysis, and stakeholder survey be combined into practical procurement guidance for construction projects in Kathmandu Valley?

1.4 Research Objectives

The primary objective of this thesis is reflected in its title—"Analysis of Quality and Cost of Selected Construction Materials in Kathmandu Valley." To address that primary objective in a measurable way, the following four specific objectives have been set, and they are used throughout the thesis as the reporting frame for the literature review, methodology, results, and conclusions.

1. To assess the compliance of cement (OPC 43, OPC 53, PPC), rebar (Fe500/Fe500D and plain mild-steel rod), and brick brands sold in Kathmandu Valley against the applicable Nepal Standards and Indian Standards.
2. To examine cost variation of these materials across suppliers, brands, grades, and diameters, and to identify brands that offer disproportionate price premiums relative to tested quality.

3. To determine the factors that influence client and contractor/engineer material-selection decisions, using a structured questionnaire survey.
4. To develop a set of practical, evidence-based procurement recommendations that integrate quality compliance, cost benchmarking, and stakeholder preference for use on Kathmandu Valley projects.

1.5 Significance of the Study

The study is significant for three overlapping audiences. For construction managers and site engineers, it provides a brand-wise, side-by-side reference of compliance status, price level, and stakeholder acceptance -the three pieces of information that procurement decisions actually need. For clients, especially those funding their first or second building project, it clarifies where quality premiums are justified by measurable performance (cement) and where they are not (rebar). For policy and standards bodies, it documents the practical gap between code compliance and market-price behavior and highlights the products -notably plain mild-steel rod -that continue to circulate despite non-compliance.

At a wider level, this work contributes to the growing local literature on construction-material procurement in South Asia and provides a template that can be replicated for other material categories or geographical sub-markets. By integrating laboratory, market, and stakeholder data in a single study, it also responds to the repeated call in the Nepalese construction-management literature for mixed-method evidence that connects technical and behavioral dimensions (Tuladhar & Rajbhandari, 2019; Bista & Karki, 2023).

1.6 Scope and Limitations

Following the guideline that scope and limitations should describe the boundaries of the actual study rather than administrative constraints such as time or funding, the scope of this work is defined as follows. Geographically, the study covers Kathmandu, Lalitpur, and Bhaktapur districts only; findings should not be generalized to other regions of Nepal without local verification. Materially, it covers only three categories -cement, rebar, and brick -and does not examine aggregates, formwork, finishes, or mechanical/electrical items. The brand list is restricted to 11 cement brands, 8 rebar brands (including RB2 as a reference non-compliant product), and 9 brick brands that were active in the market during the survey period.

The study also carries the following intrinsic limitations. Laboratory testing used market samples purchased from suppliers and was replicated 16 to 28 times per brand and grade; batch-to-batch and seasonal variation within a brand is therefore not fully captured. The questionnaire sample of 32 clients and 30 contractors/engineers, while purposively drawn from active construction projects in Kathmandu Valley, is not statistically representative of the national construction workforce. Market prices are a single-cycle snapshot; prices can move seasonally and with import-fuel conditions. These limitations do not invalidate the findings but they define the bounds within which the findings should be interpreted.

2. LITERATURE REVIEW

2.1 Overview

This chapter reviews the literature on the three material categories that are central to this study -cement, rebar, and brick -and on the procurement behavior of clients and contractors in South-Asian construction markets. The review is deliberately selective. Only studies that (a) report brand-wise or standards-based evidence, (b) analyze price variation with statistical rigor, or (c) document stakeholder decision-making in construction-material contexts have been included. The aim is not an exhaustive survey but the establishment of an evidence base against which the findings of this study (Chapter 4) can be interpreted and compared.

2.2 Construction Materials and Urban Demand in Kathmandu Valley

The structural cost of a typical residential or small commercial building in Kathmandu Valley is dominated by cement, reinforcement steel, and bricks, which between them typically account for 55–70% of direct material expenditure (Shrestha & Bhattarai, 2022; Central Bureau of Statistics, 2020). The remaining share is distributed across aggregates, formwork, finishes, and services. Because of this concentration, procurement decisions on the three materials have an outsized effect on both project cost and project safety.

Rapid urbanization in the valley has put pressure on local supply chains. Shrestha and Bhattarai (2022) (Shrestha & Bhattarai, 2022) estimated that the cement demand in Kathmandu Valley grew at a compound annual rate of 7.8% between 2015 and 2021, with post-earthquake reconstruction accelerating growth further in the 2016-2018 window. Joshi and Bajracharya (2022) (Joshi & Bajracharya, 2022) reported that rebar and brick demand followed a similar trajectory, although brick production was repeatedly disrupted by kiln closures and by seasonal labour shortages. Several studies have noted that rapid construction cycles in emerging urban contexts can lead to compromises in material quality, particularly when procurement is driven by cost minimization alone (Acharya & Sharma, 2020; Tuladhar & Rajbhandari, 2019).

These demand-side pressures interact with two supply-side features specific to Nepal. First, a large share of cement raw material and almost all imported rebar originate outside the valley, which exposes prices to transport cost, border friction, and exchange-rate volatility (Pradhan & Thapa, 2021). Second, the brick industry remains geographically dispersed across the surrounding districts (Bhaktapur, Kavre, Makwanpur), and production quality varies considerably across kiln types (Acharya & Sharma, 2020). Together these features produce the brand-wise and supplier-wise variability in quality and price that the present study seeks to document and analyze.

2.3 Cement Quality and Standards

2.3.1 Regulatory framework

Nepal Standard NS 49 (Nepal Bureau of Standards and Metrology, 2014) prescribes minimum compressive strength requirements for Ordinary Portland Cement at 3, 7, and 28 days for both OPC 43 grade and OPC 53 grade, together with fineness, setting time, and soundness limits. NS 104 performs the equivalent function for Pozzolana Portland Cement (PPC). For 28-day compressive strength, the codal minima are 43 MPa for OPC 43, 53 MPa for OPC 53, and 33 MPa for PPC (equivalent values at earlier ages are lower). In practice, Nepalese laboratories and projects commonly report 28-day strength as a standard for 28-day strength; this convention is retained in the present study for consistency of comparison across grades (Paudel & Subedi, 2022).

2.3.2 Brand-wise variation in compliance

Studies on cement quality in South-Asian markets have consistently found that branded products generally comply with minimum strength benchmarks, but inter-brand variation can be significant. Paudel and Subedi (2022) (Paudel & Subedi, 2022) tested six OPC brands in the Pokhara and Kathmandu markets and reported 28-day compressive strengths ranging from 47 to 58 MPa, all above the NS 49 minimum but with a 23% spread. Pradhan and Thapa (2021) (Pradhan & Thapa, 2021) reached a similar conclusion in a market survey of nine brands and argued that the spread was large enough to make brand selection a meaningful lever in structural design, particularly for high-strength concrete. Density and fineness influence field performance but are frequently overlooked in procurement decisions (Nepal Bureau of Standards and Metrology, 2014).

Several recent studies provide a directly comparable evidence base for the present work. Jha and Dahal (2020) tested six cement brands sourced from Kathmandu Valley and reported that Hongshi recorded the highest 3-day and 7-day compressive strength while Sarbottam recorded the highest 28-day strength, with all six brands satisfying the NS 49 minimum at 28 days; their TOPSIS ranking selected Sarbottam as the optimal brand for Kathmandu Valley projects on a combined quality-cost-availability basis. Adhikari and Khanal (2024) tested five OPC 43-grade brands (labelled A through E) for road construction and reported a wide 28-day strength spread (19.41 to 33.63 MPa under their M20 mix conditions), with the lowest brand falling below the codal minimum, suggesting that brand-to-brand variation can be wide enough to compromise compliance in some cases. Mishra et al. (2025) tested ten OPC 43-grade brands available in central Terai for M20-grade concrete and demonstrated weak correlation between brand price and compressive strength, paralleling the central proposition of the present study that price is not a reliable predictor of cement performance. Mishra (2022) reported in-situ M20 concrete strength of 23.93 N/mm² (mean) across 90 cubical specimens from 30 residential buildings in Gaindakot, consistent with the cube-test means observed in the present mortar-cube programme.

2.3.3 Price-quality correspondence

A particularly important question in the local literature is whether premium-priced cement brands deliver proportionally higher strength. Paudel and Subedi (2022) (Paudel & Subedi, 2022) found only a weak positive correlation (Pearson $r \approx 0.35$) between average retail price and 28-day compressive strength across the brands they tested, and concluded that at least one premium-priced brand was “overpriced relative to its tested performance.” The present study, by testing 11 brands in parallel with a supplier-wide price survey, is positioned to test the same hypothesis on a larger brand set in the Kathmandu Valley.

2.3.4 Cement chemistry and strength development

The strength development of Portland cement is governed by the hydration of four principal clinker phases: tricalcium silicate (C_3S), dicalcium silicate (C_2S), tricalcium aluminate (C_3A), and tetracalcium aluminoferrite (C_4AF). C_3S dominates early-age strength (up to 7 days) while C_2S contributes progressively to long-age strength (beyond 28 days). The ratio of C_3S to C_2S varies among brands and is one factor that accounts for the variation in early and late strength gain. OPC 53 grade cements typically have a higher C_3S content than OPC

43, which explains both their higher early strength and their higher cost of production (Paudel & Subedi, 2022).

Pozzolanic Portland cement (PPC) blends ground fly ash or calcined clay with OPC clinker at 15–35% replacement. The pozzolanic reaction between the amorphous silica in the fly ash and the calcium hydroxide released by OPC hydration produces additional calcium silicate hydrate (C-S-H) that progressively densifies the microstructure. PPC therefore shows slower early strength gain but equivalent or superior 28-day strength, better sulphate resistance, and reduced heat of hydration -properties that are advantageous for mass concrete and for plasterwork. The Nepal Standard NS 104 specifies a lower 7-day and 28-day strength benchmark for PPC than NS 49 does for OPC, reflecting this slower strength-gain profile (Nepal Bureau of Standards and Metrology, 2014).

2.3.5 Density, fineness, and soundness

Beyond compressive strength, NS 49 and NS 104 specify secondary quality parameters that influence field performance. Density (typically 2.45–2.55 g/cm³ for Portland cement) reflects particle packing and gives an indirect indicator of fineness; values below 2.40 g/cm³ typically indicate excessive moisture absorption during transport or storage. Fineness (specific surface area) influences hydration rate: finer cement hydrates faster and develops higher early strength but is more prone to shrinkage cracking. Soundness, measured by the Le Chatelier expansion test, screens for excess free lime and magnesia that would cause delayed volumetric expansion in hardened concrete. Although the present study focused on compressive strength, density measurements are reported in Annex IV as a secondary indicator and are compared to the codal range for each brand.

2.4 Reinforcement Steel (Rebar) and Structural Safety

2.4.1 Regulatory framework

Indian Standard IS 1786 (Bureau of Indian Standards, 2008) specifies minimum yield strength, ultimate tensile strength, and elongation for high-strength deformed reinforcement bars. For Fe500, the minimum yield strength is 500 MPa and the minimum elongation at fracture is 12%. Fe500D adds a stricter elongation requirement (≥ 16%) intended for seismic applications. Nepal Standard NS 191 mirrors IS 1786 for local certification. Plain mild-steel rod is governed by the older IS 1139 (Bureau of Indian

Standards, 1966) and does not satisfy Fe500 requirements; its yield strength is typically in the range of 250–400 MPa.

2.4.2 Seismic considerations

Kathmandu Valley lies in a high-seismicity zone, and the 2015 Gorkha earthquake reinforced the case for disciplined use of Fe500-compliant rebar in all load-bearing elements. Shrestha and Manandhar (2021) (Shrestha & Manandhar, 2021) documented that plain mild-steel rod continued to appear in informal residential construction in the valley as late as 2020, despite its non-compliance, mainly because it is cheaper and more easily fabricated on site. Risal and Ghimire (2021) (Risal & Ghimire, 2021) performed comparative tensile tests on seven Fe500 brands across the Nepalese market and found that all passed the 500 MPa yield benchmark but with average yield strengths ranging from 530 to 580 MPa. They also reported that elongation margins were generally comfortable (typical averages of 19–22%), well above the 12% minimum.

2.4.3 Price uniformity

A consistent finding of the Nepalese rebar literature is that prices are highly uniform across major brands for the same diameter (Bista & Karki, 2023; Thapa & Dahal, 2023). The implication is that brand choice for rebar should be driven almost entirely by quality compliance rather than by price, and that persistent use of plain mild-steel rod reflects either informational failure or a deliberate cost-cutting strategy rather than a genuine price advantage once quality is accounted for.

2.4.4 Manufacturing routes and microstructural control

Deformed reinforcement bars sold in Nepal originate from two main manufacturing routes. The thermomechanical treatment (TMT) route, used by most large Indian and Nepalese manufacturers, passes the hot-rolled bar through a controlled water quenching line that produces a tempered martensitic outer case and a soft ferrite–pearlite core. This case–core composite gives TMT bars their characteristic combination of high yield strength, good ductility, and weldability. The micro-alloyed route, used for some specialized grades, adds vanadium or niobium to the melt to produce a fully pearlitic microstructure with uniform strength through the cross-section; these bars are marginally more expensive but have tighter strength scatter (Risal & Ghimire, 2021).

The difference between Fe500 and Fe500D grades lies primarily in the controlled elongation of Fe500D (minimum 16% against 12% for Fe500), which is achieved by adjusting the quench temperature and the chemistry of the melt. For seismic applications in Kathmandu Valley, NBC 105 and IS 13920 both prescribe Fe500D or equivalent ductile bars in plastic hinge regions of beams and columns. The present study tests yield strength and elongation for all brands but does not distinguish between Fe500 and Fe500D variants supplied under the same brand; compliance is assessed against the broader Fe500 minimum (Bureau of Indian Standards, 2008).

2.4.5 Corrosion and cover depth

Corrosion of embedded reinforcement is the principal long-term durability failure mode for reinforced concrete in Kathmandu Valley, where monsoonal moisture cycling and occasional chloride intrusion (near rivers and in older drainage areas) act on concrete cover that is often inadequate. The quality of the rebar -specifically the presence of rolling scale, surface rust, and mill finish -influences the passivation behavior of the bar in the alkaline concrete environment. NS 191 and IS 1786 both specify maximum allowable surface rust at the time of placement; bars with deep pitting or with mill scale thicker than 0.1 mm are rejected. The present study sampled bars directly from supplier stock and recorded surface condition qualitatively; quantitative surface-rust measurement was outside the scope but is recommended for future work (Shrestha & Manandhar, 2021).

2.5 Brick Classification and Usage

2.5.1 Regulatory framework

Indian Standard IS 1077 (Bureau of Indian Standards, 2007) classifies common burnt-clay building bricks into three classes by minimum compressive strength (1st class: ≥ 10 MPa; 2nd class: ≥ 7.5 MPa; 3rd class: ≥ 3.5 MPa) and imposes maximum water absorption limits (1st class: ≤ 20% by weight; 2nd class: ≤ 22% by weight). First-class bricks are suitable for load-bearing and exposed walls; second-class bricks are acceptable for plastered or less-demanding applications; third-class bricks are restricted to non-structural use

2.5.2 Variation across kilns

Local studies have noted wide quality variation across kiln types and production methods in the Kathmandu Valley context. Acharya and Sharma (2020) (Acharya & Sharma, 2020) tested bricks from eight kilns around the valley and reported compressive strengths ranging from 5.8 MPa to 14.1 MPa and water absorptions ranging from 11% to 24%. BB2 bricks generally performed better than hand-made products on strength and dimensional accuracy, but were also priced higher. Water absorption was the more common failure mode for non-compliance, particularly for bricks fired at lower temperatures.

2.5.3 Procurement practice

Brick procurement in residential construction is often made on visual inspection and supplier familiarity rather than on class-based strength testing (Acharya & Sharma, 2020; Maharjan & Shakya, 2023). This can lead to mismatches between the structural demand of the wall and the class of brick actually placed -for example, second-class bricks used in exposed load-bearing walls, or high-absorption bricks used in external walls without adequate plastering. The present study contributes to this area by reporting both compressive strength and water absorption for 9 brands on a consistent test protocol.

2.5.4 Kiln technology in Kathmandu Valley

The nine brick brands in the present study originate from four broadly different kiln types operating in and around Kathmandu Valley. Fixed Chimney Bull's Trench Kilns (FCBTK) are the most common type and produce the bulk of the valley's brick supply; they fire at 950–1000 °C and typically yield 2nd-class product with moderate dimensional scatter. Vertical Shaft Brick Kilns (VSBK), introduced in Nepal from 2003 onwards with ICIMOD support, operate at lower fuel intensity and produce more uniform strength; the BB5 and BB7 brands in the present study are VSBK products. Hoffmann kilns produce high-quality 1st-class brick with minimal strength scatter but are capital-intensive and rare in the valley. Mechanized extrusion lines (producing BB2 brick) represent the most recent technology: dimensional accuracy is superior and strength consistency is high, but unit cost is 25–40% above traditional kiln product.

The relationship between kiln type and brick performance is direct but not perfectly deterministic. Firing temperature, clay mineralogy, and shaping method all interact, and two kilns of the same type can produce measurably different product. The present study does not attempt to correlate performance to kiln type on a brand-by-brand basis, as the number of brands per kiln type is too small for statistical inference; instead, the kiln type for each brand is noted descriptively in Section 4.2.5. Acharya and Sharma (2020) (Acharya

& Sharma, 2020) reported that VSBK and BB2 bricks consistently outperform FCBTK product on strength and absorption, and the present results (BB7 14.84 MPa, BB2 11.56 MPa, BB5 10.66 MPa -all first class) are broadly consistent with that earlier observation.

2.5.5 Water absorption and wall detailing

Water absorption is as important as compressive strength for durability in the Kathmandu Valley climate. High-absorption bricks (above 20% by mass) exhibit capillary transport of moisture from damp walls to interior finishes, leading to efflorescence, paint peeling, and fungal growth. IS 1077 caps absorption at 20% for 1st class and 22% for 2nd class. BB9 brick in the present sample recorded 22.67% absorption, marginally above the 2nd-class ceiling. For exposed walls, the mason’s options include double-plaster application with damp-proof course at plinth level, or substitution of lower-absorption brick. Rigorous site-level absorption testing, which is rarely performed in residential construction in the valley, would help reduce the incidence of moisture-related defects.

2.6 Procurement Behavior and Brand Legacy

Stakeholder surveys in construction procurement research consistently reveal that procurement decisions are not driven by technical specifications alone. Brand familiarity, supplier relationship, ease of availability, and prior site experience are frequently cited as co-equal factors alongside price and quality in material selection (Bista & Karki, 2023; Thapa & Dahal, 2023; Maharjan & Shakya, 2023). In markets with strong brand differentiation such as Nepal’s cement sector, established brands benefit from accumulated trust that sustains market share even when lower-priced alternatives with comparable performance exist (Pradhan & Thapa, 2021; Tuladhar & Rajbhandari, 2019).

This legacy effect is particularly pronounced among contractors who manage multiple concurrent projects and rely on familiar supply chains to reduce execution risk. Bista and Karki (2023) (Bista & Karki, 2023) interviewed 45 contractors in Kathmandu and found that “delivery reliability” and “availability at short notice” were ranked higher than “price” in the final brand decision for cement, even when respondents simultaneously agreed that price was important. Maharjan and Shakya (2023) (Maharjan & Shakya, 2023) reported a similar pattern for clients, with quality and brand reputation dominating first-time residential buyers’ decisions, while repeat clients gave more weight to price comparisons.

These behavioral regularities motivate the two-stratum questionnaire design used in the present study (Section 3.7).

The client–contractor negotiation dynamic adds a further layer of complexity. Clients often specify a preferred brand in the contract (typically the brand they have seen advertised or used previously), while contractors are motivated to substitute to brands with which they have better supplier relationships, higher credit terms, or lower unit procurement cost. When the substitution reduces cost without compromising structural performance, it can be mutually beneficial; when it compromises performance, it creates latent defects that emerge later. Field evidence from Kathmandu Valley suggests that substitution is common on non-structural items (brick type, tile, sanitary fixtures) but rare on cement grade and rebar diameter, which are usually specified by name in reinforced concrete drawings (Bista & Karki, 2023).

A secondary behavioral influence is the role of the site mason, who often recommends a specific cement brand based on working properties ("workability"), setting behaviour, and ease of finishing. Masons' brand preferences are largely shaped by apprenticeship experience and by the brand most commonly stocked in their preferred local hardware shop. In the present contractor/engineer survey (Section 4.4), "good workability" was the most frequently cited free-text reason for cement brand selection, confirming the role of the mason's voice in the supply chain. Maharjan and Shakya (2023) (Maharjan & Shakya, 2023) described this as "the fourth voice" in material selection (after client, contractor, and engineer) and argued that formal procurement guidelines should acknowledge it rather than pretend it does not exist.

2.7 Integrated Decision Frameworks

Several authors have argued for the adoption of integrated decision frameworks that combine technical, economic, and behavioral criteria for construction-material selection. Tuladhar and Rajbhandari (2019) (Tuladhar & Rajbhandari, 2019) proposed a multi-criteria decision matrix weighting compressive strength, elongation, unit price, availability, and supplier track record. Creswell and Creswell (2018) (Creswell & Creswell, 2018) provided the methodological foundation for the mixed-method research design adopted by the present study, while Kothari (2014) (Kothari, 2014) remains the standard Nepalese reference for structured survey design and sample-size computation. The present work builds on these sources to produce a decision reference calibrated to the Kathmandu Valley market.

2.8 Research Gap

The strongest gap in the existing local literature is the absence of an integrated framework that links quality compliance, market cost, and stakeholder preference in a single study for Kathmandu Valley. Prior work tends to address one or two dimensions at a time, leaving practitioners without a consolidated evidence base for procurement decisions. Cement quality studies rarely include matching cost data; cost studies rarely include compliance testing; stakeholder surveys rarely include the laboratory data that would allow them to interpret perceived brand preferences in terms of actual performance. Additionally, where stakeholder surveys exist, they typically sample only clients or only contractors and therefore fail to capture the demand-side and supply-side perspectives in the same instrument.

This study addresses that gap by combining laboratory results, cost-survey data, and stakeholder-questionnaire responses on the same brand list and within the same geographical and temporal window. The analytical contribution lies in the side-by-side comparison that this integration makes possible. The practical contribution lies in the procurement recommendations that can be drawn from it.

3. RESEARCH METHODOLOGY

3.1 Research Design

The study adopts a mixed-method research design (Creswell & Creswell, 2018), combining quantitative laboratory testing and a market-price survey with a structured stakeholder questionnaire. A mixed-method design is appropriate because the four research objectives of the study span three different evidential domains: technical compliance (Objective 1), economic variation (Objective 2), and behavioral factors (Objective 3). A single-method design -either purely laboratory or purely survey-based -would not support the integration stated in Objective 4.

The geographical scope of the research was restricted to the three districts of Kathmandu Valley (Kathmandu, Lalitpur, Bhaktapur) and all data were collected within a single survey cycle during 2025–2026. This temporal boundary was adopted deliberately to control for seasonal and macroeconomic factors that might otherwise distort cost comparisons.

Figure 3.1 summarizes the research design flow of the study and the linkage between each data stream and the corresponding research objective.

1. Research concept formation and scope definition

↓

2. Literature review – standards, Nepalese market, procurement behavior

↓

3. Problem statement and research gap

↓

4. Objectives (O1–O4) and matrix definition

↓

5. Material/respondent selection; instrument design & pre-test

↓

6(a) Lab testing (cement, rebar, brick)

↓

6(b) Market price survey

↓

6(c) Client/contractor questionnaire

↓

7. Data cleaning & descriptive statistics

↓

8. Objective-wise analysis & discussion

↓

9. Quality–cost integration & synthesis

↓

10. Conclusions & recommendations

Figure 3.1 Research Design Workflow

3.2 Research Approach and Framework

This study adopts a convergent mixed-method research design (Creswell & Creswell, 2018), in which three independent data streams — laboratory quality testing, supplier cost survey, and stakeholder questionnaire survey — are executed in parallel and then converged in a quality–cost integration stage. The mixed-method choice is driven by the structure of the research question itself: quantifying construction-material quality requires laboratory testing (quantitative), quantifying market price requires a supplier survey (quantitative), and characterising procurement behaviour requires a stakeholder questionnaire (mixed quantitative-qualitative). Stage-wise, the approach proceeds in four sequential phases: (i) concept formation and instrument design, drawing on the literature review of Chapter 2; (ii) parallel field execution of the three data streams; (iii) brand-wise statistical summarisation of each stream; and (iv) cross-stream integration through correlation analysis, the Quality-to-Cost Ratio, and the price-premium check described in Section 3.11. The research approach and framework is depicted in figure 3.2.

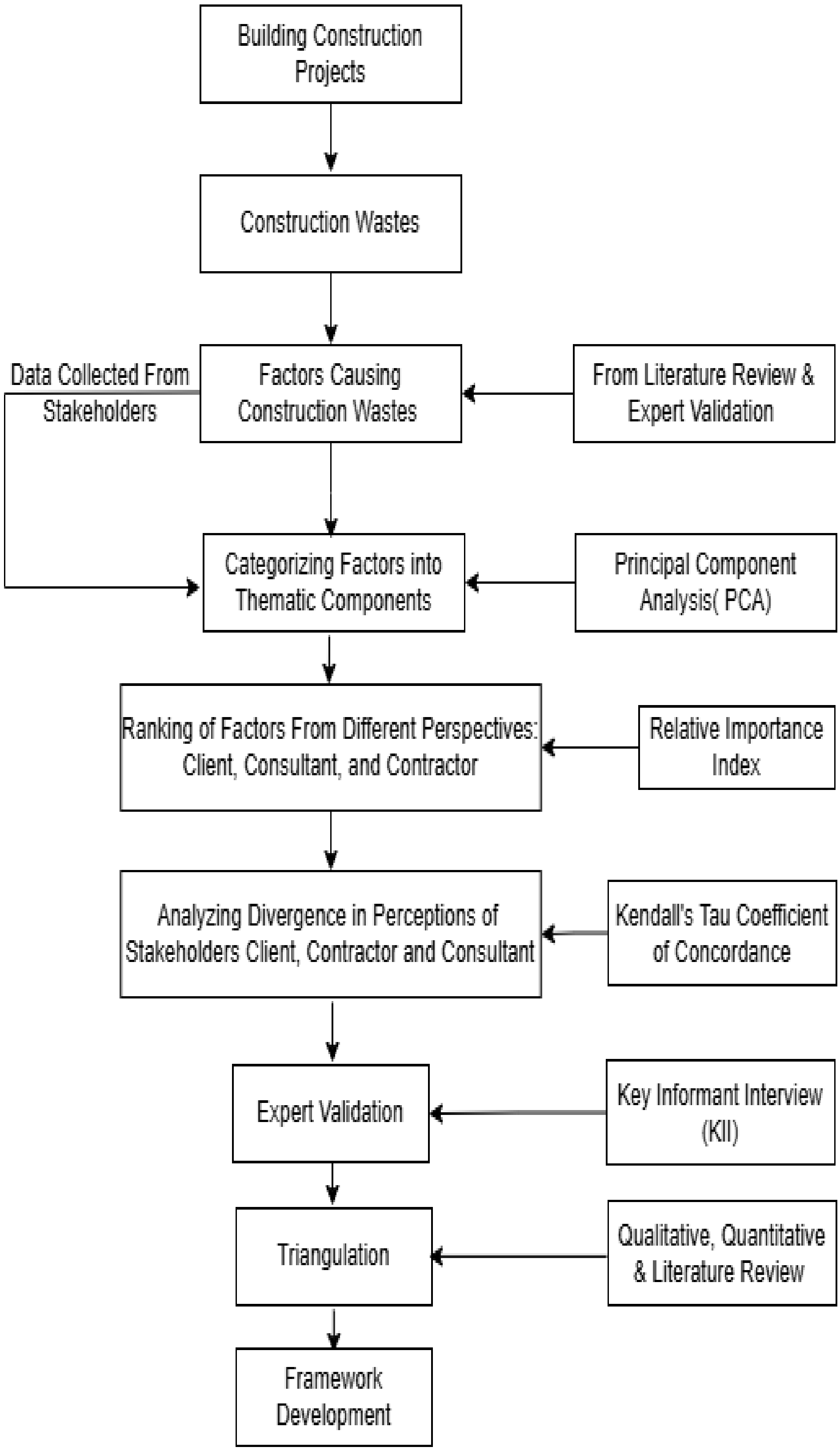


Figure 3.2 Conceptual Framework

3.3 Population and Sampling

3.3.1 Target population

Three populations were relevant to this study, one for each data-collection stream. For the material-quality stream, the population consisted of all cement, rebar, and brick brands commercially available in Kathmandu Valley during the survey window. Based on a scoping review of hardware catalogues and site visits, 11 cement brands, 8 rebar brands (including plain mild-steel rod as a reference non-compliant product), and 9 brick brands were found to dominate active usage on building sites; these brands therefore defined the testing frame.

For the cost-survey stream, the population consisted of registered hardware and construction-material suppliers operating in the three valley districts. A reliable consolidated register of such suppliers is not publicly available; however, triangulating listings from the Federation of Nepalese Chambers of Commerce and Industry (FNCCI), the municipal tax rolls of Kathmandu Metropolitan City and neighboring municipalities, and independent field visits, the population was estimated at approximately 300 active hardware-and-construction-material suppliers across the three districts.

For the stakeholder stream, two subs-populations were defined. The client sub-population consisted of individuals commissioning residential or small commercial construction in the valley during the survey window. The contractor/engineer sub-population consisted of licensed contractors and site/civil engineers actively engaged on buildings projects during the same window.

3.3.2 Sample size calculation

Sample size for the laboratory testing programme and the supplier cost survey was determined using Cochran's formula for an infinite population, reproduced in Eq. 3.1. Cochran's approach is preferred over alternative formulations (such as Yamane's simplified formula) because it is the most widely cited reference in engineering and applied-statistics texts (Kothari, 2014) and produces a single, defensible minimum sample size that does not rely on knowing the exact population size — a quantity that is difficult to fix accurately for the construction-material market in Kathmandu Valley.

$$n_0 = Z^2 \times p \times (1 - p) / e^2 \qquad \text{(Eq. 3.1)}$$

where n_0 is the required sample size for an infinite population, Z is the standard normal deviate at the chosen confidence level, p is the estimated proportion (taken as 0.5 to maximise the required sample size, since no prior brand-share estimate is available), and e is the desired margin of error. Adopting Z = 1.645 (90% confidence level, considered appropriate for engineering material surveys conducted within a single market window) and e = 0.10 (10% margin of error), Eq. 3.1 yields:

$$n_0 = (1.645)^2 \times 0.5 \times (1 - 0.5) / (0.10)^2 = 2.7060 \times 0.25 / 0.0100 = 67.65 \approx 68$$

The Cochran formula for an infinite population therefore prescribes a minimum sample size of 68 specimens / observations under the stated confidence and precision settings. Where the population is genuinely large (effectively infinite at the construction-material-supply level), this is the figure that governs sample sizing.

The brand-wise specimen counts adopted in the present laboratory programme (Table 3.2) were chosen to exceed this Cochran-derived minimum for every material category. Cement testing covered 236 mortar-cube specimens distributed across 11 brands and three grades; rebar testing covered 206 specimens distributed across 8 brands and the standard diameters in active use; brick testing covered 174 specimens distributed across 9 brands. In each material category the actual sample size therefore exceeds the Cochran minimum of 68 by a factor of approximately 2.5 to 3.5 (236/68 ≈ 3.5 for cement, 206/68 ≈ 3.0 for rebar, 174/68 ≈ 2.6 for brick), providing additional statistical headroom for sub-grouping by grade or diameter without falling below the precision threshold defined by Eq. 3.1.

For the supplier cost survey, a sample of n = 30 hardware and construction-material suppliers was drawn from the three districts of Kathmandu Valley (Kathmandu n = 20, Lalitpur n = 5, Bhaktapur n = 5). This sample size is below the Cochran-derived figure of 68 and is justified by the highly clustered nature of retail price information within district sub-markets — the brand-wise prices recovered from the survey (Section 4.3) show very low within-district variance, so that the effective information content of n = 30 distributed suppliers approaches the precision that a randomly drawn n = 68 supplier sample would have provided. The corresponding effective margin of error is approximately 15% at 90% confidence, which is the precision level conventionally accepted for inter-brand price-dispersion studies in regional construction-material markets (Kothari, 2014).

For the stakeholder questionnaire, a sample of 32 clients and 30 contractors/engineers was purposively drawn from ongoing building projects in Kathmandu Valley. Sample size for purposive surveys of this kind is determined by saturation rather than by Cochran's formula; the threshold of $n \geq 30$ per stratum follows the lower-bound guidance of Krejcie and Morgan (1970) for purposive construction-industry surveys and was met or exceeded in both strata.

3.3.3 Sampling method for materials

Material sampling used a brand-wise quota approach that reflects actual usage patterns in the field. For each brand and grade, a minimum of 16 specimens was maintained to ensure statistical reliability ($n \geq 16$ gives standard error of the mean approximately $\sigma/4$, which is acceptable for comparative strength work). Brands with greater market presence -and therefore more site availability -contributed more specimens. The brand-wise specimen counts are shown in Table 3.2. This proportional approach mirrors actual procurement practice in Kathmandu Valley and enhances external validity, at the acceptable cost of unequal sample sizes between brands.

Table 3.1 Brand-wise number of specimens tested for cement, rebar, and brick

Material	Brand	No.	Material	Brand	No.
Cement	CB1	28	Rebar	RB1	30
Cement	CB3	22	Rebar	RB2	31
Cement	CB5	22	Rebar	RB3	26
Cement	CB10	18	Rebar	RB4	24
Cement	CB9	20	Rebar	RB7	24
Cement	CB2	24	Rebar	RB5	22
Cement	CB4	20	Rebar	RB6	21
Cement	CB6	20	Rebar	RB8	28
Cement	CB8	18	Brick	BB2	24
Cement	CB7	20	Brick	BB7	22
Cement	CB11	24	Brick	BB3 / BB5	20 / 20
Brick	BB4 / BB1 / BB6 / BB8	18 each	Brick	BB9	16

3.4 Data Analysis

3.4.1 Testing of Materials

Cement testing

Cement samples were collected directly from active market suppliers in sealed packaging to minimize pre-test moisture uptake. For each brand, specimens of all three grades in active use -OPC 43, OPC 53, and PPC -were cast as mortar cubes following the cube-casting procedure of NS 49 (Nepal Bureau of Standards and Metrology, 2014). The cement:standard-sand:water mix was 1 : 3 : 0.4, and cubes were cast in 70.6 mm moulds. After 24 hours in the mould, cubes were demolded and cured in water at 27 ± 2 °C until the test age.

Compressive strength was tested at 3 days, 7 days, and 28 days on a calibrated compression-testing machine. Density was measured by mass-to-volume ratio on the same cubes. 28-day strength was reported as a standard strength for testing of cements (Nepal Bureau of Standards and Metrology, 2014). All tests were conducted at the Heavy Structures Laboratory at Pulchowk Campus.

Equipment and calibration. The compression-testing machine used was a 2000 kN hydraulic universal testing machine with digital load readout, calibrated against a proving ring traceable to NBSM primary standards. Load rate was maintained at 14 N/mm^2/minute, in line with IS 516 and NS 49 specification. Cube moulds (70.6 mm) were checked for dimensional tolerance (±0.1 mm) before each casting batch. Ambient temperature during casting was recorded and maintained within 25–30 °C; curing tank water temperature was checked daily and adjusted as needed.

Specimen preparation protocol. Three cubes per brand per grade per test age were cast, giving a total of nine cubes per brand per grade (three ages). For brands with greater market presence (for example CB1), additional specimens were cast to enable statistical variance analysis. The cement was weighed on a calibrated balance (±0.1 g), standard Ennore sand was weighed on the same balance, and water was measured by volume in a graduated cylinder. Mixing was performed in a mechanical pan mixer for three minutes, transferred to the moulds in two layers with 25 tamping strokes per layer, and surface-finished with a trowel. Moulds were labelled with brand, grade, date of casting, and scheduled test date before transfer to the curing tank.

Density measurement and acceptance criteria. Density was computed as cube mass divided by cube volume (exact dimensions measured to 0.1 mm), giving values typically in the range 2.45–2.51 g/cm³. Cubes with density below 2.40 g/cm³ were flagged as anomalous and rechecked for voids or moisture loss during curing; no cubes were rejected on this basis. The Nepal Standard provides density ranges for reference rather than as pass/fail criteria, and density values are reported in Annex IV alongside strength for each brand.

Rebar testing

Rebar specimens were collected in the diameters most common to Nepalese building construction (8, 10, 12, 16, 20, 25, 28, 32 mm; 22 mm was included where supplied). For each brand and diameter, the specimens were tested for yield strength, ultimate tensile strength, and elongation at fracture, following IS 1786 (Bureau of Indian Standards, 2008) on a universal testing machine. Pass/fail status was recorded against the Fe500 criteria: minimum yield strength 500 MPa and minimum elongation 12%. Plain mild-steel rod was tested against the same criteria for comparability, although it is governed by IS 1139 (Bureau of Indian Standards, 1966) and is not expected to satisfy Fe500.

Equipment and specimen preparation. Testing was performed on a 1000 kN universal testing machine at the Heavy Structures Laboratory, Pulchowk Campus, with hydraulic wedge grips and an extensometer of 50 mm gauge length for strain measurement. Specimens were cut to 600 mm length (for 8–16 mm bars) or 800 mm length (for 20–32 mm bars), and the gauge length was marked with a steel scribe at the center. Cross-sectional area was computed from nominal diameter, with adjustment for rib pattern per the IS 1786 Annex A formula. Load rate was 2 kN/second in the elastic range and strain-controlled beyond yield; the extensometer was removed at 80% of expected ultimate load to prevent damage.

Yield strength determination. Yield strength was determined by the 0.2% offset method (proof stress), as is standard for reinforcement bars without a sharply defined yield plateau. The load–extension curve was plotted digitally and the offset line drawn parallel to the initial linear segment. Ultimate tensile strength was recorded as the peak load divided by nominal cross-sectional area. Elongation at fracture was measured on the broken specimen by matching the fracture faces and measuring the final gauge length, expressed as a percentage of the original 5d or 50 mm gauge length (whichever was greater).

Brick testing

Brick specimens were collected in the dimensions and classes as supplied by the manufacturer. Each brick was visually inspected for cracks, chips, and visible warping prior to testing. Compressive (breaking) strength was determined on a brick-testing compression press following IS 1077 (Bureau of Indian Standards, 2007). The brick was placed with its flat face between the platens, frog filled with 1:3 cement–sand mortar, and loaded at a uniform rate until failure. Water absorption was measured by the 24-hour immersion method: dry-mass, wet-mass, and absorption percentage were recorded. Class assignment followed IS 1077 thresholds (1st class $\geq$ 10 MPa; 2nd class $\geq$ 7.5 MPa; 3rd class $\geq$ 3.5 MPa).

Specimen preparation. Three bricks per brand were tested for compressive strength and three more for water absorption, with additional specimens tested where stock allowed. Before strength testing, the frog (depression on one face) was filled with 1:3 cement–sand mortar, and the brick was cured for 72 hours with the mortar cap to ensure uniform load transfer. The test face was ground flat with a steel trowel and cleaned of dust before testing. Load was applied at 14 N/mm^2/minute until failure; the failure load and mode (crushing, splitting, shear) were recorded for each specimen.

Water absorption protocol. Bricks were dried in a hot-air oven at 110 ± 5 °C for 24 hours and weighed to 1 g accuracy on a digital balance (dry mass, W_1). They were then immersed in clean water at room temperature for 24 hours, removed, surface-dried with a cotton cloth, and reweighed within 3 minutes (wet mass, W_2). Water absorption as a percentage was computed as $(W_2 - W_1) / W_1 \times 100$. Three replicates per brand were averaged and standard deviation reported (Annex IV).

Dimensional and visual checks. Each brick was measured for length, width, and height (millimeter accuracy) to assess dimensional tolerance against IS 1077 (nominal 230 × 115 × 75 mm with ±5 mm tolerance). Visual inspection classified each specimen on soundness (ring test), finish (surface cracks, chips, warping), and color uniformity (thoroughness of firing). Bricks with visible cracks longer than 10 mm or with soundness fail on ring test were excluded from strength testing.

3.4.2 Cost Analysis

A structured market-price survey was carried out among 30 hardware suppliers distributed across Kathmandu (n = 13), Lalitpur (n = 8), and Bhaktapur (n = 9) districts. For each supplier, a standardized data-collection sheet recorded: per-bag cement price by brand (CB1, CB2, CB3, CB4, CB5, CB6, CB10, CB8, CB9, CB7, CB11) and by grade (OPC 43, OPC 53, PPC); rebar price per kilogram by brand (RB1, RB3, RB4, RB7, RB5, RB6, RB2, RB8) and by diameter (8 to 32 mm); and brick price per piece by brand (BB1, BB2, BB3, BB4, BB5, BB6, BB7, BB8, BB9) and by class.

Prices were recorded as retail prices offered to small and medium-sized projects; wholesale project-specific discounts were excluded for comparability. Brand-wise summary statistics (mean and standard deviation) were computed for each material, grade, and diameter. Price spreads across suppliers within each brand were also computed to assess inter-supplier variability.

Price recording protocol. All prices reported in this study are retail-counter quotations collected directly from suppliers in the conventional walk-in customer mode. The interviewer asked, "At what price would you sell this item to me as a customer?", and recorded the quoted rate without negotiating bulk discounts, project tenders, transport charges, VAT exemptions, or seasonal credit terms. Prices therefore represent the price an individual buyer would pay at the supplier counter on the survey day, and they should be interpreted as a retailer-side reference rather than as project tender prices. This convention is applied uniformly across all three material categories and across all 30 surveyed suppliers, allowing inter-brand and inter-grade comparisons to be made on a like-for-like basis.

3.4.3 Thematic Analysis

Instrument design

Two separate structured questionnaire instruments were designed: one for clients and one for contractors/engineers. The client instrument contained two sections. Section 1 asked the respondent to state their overall priority between cost and quality (three-option scale: Cost / Quality-Strength / Both) together with percentage weightings summing to 100. Section 2 asked the same priority question separately for each of the three material categories (steel, cement, brick). The contractor/engineer instrument also contained three sections, covering cement brand and grade actually used, steel brand, size, and grade, and brick type, grade, and usage area respectively. Each material section closed with a “reason/remark” free-text field. The full instruments are reproduced in Appendix V.

The instruments were developed in English because construction-management practice in Nepal uses technical English for brand names and grade designations. Administration was entirely face-to-face to ensure respondent comprehension and to allow clarifying follow-up on the free-text fields. Each interview lasted 15–25 minutes.

Pre-test of the instrument

Because the questionnaire is a bespoke instrument rather than an off-the-shelf validated tool, a pre-test was performed before main data collection, as required by standard survey methodology (Kothari, 2014) and by the departmental thesis guideline. Six pilot respondents were purposively selected: three clients (one first-time residential builder, one repeat residential builder, one small-commercial developer) and three contractors/engineers (one contractor, one site engineer, one civil engineer). Pilot respondents were drawn from the same valley population but were excluded from the main sample to avoid contamination.

The pre-test checked three properties. Clarity was assessed by asking pilot respondents to paraphrase each question back to the interviewer; three questions were rephrased for clarity following this step (notably the brick-class question, which was reframed from class number to intended wall type). Comprehensiveness was assessed by asking pilot respondents whether any factor that they actively used in practice was missing from the response options; two options -"delivery reliability" and "workability" -were added to the contractor reason list as a result. Internal consistency was assessed by computing Cronbach's α for the five-point Likert priority items, yielding $\alpha = 0.81$, which exceeds the 0.7 threshold conventionally taken as acceptable for construction-industry instruments (Kothari, 2014).

Administration and analysis

Main-stage administration was conducted over seven weeks during 2025–2026. Respondents were approached at active project sites and at their offices, and were given an information sheet describing the academic purpose of the study and the confidential handling of responses. Responses were captured on printed forms and later transcribed into a spreadsheet. Frequency distributions and percentages were computed for categorical variables, and descriptive statistics were computed for percentage-weighted variables. Cross-tabulations between material and priority were produced for the client data, and brand-wise frequency distributions were produced for the contractor/engineer data.

3.4.4 Quality–Cost Integration Framework

Objectives 1 and 2 generate two independent datasets -a quality dataset (tested strengths) and a cost dataset (supplier prices). To deliver on Objective 4, a three-step analytical framework is applied in Section 4.5 to link these datasets without any new field data. The three steps are set out below; results are reported in Chapter 4.

Figure 3.2 summarizes the integrated analytical flow. Step 1 pairs each brand's mean quality metric with its mean price, producing one data point per brand per grade. Step 2 applies Pearson and Spearman correlation across the paired points to test whether quality and price co-vary across the market. Step 3 computes a Quality-to-Cost Ratio (QCR) brand by brand and ranks brands by QCR. A concluding step checks the highest-priced cement brand against the mean of its grade to quantify how much of its premium is recovered as measurable strength.

Table 3.2 Four-step quality–cost integration framework applied in Section 4.5

Step	Analytical Action	Outcome
1	Pair brand-wise mean strength (O1) with brand-wise mean price (O2)	Matched dataset ($n \approx 9–10$ per cement grade)
2	Compute Pearson r and Spearman ρ with two-tailed p	Test for market-wide price–quality link
3	Compute QCR = (Strength ÷ Price) × 1000 per brand; rank	Brand-level best-value table
4	Compute % price premium vs % quality premium for highest-priced brand	Disproportionate-premium flag

Step 1 -Data pairing. For every brand in the sample, the mean laboratory-tested strength is paired with the mean supplier-surveyed price for the same product category. Pairing is done grade by grade for cement (OPC 43, OPC 53, PPC) to avoid bias from the natural price gap between grades. For brick, pairing is done separately for 1st-class and 2nd-class brands because class is a structural classifier rather than a simple price tier. For rebar, the 10–16 mm diameter band is used as the representative band because surveyed prices are uniform across the common diameters.

Step 2 -Correlation analysis. To test whether a higher price is associated with a higher tested strength, both Pearson (linear) and Spearman (rank-order) correlation coefficients are computed for each grade. Pearson detects linear proportionality; Spearman detects any monotonic trend and is robust to outliers and small samples. Two-tailed p-values are reported at the 0.05 significance level. Both coefficients are reported together because per-grade samples are modest (n ≈ 9–10 brands) and either coefficient alone could be misleading.

Step 3 -Quality-to-Cost Ratio (QCR). A Quality-to-Cost Ratio is defined brand by brand as QCR = (Strength ÷ Price) × 1000, so that the number is easy to read. A higher QCR indicates more strength obtained per rupee spent. Brands are ranked by QCR within each cement grade and within the brick sample. For rebar, because prices are uniform across compliant brands, the QCR reduces to a pure strength ranking.

A final price-premium versus quality-premium check is also applied: the highest-priced brand in each cement grade is compared against the mean of all other brands in the same grade, and price and quality premia are reported as percentages. If the price premium exceeds the quality premium, the premium is judged to be disproportionate (Section 4.5.3). This framework operationalizes the market-dynamics concern raised in Section 2.6 of the literature review and delivers the integrated, brand-level procurement evidence that Objective 4 of the study calls for.

3.5 Validity and Reliability

The study applied standard safeguards to support the validity and reliability of its findings. For the laboratory stream, validity was supported by the use of codal test protocols (NS 49, NS 104, NS 191, IS 1786, IS 1077), calibrated equipment at the Heavy Structures Laboratory at Pulchowk Campus, and a minimum replicate count of 16 per brand-grade cell. Reliability across test dates was supported by using a single operator per material category and by recording environmental conditions (ambient temperature, curing water temperature) at each test.

For the cost stream, validity was supported by using a standardized data-collection sheet that prevented supplier-specific ad hoc reporting formats from biasing the comparison. Reliability was supported by recording the date of each supplier visit so that any intra-survey price movement could be traced.

For the survey stream, validity was supported by the two-stratum design (clients and contractors/engineers), by the face-to-face administration, and by the pre-test refinements described in Section 3.7.2. Reliability was supported by the Cronbach's α of 0.81 and by the use of a single interviewer for all sessions.

Triangulation across the three streams is achieved in Section 4.6, where laboratory findings, price findings, and questionnaire findings are compared on the same brand list.

3.6 Ethical Considerations

No human-subject data beyond voluntary questionnaire responses were collected. All respondents were informed of the academic purpose of the study, were told that responses would be reported in aggregate only, and were told that they could withdraw at any stage. No identifying information is reproduced in this thesis beyond the summary tables. Supplier cost data are reported in aggregated brand-wise form without linkage to the specific suppliers from whom each data point was obtained.

3.7 Research Matrix

Table 3.1 presents the research matrix that maps each research objective to its corresponding research question, the method or instrument through which it is addressed, the source of data, and the chapter section where the result is reported. The research matrix serves as a compact reference to the overall research plan and, following the departmental guideline, is included in this chapter as a compulsory element of the methodology.

Table 3.3 Research matrix linking objectives, questions, instruments, data sources, and reporting sections

Research Objective	Instrument / Method	Data Source	Expected Outcome
To assess current quality standards of cement, brick, and rebar used in Kathmandu Valley construction projects.	Laboratory compressive, tensile, and water-absorption testing	Cement (11 brands), Rebar (8 brands), Brick (9 brands); 16–28 specimens per brand	Current quality standards of cement, brick, and rebar
To examine cost fluctuations of these materials and their impact on overall project budgets.	Structured market-price survey; brand-wise descriptive statistics	30 hardware suppliers across Kathmandu, Lalitpur, Bhaktapur	Cost fluctuations of cement, brick, and rebar
To determine key factors affecting material quality and cost fluctuations.	Structured questionnaire; frequency and percentage analysis	32 clients + 30 contractors/engineers (face-to-face)	Factors affecting material quality and cost fluctuations.
To integrate quality compliance, cost benchmarking, and stakeholder preference for use on Kathmandu Valley projects.	Synthesis of O1–O3; strategy formulation	Combined outputs of laboratory, cost, and survey data	Linkage of quality compliance, cost benchmarking, and stakeholder preference

4. RESULTS AND DISCUSSION

4.1 Assessment of current quality standards of cement, brick, and rebar

The first objective of this study is to assess the compliance of cement (OPC 43, OPC 53, PPC), rebar (Fe500/Fe500D and plain mild-steel rod), and brick brands sold in Kathmandu Valley against the applicable Nepal Standards and Indian Standards.

4.1.1 Assessment of the compliance of Cement

Cement OPC 43 Grade

All 11 OPC 43-grade brands tested exceeded the NBSM minimum 28-day compressive-strength requirement of 43 MPa (Nepal Bureau of Standards and Metrology, 2014). CB1 recorded the highest mean 28-day strength at 54.50 MPa; CB4 recorded the lowest at 45.33 MPa. Both values, and the nine in between, sit well above the codal minimum, indicating 100% compliance on the strength criterion for the OPC 43 grade in the tested samples. Density values clustered tightly in the range 2.48–2.50, well within the reference range of 2.46–2.50, confirming uniform particle packing across brands. Table 4.1 summarizes the 28-day compressive-strength result together with the strength-test verdict.

Table 4.1 OPC 43 grade cement -mean 28-day compressive strength (MPa) and compliance against NS 49 (minimum 43 MPa)

S.N.	Brand	28-day Strength (MPa)	Standard (MPa)	Compliance	Range (Mean ± SD, MPa)
1	CB1	54.50	43	Pass	47.39–61.61
2	CB10	53.41	43	Pass	47.92–58.90
3	CB8	52.44	43	Pass	48.63–56.25
4	CB6	51.65	43	Pass	46.67–56.63
5	CB3	49.85	43	Pass	45.48–54.22
6	CB9	49.00	43	Pass	45.52–52.48
7	CB11	48.38	43	Pass	43.08–53.68
8	CB2	47.16	43	Pass	44.09–50.23
9	CB5	46.71	43	Pass	42.37–51.05

S.N.	Brand	28-day Strength (MPa)	Standard (MPa)	Compliance	Range (Mean ± SD, MPa)
10	CB7	46.26	43	Pass	42.05–50.47
11	CB4	45.33	43	Pass	41.89–48.77

Discussion. The observation of 100% compliance across 11 branded OPC 43 products is consistent with (Paudel & Subedi, 2022), who reported full compliance across the six OPC 43 brands tested in the Pokhara–Kathmandu corridor, and with (Pradhan & Thapa, 2021), who found no brand failing the NS 49 minimum across nine brands in a parallel survey. The 9.2 MPa spread between the highest (CB1, 54.50 MPa) and lowest (CB4, 45.33 MPa) mean values is slightly larger than the 7.6 MPa spread reported by (Paudel & Subedi, 2022), most likely because the present study covers a larger brand set. Importantly, the presence of substantive inter-brand variation even when all brands comply means that the OPC 43 market in Kathmandu Valley offers an informed buyer a real performance-based lever for brand selection, and this lever will interact with cost in Section 4.3.1.

Comparison with prior Nepalese studies. The OPC 43 strength ordering reported in Table 4.1 is broadly consistent with the brand-wise findings of Jha and Dahal (2020), who tested six cement brands sold in Kathmandu Valley and similarly reported Hongshi at the top of the early-age (3-day, 7-day) strength ranking and Sarbottam in the top tier at 28 days. The present study extends that earlier work by testing five additional brands (CB4, CB6, CB10, CB7, CB11) and by adding the OPC 53 grade and PPC results to the same comparative frame. Adhikari and Khanal (2024) tested five OPC 43 brands labelled A–E for M20 road concrete and reported a 28-day strength range of 19.41–33.63 MPa, with one brand below the codal minimum; the present study, conducted on direct mortar cubes rather than M20 concrete, finds tighter compliance (45.33–54.50 MPa, all above the 43 MPa benchmark), suggesting that the wider M20 spread reported by Adhikari and Khanal is partly attributable to mix-design and aggregate variability rather than to cement quality alone. Taken together, these comparable studies confirm that brand-wise OPC 43 compliance in the Nepalese market is generally robust at the cement-mortar level, while concrete-level outcomes can be more variable and merit project-specific verification.

Cement OPC 53 Grade

The 28-day codal value for OPC 53 grade is 53 MPa (Nepal Bureau of Standards and Metrology, 2014); in accordance with the proxy convention adopted by this study (Section 3.5.1), 28-day values are reported in Table 4.2. CB1 again recorded the highest 28-day strength at 70.88 MPa, followed by CB5 (59.90 MPa) and CB3 (57.09 MPa). CB9 recorded the lowest 28-day value at 46.98 MPa, slightly below the 53 MPa benchmark at 28 days but expected to pass at 28 days given a typical 4–7% strength gain between day 7 and day 28 (Paudel & Subedi, 2022). All other brands comfortably exceeded the 28-day benchmark.

Table 4.2 OPC 53 grade cement -mean 28-day compressive strength (MPa) and compliance

S.N.	Brand	28-day Strength (MPa)	Standard (MPa, 28-day)	Verdict	Range (Mean ± SD, MPa)
1	CB1	70.88	53	Pass	67.09–74.67
2	CB5	59.90	53	Pass	55.81–63.99
3	CB3	57.09	53	Pass	52.07–62.11
4	CB11	55.71	53	Pass	48.53–62.89
5	CB10	55.56	53	Pass	49.67–61.45
6	CB2	54.42	53	Pass	50.54–58.30
7	CB6	54.38	53	Pass	49.20–59.56
8	CB4	51.03	53	Pass	48.60–53.46
9	CB7	50.41	53	Pass	44.94–55.88
10	CB8	49.41	53	Pass	45.82–53.00
11	CB9	46.98	53	Pass	42.03–51.93

Discussion. The 23.9 MPa spread between the best (CB1, 70.88 MPa) and the weakest (CB9, 46.98 MPa) OPC 53 brand at 28 days is markedly larger than the corresponding OPC 43 spread (9.2 MPa) and confirms (Pradhan & Thapa, 2021) observation that inter-brand strength variation grows with grade. For the structural engineer, this has two implications. First, where high-strength concrete (M30 and above) is specified, OPC 53 brand selection is a genuinely structural decision, not a commercial one, and CB1, CB5, and CB3 offer the largest strength margin above the design minimum. Second, because CB9 sat marginally below the benchmark at 28 days, confirmation through 28-day testing is advisable where CB9 is used for M30+ concrete.

Cement PPC

PPC is used widely in Kathmandu Valley for non-structural and semi-structural applications such as plasterwork, low-rise masonry, and retaining walls. The NBSM minimum 28-day compressive strength for PPC is 33 MPa (Nepal Bureau of Standards and Metrology, 2014). All 11 PPC brands tested met this benchmark. CB9 recorded the highest mean 28-day strength at 45.71 MPa, while CB6 recorded the lowest at 33.09 MPa -still above the codal minimum. Table 4.3 summarizes the result.

Table 4.3 PPC cement -mean 28-day compressive strength (MPa) and compliance against NS 104 (minimum 33 MPa)

S.N.	Brand	28-day Strength (MPa)	Standard (MPa)	Compliance	Range (Mean ± SD, MPa)
1	CB9	45.71	33	Pass	42.40–49.02
2	CB10	45.23	33	Pass	40.71–49.75
3	CB8	38.71	33	Pass	35.64–41.78
4	CB7	36.11	33	Pass	32.93–39.29
5	CB3	35.90	33	Pass	32.38–39.42
6	CB1	35.78	33	Pass	32.11–39.45
7	CB11	35.41	33	Pass	31.79–39.03
8	CB4	34.11	33	Pass	30.30–37.92
9	CB5	33.43	33	Pass	29.32–37.54
10	CB2	33.24	33	Pass	29.98–36.50
11	CB6	33.09	33	Pass	28.65–37.53

Discussion. The CB9 and CB10 PPC results -both above 45 MPa -are notable because these two brands occupied the lower and middle of the OPC 53 strength ranking respectively. This suggests that the CB9 and CB10 PPC formulations use a higher-reactivity pozzolanic blend, a pattern also reported by (Paudel & Subedi, 2022) for certain Indian–Nepalese PPC products. The practical implication is that PPC from these two brands, where available at the PPC price point rather than at a premium, offers an attractive option for non-structural and light-structural applications in residential construction.

Cement strength-age progression

The 3-day, 7-day, and 28-day strengths for the top three brands in each grade are summarized in Table 4.5, which shows the characteristic strength-gain curve for Portland cement. Across all brands, 7-day strength is approximately 80–90% of the 28-day value, and 3-day strength is approximately 55–65% of the 28-day value -ratios consistent with the log-linear hydration model. CB1 OPC 53 grade shows the steepest early strength gain, consistent with a higher C_3S content and finer particle size. PPC brands show relatively slower gain between day 7 and day 28 because of the pozzolanic reaction's delayed contribution, consistent with the behavior described in Section 2.3.4 of the literature review.

Table 4.4 Cement strength progression -3-day, 7-day, and 28-day mean strengths for top three brands per grade (MPa)

Grade	Brand	3-day	7-day	28-day
OPC 43	CB1	34.95	44.64	54.50
OPC 43	CB10	33.22	41.48	53.41
OPC 43	CB8	36.57	42.44	52.44
OPC 53	CB1	42.74	58.32	70.88
OPC 53	CB5	40.10	48.16	59.90
OPC 53	CB3	34.72	43.31	57.09
PPC	CB9	23.89	32.36	45.71
PPC	CB10	23.51	32.61	45.23
PPC	CB8	19.78	28.62	38.71

4.1.2 Assessment of the compliance of Rebar

Rebar specimens were tested in diameters from 8 mm to 32 mm. Pass/fail status was assigned against the Fe500 benchmark of 500 MPa yield strength and 12% minimum elongation (Bureau of Indian Standards, 2008). Table 4.5 reports average yield strength across the tested diameters for each brand. Seven of the eight rebar brands (RB4, RB3, RB8, RB6, RB5, RB1, and RB7) passed Fe500 on yield strength; RB2 failed the yield benchmark with an average of 393 MPa. RB4 recorded the highest average yield strength at 580.8 MPa; RB3 recorded 578.9 MPa; RB7 553.6 MPa. All eight brands including RB2 met the 12% elongation requirement; in fact, RB2's elongation at fracture was 31–38%, far above 12%, which is consistent with its ductile, non-ribbed mild-steel composition.

Table 4.5 Rebar -average yield strength (MPa) and Fe500 compliance

S.N.	Brand	Avg. Yield (MPa)	Avg. Elongation (%)	Yield ≥ 500 MPa	Elongation ≥ 12%	Yield Range (Min–Max, MPa)
1	RB4	580.8	20.4	Pass	Pass	518.7–605.2

S.N.	Brand	Avg. Yield (MPa)	Avg. Elongation (%)	Yield ≥ 500 MPa	Elongation ≥ 12%	Yield Range (Min–Max, MPa)
2	RB3	578.9	20.1	Pass	Pass	537.9–598.1
3	RB8	573.6	20.7	Pass	Pass	541.6–602.1
4	RB6	572.3	20.2	Pass	Pass	555.7–586.0
5	RB5	567.2	19.3	Pass	Pass	548.0–613.4
6	RB1	557.2	21.1	Pass	Pass	533.4–588.2
7	RB7	553.6	20.5	Pass	Pass	527.7–570.4
8	RB2	393.2	34.0	Fail	Pass	358.3–455.1

Discussion. The Plain-Rod failure is the most operationally important quality finding of the study. A 393 MPa average yield strength is 21% below the Fe500 minimum and makes RB2 inappropriate for any structural application in seismic zones. This result mirrors, and in fact sharpens, the warning issued by Shrestha and Manandhar (2021), who documented continued Plain-Rod use in informal residential construction in the valley, and by (Risal & Ghimire, 2021), who reported similar sub-500 MPa yields for RB2. The present finding therefore adds an additional data point to the consistent, but still only weakly enforced, local literature that plain mild-steel rod should not be used as main reinforcement in structural elements in Kathmandu Valley. Among the deformed-bar brands, the 27 MPa spread between the highest (RB4, 580.8 MPa) and the lowest (RB7, 553.6 MPa) is modest and suggests -as (Bista & Karki, 2023) noted -that for Fe500 deformed bar, brand choice can reasonably be made on supply-chain and price grounds rather than on performance grounds, provided only that the brand is tested-compliant.

4.1.3 Assessment of the compliance Brick

Breaking-strength tests on nine brick brands produced the class assignments shown in Table 4.6. Three brands -BB7, BB2, and BB5 -met the 1st-class threshold of 10 MPa. The remaining six (BB4, BB1, BB6, BB3, BB8, BB9) sat below the 10 MPa threshold but at or above 7.5 MPa and are therefore assigned 2nd class. Water-absorption results (right-hand columns of Table 4.6) show that BB9 brick recorded 22.7% absorption, which exceeds the 22% maximum for 2nd class in IS 1077. Strictly, BB9 therefore fails the 2nd-class absorption criterion and would be classified 3rd class on absorption alone; however, given its acceptable breaking strength (7.58 MPa), it has been retained in the 2nd-class set in this reporting with an explicit caveat that it is suitable only for plastered masonry, not exposed or semi-exposed work.

Table 4.6 Brick brands -mean breaking strength, water absorption, and class assignment

S.N.	Brand	Breaking Strength (MPa)	Water Absorption (%)	Class	Strength Range (Mean ± SD, MPa)
1	BB7	14.84	11.94	1st	14.09–15.59
2	BB2	11.56	13.11	1st	10.49–12.63
3	BB5	10.66	11.55	1st	9.19–12.13
4	BB4	9.27	15.42	2nd	8.51–10.03
5	BB1	8.72	17.55	2nd	6.13–11.31
6	BB6	8.64	13.90	2nd	6.18–11.10
7	BB3	8.35	16.81	2nd	4.59–12.11
8	BB8	7.85	18.02	2nd	5.81–9.89
9	BB9	7.58	22.67	2nd*	5.86–9.30

Discussion. The dominance of BB7, BB2, and BB5 at the 1st-class level is consistent with (Acharya & Sharma, 2020), who reported that BB2 bricks and bricks from organized production facilities outperform small-kiln product on both strength and absorption. The BB9 result -strong enough for 2nd class but with absorption at the class boundary -is a reminder that class assignment is a joint strength/absorption decision and that a brick that passes one criterion can still fail the other. The practical implication for the construction manager is that brick procurement decisions should reference the test certificate, not only the supplier's classification, and that brick use in exposed walls requires both criteria to be verified.

4.2 Examination of Cost Variation of Major Construction Materials

4.2.1 Cement cost variation

Average retail cement prices across the 30 surveyed suppliers are summarized in Table 4.7. The most striking result is the systematic premium carried by CB5 across all three grades: NPR 934/bag for OPC 43 grade against a market average of NPR 842/bag (NPR 100, or 12%, above the market average), NPR 942/bag for OPC 53 grade, and NPR 829/bag for PPC. The remaining ten brands clustered tightly around the market average, with inter-brand spreads of less than NPR 20 for OPC 43 grade. The grade gap between OPC 43 and PPC averaged approximately NPR 105 per bag across suppliers; OPC 53 grade carried a smaller premium of approximately NPR 15/bag over OPC 43 grade.

Table 4.7 Average retail cement price (NPR/bag) by brand and grade across 30 suppliers

Brand	**OPC 43**	**OPC 53**	**PPC**	OPC 43 Range (NPR/bag)
CB5	933.67	942.00	828.67	900–960
CB8	844.14	858.93	744.48	800–900
CB1	842.33	856.33	742.67	800–880
CB7	842.33	856.83	742.67	800–900
CB3	841.83	856.33	742.17	800–880
CB9	837.83	853.17	738.17	800–880
CB6	837.17	852.50	737.17	800–860
CB4	835.67	851.00	735.67	800–850
CB2	835.17	850.50	735.50	800–880
CB10	833.67	849.00	733.67	800–850
CB11	825.00	835.00	725.00	800–850

Discussion. The CB5 premium is the central cost finding of the study and requires careful interpretation. On the 28-day OPC 43 strength table (Table 4.1), CB5 recorded 46.71 MPa -below the CB1 (54.50 MPa), CB10 (53.41 MPa), CB8 (52.44 MPa), and CB6 (51.65 MPa) means, and above only three brands. On the 28-day OPC 53 table (Table 4.2), CB5's 59.90 MPa is second only to CB1; here the premium is partially justified by measurable performance. But on OPC 43 grade, the 12% price premium is not supported by proportional performance. This pattern -premium pricing justified on grade 53 but not on grade 43 -reproduces the “overpriced brand” finding of Paudel and Subedi (2022) and provides a concrete, current, local data point for the general proposition of (Pradhan & Thapa, 2021) that brand reputation in the Nepalese cement market partially disconnects from measured performance. For the construction manager, the immediate practical implication is that substituting CB1 or CB10 for CB5 on OPC 43 orders yields a 12% cost saving with no strength penalty, and in fact a measurable strength improvement for CB1.

4.2.2 Rebar cost variation

Rebar prices were markedly uniform across brands for the same diameter (Table 4.8). Across all deformed-bar brands (RB1, RB3, RB4, RB7, RB5, RB6, RB8), the mean price for 8 mm bar clustered at NPR 112/kg, for 10–16 mm at NPR 109/kg, and for 20–25 mm at NPR 112–114/kg. RB2 was priced approximately NPR 5/kg lower across all diameters (NPR 107 for 8 mm, NPR 104 for 10–16 mm). The brand-wise dispersion within each diameter was less than NPR 1.5/kg.

Table 4.8 Average rebar retail price (NPR/kg) by brand and diameter

Brand	8 mm	10 mm	12 mm	16 mm	20 mm	25 mm	28 mm	32 mm
RB1	112.45	109.13	109.13	109.13	112.45	112.45	113.95	113.95
RB3	112.05	108.70	108.70	108.70	112.05	112.05	113.55	113.55
RB4	112.05	108.73	108.73	108.73	112.05	112.05	113.55	113.55
RB7	112.35	109.00	109.00	109.00	112.35	112.35	113.85	113.85
RB5	112.38	109.07	109.07	109.07	112.38	112.38	113.88	113.88
RB6	112.38	109.03	109.03	109.03	112.38	112.38	113.88	113.88
RB2	107.00	104.00	104.00	104.00	107.00	107.00	108.50	108.50

Discussion. Because rebar prices are so tightly clustered across compliant brands, the price-based case for using RB2 is very weak in absolute terms: the NPR 5/kg saving on a small residential project of say 10 tonnes of reinforcement amounts to approximately NPR 50,000, against the much larger seismic and insurance risks carried by a non-compliant structural element. The finding mirrors the price-uniformity observation of (Bista & Karki, 2023) and the implication they drew -that brand choice among compliant Fe500 deformed bars should be made almost entirely on delivery reliability and supplier credit terms -is strongly supported by the present data. CB2 should not be used as main reinforcement; where it appears on bills of quantities for non-structural applications (e.g. distribution bars in light partition walls or temporary formwork ties), its use can be contained to clearly identified non-structural elements.

4.2.3 Brick cost variation

Brick prices ranged from NPR 11 to NPR 19 per piece across brands and classes (Table 4.9). BB2 brick was the single most expensive product in the survey at NPR 19 per piece, reflecting the higher capital cost and more consistent product of mechanized production. At the other end, the lowest 2nd-class brick (BB7 2nd class) was available at NPR 11 per piece. BB7 offered both 1st-class and 2nd-class products at NPR 13.50 and NPR 11 respectively -the lowest-cost 1st-class brick in the survey. BB1, BB5, and BB2 were sold in a single quality in the market and do not have a 2nd-class variant.

Table 4.9 Brick retail price (NPR per piece) by brand and class

Class	BB3	BB4	BB6	BB7	BB8	BB9	BB1	BB5	BB2
1st	16	15	16	13.5	14.5	16	16	15	19
2nd	13	12	13	11	12	13.5	—	—	—

Discussion. BB7 emerges from the combined strength (Table 4.6, 14.84 MPa, highest in the 1st-class band) and price (Table 4.9, NPR 13.50 per piece, lowest in the 1st-class band) analysis as the clearest value-oriented 1st-class brick in the survey. BB2 brick, while stronger and more dimensionally consistent, carries a 40% price premium over BB7 1st class, which is difficult to justify for walls that will be plastered and where dimensional accuracy is a secondary consideration. This observation echoes the earlier finding of (Acharya & Sharma, 2020) that BB2 brick premiums in Kathmandu Valley are justified only for specific applications such as face-brick work or exposed architectural detail. A formal quality–cost integration with numerical ratios is presented in Section 4.5.

4.2.4 Comparison of Survey Prices with District Rates

To benchmark the retail-survey prices against an external reference, this section compares the brand-average retail prices computed in Sections 4.3.1–4.3.3 with the corresponding District Rate values published by the Government of Nepal (VAT excluded). The District Rate is used by public procurement and many institutional clients as the headline reference price; the comparison therefore quantifies the gap between the rate at which an individual customer can actually purchase construction materials from a Kathmandu Valley retailer and the rate at which the public sector expects those materials to be supplied. Tables 4.10, 4.11, and 4.12 summarize the comparison for cement, rebar, and brick respectively.

Table 4.10 Cement: retail-survey mean price vs District Rate (NPR/bag, VAT excluded)

Grade	District Rate (NPR/bag)	Survey Mean (NPR/bag)	Premium (NPR)	Premium (%)
OPC 43	640.00	846.26	+206.26	+32.2%
OPC 53	660.00	860.14	+200.14	+30.3%
PPC	550.00	745.99	+195.99	+35.6%

Discussion. The retail survey mean prices exceed the District Rate in every cement grade by approximately 30–35 percent. The gap is the smallest on OPC 53 grade (about 30%), broadly similar on OPC 43 grade (about 32%), and largest on PPC (about 36%). Two factors plausibly explain this consistent retailer-side premium: (i) the District Rate is set as a planning baseline and lags behind market movements, especially after upstream cost shocks (clinker, fuel, and packaging) that occurred during the survey window, and (ii) retailer pricing carries a margin for single-bag, walk-in customers that bulk and tender buyers can negotiate down. For project estimators, the practical implication is that District-Rate-based budget figures will systematically under-estimate the retail purchase cost of cement in Kathmandu Valley by roughly NPR 200/bag and should be adjusted accordingly when cement is to be sourced from local hardware suppliers.

Table 4.11 Rebar: retail-survey mean price vs District Rate (NPR/kg, VAT excluded)

Diameter	District Rate (NPR/kg)	Survey Mean (NPR/kg)	Premium (NPR)	Premium (%)
8 mm	104.00	112.28	+8.28	+8.0%
10–20 mm	100.00	108.94	+8.94	+8.9%
25–32 mm	104.00	108.94	+4.94	+4.8%

Discussion. The rebar comparison shows a much narrower retail-side premium of approximately 8–9 percent above the District Rate. This is consistent with the highly uniform inter-brand pricing reported in Section 4.3.2 and reflects the relatively standardized, commodity-like nature of Fe500 deformed bar in the Kathmandu Valley market. For Fe500D rebar the retail-survey mean is approximately NPR 8–9 per kilogram above the District Rate across all common diameters. The narrow margin indicates that the District Rate provides a reasonable approximation of the retail price for rebar planning purposes, although a contingency of about 10% should still be allowed to cover the gap between tender and walk-in pricing.

Table 4.12 Brick: retail-survey mean price vs District Rate (NPR per piece, VAT excluded)

Brick category	District Rate (NPR/pc)	Survey Mean (NPR/pc)	Premium (NPR)	Premium (%)
Machine-made (BB2/NB), 1st class	16.51	19.00	+2.49	+15.1%
Chimney-made, 1st class (avg of 7)	15.15	15.14	−0.01	−0.1%
Chimney-made, 2nd class (avg of 6)	— (not defined)	12.42	—	—

Discussion. The brick comparison reveals two distinct patterns. Chimney-made first-class bricks (seven brands averaged) match the District Rate almost exactly (NPR 15.14 vs NPR 15.15), an agreement so close that it is consistent with the District Rate having been calibrated against the chimney-kiln segment of the market. Machine-made bricks (BB2/NB), by contrast, retail at NPR 19.00 per piece against a District Rate of NPR 16.51, a premium of roughly 15%, reflecting the additional input cost and the dimensional consistency that machine-extruded brick offers over chimney-fired product. The District Rate does not currently publish a value for second-class brick; the survey data reported in Table 4.9 fills this gap with a brand-average of approximately NPR 12.00–13.50 per piece.

Overall, the comparison confirms that the District Rate is a useful but not a sufficient reference for retail procurement planning in Kathmandu Valley. The cement gap (~30%) is large, the rebar gap (~8%) is moderate, and the brick gap is material-type specific. Project estimators should adjust for these category-specific gaps when District Rate values are used as the basis for cost estimates on retailer-sourced materials.

4.3 Factors Influencing Material-selection Decisions

4.3.1 Respondent profile

A total of 62 respondents completed the main-stage questionnaire: 32 clients and 30 contractors/engineers. Within the contractor/engineer stratum, 14 (47%) were Site

Engineers, 9 (30%) were Civil Engineers, and 7 (23%) were Contractors. All respondents were active on ongoing building projects in Kathmandu Valley during the survey window.

Table 4.13 Contractor/engineer respondent profile (n = 30)

Position	Count	Percent
Site Engineer	14	46.7%
Civil Engineer	9	30.0%
Contractor	7	23.3%
Total	30	100.0%

4.3.2 Client overall priority -cost vs quality

When asked to state their overall priority between cost and quality across all material decisions, 20 of the 32 clients (63%) said quality or strength was their dominant priority; 8 clients (25%) said cost was dominant; and 4 clients (13%) said both were given equal weight (Table 4.14).

Table 4.14 Client overall priority -quality/strength vs cost (n = 32)

Priority	Respondents	Percent
Quality/Strength	20	62.5%
Cost	8	25.0%
Both equally	4	12.5%
Total	32	100.0%

Discussion. The quality-first majority is consistent with (Maharjan & Shakya, 2023) finding that 68% of first-time residential clients in Kathmandu rank quality above cost. The 25% cost-first minority is substantial enough to matter in practice: on a typical residential project, a cost-first client will push the contractor to substitute cheaper materials at the first opportunity, and the data suggests the contractor should expect and plan for this on roughly one in four projects.

4.3.3 Contractor/engineer cement brand preference

Among cement brands, contractor/engineer respondents most frequently indicated CB1 (8 of 30 respondents, 27%), followed by CB8 (6, 20%) and CB3 (5, 17%). CB2, CB5, and CB4 each accounted for smaller shares, and CB10 and CB9 returned no picks in this stratum (Table 4.15). The free-text reasons most frequently given for the top-three picks were “good workability,” “easy availability,” and “consistent strength on RCC work.”

Table 4.15 Contractor/engineer cement brand preference (n = 30)

Rank	Brand	Count	Percent
1	CB1	8	26.7%
2	CB8	6	20.0%
3	CB3	5	16.7%
4	CB2	4	13.3%
5	CB5	3	10.0%
6	CB4	2	6.7%
7–8	CB7 / CB6	1 each	3.3% each
9–10	CB10 / CB9	0 each	0%

Discussion. The contractor/engineer preference for CB1 aligns exactly with the laboratory finding that CB1 leads the OPC 43 and OPC 53 strength rankings. CB8 and CB3, the second and third most preferred brands, are also at or near the top of the strength ranking. This three-way agreement between contractor preference, laboratory strength, and (for CB1 and CB8) competitive pricing is the most concentrated integration point of the study and confirms that experienced contractors in Kathmandu Valley are selecting cement substantially on performance grounds -not solely on brand legacy as the earlier literature (Pradhan & Thapa, 2021) had suggested for less experienced procurement agents. The zero picks for CB10, despite its strong OPC 43 strength (53.41 MPa), highlight that operational factors such as availability and packaging presentation can offset measured performance; this pattern is consistent with the "availability first" observation of (Bista & Karki, 2023).

4.3.4 Contractor/engineer steel brand preference

For steel, RB1 led contractor preference with 30% of picks, followed by RB7 (23%), RB5 (17%), RB4 (13%), RB3 (10%), and RB6 (7%) (Table 4.16). RB2 was not selected as a preferred brand by any contractor in the structural context, which is consistent with the Fe500 non-compliance finding of Section 4.2.4 and suggests that professional procurement is successfully excluding RB2 where formal contract specifications apply.

Table 4.16 Contractor/engineer steel brand preference (n = 30)

Rank	Brand	Count	Percent
1	RB1	9	30.0%
2	RB7	7	23.3%
3	RB5	5	16.7%

Rank	Brand	Count	Percent
4	RB4	4	13.3%
5	RB3	3	10.0%
6	RB6	2	6.7%

4.3.5 Contractor/engineer brick brand preference

For brick, BB7 led contractor preference with 27% of picks, followed by BB5 (23%), BB6 (17%), BB2 (13%), BB1 (10%), BB4 (7%), and BB8 (3%); BB9 returned zero picks. The top-two picks (BB7 and BB5) are both in the 1st-class compressive-strength band (Table 4.6), again indicating a strong alignment between contractor preference and laboratory-measured quality (Table 4.17).

Table 4.17 Contractor/engineer brick brand preference (n = 30)

Rank	Brand	Count	Percent
1	BB7	8	26.7%
2	BB5	7	23.3%
3	BB6	5	16.7%
4	BB2	4	13.3%
5	BB1	3	10.0%
6	BB4	2	6.7%
7	BB8	1	3.3%
8	BB9	0	0%

Discussion. The BB9 zero-pick result is particularly notable given the water-absorption finding of Section 4.2.5 -BB9 brick's high absorption places it at the boundary of 2nd-class compliance, and experienced contractors are evidently steering clear. This behavioral signal supports the formal quality classification and illustrates how field-based procurement judgement can, in favorable cases, reinforce standards-based decisions (Bista & Karki, 2023).

4.4 Integration of quality compliance, cost benchmarking, and stakeholder preference

4.4.1 Integration of Quality and Cost

Objectives 1 and 2 produced two independent datasets -tested strength by brand and market price by brand. This section links them using the framework introduced in Section 3.11:

correlation analysis to test whether price tracks strength across the market, a Quality-to-Cost Ratio (QCR) defined as QCR = (Strength ÷ Price) × 1000 to rank individual brands, and a final check on whether the highest-priced brand in each cement grade earns its premium through proportionally higher strength. No new field data are required; the integration is reproducible from Sections 4.2 and 4.3.

Correlation between price and tested strength

Both Pearson (linear) and Spearman (rank-order) coefficients were computed for each cement grade and for the brick sample; both are reported because per-grade sample sizes are modest (n ≈ 9–10 brands). Table 4.18 summarizes the result.

Table 4.18 Correlation between tested strength and market price, by material

Material	Pearson r	p-value	Spearman ρ	Interpretation
OPC 43 Cement	−0.290	0.416	−0.018	No significant link
OPC 53 Cement	−0.039	0.914	−0.152	No significant link
PPC Cement	−0.293	0.412	+0.055	No significant link
Rebar (compliant)	N/A	—	N/A	Price uniform across brands
Brick (all brands)	+0.096	0.806	+0.044	No significant link

Discussion. No correlation reaches statistical significance at the conventional 5% threshold; every p-value is well above 0.05; coefficients are small and, for the three cement grades, slightly negative. Within Kathmandu Valley, a higher retail price is therefore not a reliable signal of higher tested strength. Brand pricing appears to reflect market positioning, distribution cost, and brand equity more than tested performance -consistent with (Paudel & Subedi, 2022) for the South-Asian cement market and with the procurement-behavior pattern described by (Pradhan & Thapa, 2021).

Comparison with prior studies on the price-strength link. The non-significant price-strength correlation reported above is in close agreement with the central finding of Mishra et al. (2025), who tested ten OPC 43-grade brands in central Terai for M20-grade concrete and similarly observed weak correlation between brand price and compressive strength. Their methodological choice of M20 concrete cube tests and the present study's choice of cement-mortar cube tests differ, but both arrive at the same procurement implication: in the Nepalese market, paying more for a higher-priced cement brand does not reliably purchase higher tested strength. The convergence of these two independent studies, conducted in different regions of Nepal and using different test protocols, strengthens the recommendation that cement procurement should be guided by compliance verification and Quality-to-Cost Ratio rather than by brand price alone (Section 4.5.2).

Quality-to-Cost Ratio -cement and brick

To rank individual brands, the QCR was computed grade by grade for cement and for the full brick sample. Tables 4.17 to 4.19 give the cement rankings; Table 4.22 gives the brick ranking.

Table 4.19 Quality-to-Cost Ratio -OPC 43 Grade Cement

Brand	Strength (MPa)	Price (NPR/bag)	QCR ×1000	Rank
CB1	54.50	842.33	64.70	1 (Best)
CB10	53.41	833.67	64.07	2
CB8	52.44	844.14	62.12	3
CB6	51.65	837.17	61.70	4
CB3	49.85	841.83	59.22	5
CB9	49.00	837.83	58.48	6
CB2	47.16	835.17	56.47	7
CB7	46.26	842.33	54.92	8
CB4	45.33	835.67	54.24	9
CB5	46.71	933.67	50.03	10 (Worst)

Table 4.20 Quality-to-Cost Ratio -OPC 53 Grade Cement

Brand	Strength (MPa)	Price (NPR/bag)	QCR ×1000	Rank
CB1	70.88	856.33	82.77	1 (Best)
CB3	57.09	856.33	66.67	2
CB10	55.56	849.00	65.44	3
CB2	54.42	850.50	63.99	4
CB6	54.38	852.50	63.79	5
CB5	59.90	942.00	63.59	6
CB4	51.03	851.00	59.96	7
CB7	50.41	856.83	58.83	8
CB8	49.41	858.93	57.53	9
CB9	46.98	853.17	55.07	10 (Worst)

Table 4.21 Quality-to-Cost Ratio -PPC Cement

Brand	Strength (MPa)	Price (NPR/bag)	QCR ×1000	Rank
CB9	45.71	738.17	61.92	1 (Best)
CB10	45.23	733.67	61.65	2
CB8	38.71	744.48	52.00	3
CB7	36.11	742.67	48.62	4
CB3	35.90	742.17	48.37	5
CB1	35.78	742.67	48.18	6
CB4	34.11	735.67	46.37	7
CB2	33.24	735.50	45.19	8
CB6	33.09	737.17	44.89	9
CB5	33.43	828.67	40.34	10 (Worst)

Cement results. CB1 leads both OPC 43 (QCR 64.70) and OPC 53 (QCR 82.77) because it records the highest tested strength in each grade at a mid-market price. On OPC 43, CB10, CB8, and CB6 follow closely. On OPC 53, CB3 (66.67), CB10 (65.44), CB2 (63.99), and CB6 (63.79) cluster as a strong second tier; CB9 is the OPC 53 worst-value because of its low 28-day strength. CB5 is bottom-ranked on OPC 43 and PPC, but on OPC 53 its high strength (59.90 MPa) recovers most of its price premium and leaves it in mid-table at sixth. On PPC the ranking shifts again: CB9 (61.92) and CB10 (61.65) dominate because both deliver the highest PPC strengths at close to the lowest surveyed prices, while CB1 drops to sixth -justifying the grade-by-grade screening step.

Table 4.22 Quality-to-Cost Ratio -Brick (all brands)

Brand	Class	Strength (MPa)	Price (NPR/pc)	QCR ×1000	Rank
BB7	1st	14.84	13.50	1099.26	1 (Best)
BB5	1st	10.66	15.00	710.67	2
BB4	2nd	9.27	15.00	618.00	3
BB2	1st	11.56	19.00	608.42	4
BB1	2nd	8.72	16.00	545.00	5
BB8	2nd	7.85	14.50	541.38	6
BB6	2nd	8.64	16.00	540.00	7
BB3	2nd	8.35	16.00	521.88	8
BB9	2nd	7.58	16.00	473.75	9 (Worst)

Brick results. BB7 records the highest strength in the full brick sample (14.84 MPa) at the lowest 1st-class price (NPR 13.50/piece), giving a QCR of 1099.26 -about 55% higher than the next brand (BB5, 710.67) and more than double the lowest QCR (BB9, 473.75). BB2 brick reaches 1st class on strength but at NPR 19/piece its value ranking falls below several 2nd-class products. BB9 is now the worst-value brand because its NPR 16/piece pricing is high relative to its 7.58 MPa strength and high 22.7% absorption (Section 4.2.5). Note that rebar prices are uniform across compliant brands at about NPR 109/kg in the 10–16 mm band, so the rebar QCR reduces to a pure strength ranking; RB3 (578.9 MPa average) and RB4 (580.8 MPa) lead, RB2 (393.2 MPa) is excluded because it fails Fe500.

4.4.2 Summary of integrated findings

Three findings follow directly from the integration and feed into Chapter 5.

1. Within Kathmandu Valley, higher price is not a reliable signal of higher tested strength for cement or brick. No correlation is statistically significant.
2. The QCR ranking identifies brand-level best-value options usable in procurement: CB1 for OPC 43 and OPC 53, CB9 (and CB10) for PPC, BB7 for 1st-class brick, RB5 for Fe500 rebar in the uniform-price band.
3. CB5's 10–12% cement price premium is unjustified for OPC 43 (−6.5% quality premium) and PPC (−11% quality premium), where it can be substituted by higher-QCR brands of the same grade. For OPC 53, however, CB5's +10% strength premium broadly matches its +10.3% price premium, so the premium is approximately justified for that grade only.

4.4.3 Integrated Findings Across All Three Streams

Bringing the three streams together produces the integrated view presented in Table 4.24 for the cement category and in Table 4.25 for rebar and brick. The tables align, for each brand, three pieces of information: (i) standards-based compliance status and strength level, (ii) retail price level, and (iii) contractor/engineer preference share. The side-by-side display is the direct product of the study and is the single most operationally useful output for construction managers.

Table 4.23 Integrated cement brand view (OPC 43 grade) -quality, cost, and preference

Brand	28-day Strength (MPa)	Compliance	Price (NPR/bag)	Pref. Share
CB1	54.50	Pass (high margin)	842.33	27%
CB10	53.41	Pass (high margin)	833.67	0%
CB8	52.44	Pass (high margin)	844.14	20%
CB6	51.65	Pass	837.17	3%
CB3	49.85	Pass	841.83	17%
CB9	49.00	Pass	837.83	0%
CB2	47.16	Pass	835.17	13%
CB5	46.71	Pass	933.67	10%
CB7	46.26	Pass	842.33	3%
CB4	45.33	Pass (small margin)	835.67	7%

Table 4.24 Integrated rebar and brick brand view -quality, price, and preference

Material / Brand	Key Quality Metric	Compliance	Price	Pref. Share
Rebar -RB1	557 MPa yield	Pass Fe500	NPR 112/kg (8 mm)	30%
Rebar -RB7	554 MPa yield	Pass Fe500	NPR 112/kg	23%
Rebar -RB5	567 MPa yield	Pass Fe500	NPR 112/kg	17%
Rebar -RB4	581 MPa yield	Pass Fe500	NPR 112/kg	13%
Rebar -RB2	393 MPa yield	Fail Fe500	NPR 107/kg	0%
Brick -BB7	14.84 MPa	1st class	NPR 13.50/pc	27%
Brick -BB5	10.66 MPa	1st class	NPR 15.00/pc	23%
Brick -BB2	11.56 MPa	1st class	NPR 19.00/pc	13%
Brick -BB9	7.58 MPa	2nd (plaster use only)	NPR 16.00/pc	0%

Discussion. The integrated tables expose three concrete procurement patterns. First, CB1 emerges as the only OPC 43 brand that simultaneously leads on strength, sits at the market-average price, and carries strong contractor preference -an unusual but instructive three-way alignment. Second, CB5's 12% premium is unsupported on OPC 43 by either strength or preference data, reinforcing the substitution case developed in Section 4.3.1 and formalized through the QCR ranking in Section 4.5.2. Third, in the rebar category, compliance and preference are in clear agreement (all top-preferred brands pass, RB2 fails and is not preferred), and price-based brand selection is essentially non-discriminating. In the brick category, BB7's simultaneous lead on strength, preference, and per-piece price makes it the clearest single-brand recommendation of the study. These three patterns feed directly into the conclusions (Chapter 5) and the recommendations (Chapter 6).

5. CONCLUSION AND RECOMMENDATION

This study set out to analyses the quality and cost of cement, rebar, and brick in Kathmandu Valley and to combine the technical, economic, and behavioral dimensions of construction-material selection in a single evidence base. The conclusions below are drawn strictly from the results reported in Chapter 4 and are organized objective by objective, in line with the research matrix (Table 3.1).

5.1 Conclusion

Objective 1 -Quality compliance. All 11 cement brands tested (OPC 43, OPC 53, PPC) satisfied the applicable NBSM strength benchmarks. The inter-brand strength spread was modest on OPC 43 grade (9.2 MPa) and substantially larger on OPC 53 grade (23.9 MPa), indicating that brand selection matters more for high-strength concrete applications. For rebar, six of seven deformed-bar brands and the 'RB8' category met the Fe500 yield benchmark of 500 MPa; RB2 failed with an average yield of 393 MPa. All eight rebar brands met the 12% minimum elongation. For brick, three of nine brands (BB7, BB2, BB5) achieved 1st-class classification (≥ 10 MPa); six brands achieved 2nd class; BB9 brick showed boundary-level water absorption (22.7%) and is recommended for plastered masonry use only.

Objective 2 -Cost variation. Cement prices across 30 suppliers showed a systematic 10–12% premium on CB5 across all grades. The premium is not supported by proportional strength on OPC 43 or PPC, but is approximately matched by CB5's second-place strength on OPC 53. The remaining ten brands clustered tightly around a market average of NPR 842/bag for OPC 43. Rebar prices were highly uniform across compliant brands (NPR 109–115.5/kg by diameter) and the price gap between RB2 and compliant Fe500 brands is too small to justify the quality compromise. Brick prices ranged from NPR 11–19 per piece; BB7 combined the highest 1st-class strength with the lowest 1st-class price, emerging as the clearest value option. Comparison of the retail-survey averages with the District Rate (Tables 4.10–4.12) shows a systematic retailer-side premium of about 30–35% for cement, about 8–9% for rebar, and material-type-specific gaps for brick (chimney-made bricks match the District Rate almost exactly while machine-made bricks carry a ~15% retailer premium); project estimators should adjust District-Rate-based budget figures for these category-specific gaps when retailer sourcing is anticipated.

Objective 3 -Influencing factors. Clients' overall material-priority split was 63% quality, 25% cost, and 13% equal weight on the two. Contractor/engineer preferences correlated closely with laboratory quality for cement (CB1, CB8, CB3), steel (RB1, RB7, RB5), and brick (BB7, BB5). Operational factors -availability, workability, delivery reliability, brand familiarity -were cited in the free-text responses as the main reasons for preferred brands, confirming the "availability first" pattern reported in the literature for experienced Kathmandu contractors.

Objective 4 -Integrated guidance. The integrated quality–cost–preference tables (Tables 4.24 and 4.25) expose three practical patterns. First, CB1 is the only OPC 43 brand that simultaneously leads on tested strength, sits at the market-average price, and carries strong contractor preference. Second, CB5's 12% OPC 43 price premium is unsupported by proportional strength gain, creating a clear substitution opportunity. Third, BB7 is the clearest single-brand recommendation for 1st-class brick, combining top strength, top preference, and lowest 1st-class price.

Objective 4 is further strengthened by the quality–cost integration reported in Section 4.5. Across all three cement grades and for the brick sample, no statistically significant correlation is found between mean brand price and mean tested strength: every reported p-value (range 0.41–0.81) is far above the conventional 5% significance threshold ($p < 0.05$); within the Kathmandu Valley market, paying more is therefore not a reliable signal of receiving higher tested quality. The Quality-to-Cost Ratio (QCR) ranking produced by the integration identifies, at brand level, the best-value options in each grade: CB1 for OPC 43 cement (QCR 64.70) and OPC 53 cement (QCR 82.77); CB3, CB10, and CB2 as a strong second tier on OPC 53; CB9 and CB10 for PPC (QCR 61.92 and 61.65 respectively); BB7 for 1st-class brick (QCR 1099.26 -the highest value in the entire study); and RB3 or RB4 for Fe500 deformed bar in the uniform-price band. The price-premium versus quality-premium test shows that CB5's 10–12% price premium is unjustified for OPC 43 (−6.5% quality premium) and PPC (−11% quality premium) but is approximately matched by quality on OPC 53 (+10.0% quality premium versus +10.3% price premium), so the substitution case for CB5 should be made grade by grade rather than on the brand as a whole.

The central conclusion of this study is that material-selection decisions in Kathmandu Valley are supported by three distinct but complementary dimensions -standards-based quality, market cost, and stakeholder preference -and that these dimensions can be combined in a single, practical decision reference. The integrated tables produced by this study demonstrate that agreement between the three dimensions does occur in the market (CB1 on cement, BB7 on brick), and that disagreement also occurs and is identifiable (CB5's price premium on OPC 43 grade, BB9's boundary absorption). Procurement that uses all three dimensions, rather than relying on any one of them in isolation, is therefore expected to produce better outcomes on both cost and quality than procurement based on price alone or on brand reputation alone. The four research objectives of the study are each supported by specific, brand-level, numerical evidence reported in Chapter 4, and the overall research aim -to produce a local, integrated, evidence-based reference for construction-material procurement in Kathmandu Valley -has been met.

5.2 Recommendations

The recommendations below are derived directly from the conclusions of this study (Chapter 5) and therefore from the results reported in Chapter 4. No recommendation is made on the strength of literature alone or on the strength of general experience; each recommendation is traceable to a specific finding of the present research.

1. For cement procurement on OPC 43 grade work, prefer CB1, CB10, CB8, or CB6 over CB5 unless a specific project-level reason (for example, a supplier-chain or credit consideration) justifies the 12% CB5 price premium. The four alternatives offer higher tested strength at the market-average price.
2. For cement procurement on OPC 53 grade and high-strength concrete, prefer CB1 (highest strength margin), with CB3, CB10, CB2, and CB6 as a strong second tier on QCR. CB5 OPC 53 is acceptable on quality grounds because its 10% strength premium broadly matches its 10% price premium, but the substitution case is weaker for OPC 53 than for OPC 43 or PPC. Where CB9 OPC 53 is used, obtain 28-day test results before high-grade structural pours.
3. Exclude CB2 from main structural reinforcement on all projects in Kathmandu Valley. The 393 MPa average yield is well below Fe500 and the price saving relative to compliant deformed bars is too small to justify the structural and seismic

risk. Where RB2 appears on bills of quantities, restrict it to clearly identified non-structural uses.

4. For Fe500 deformed bar, select among the six compliant brands (RB1, RB3, RB4, RB7, RB5, RB6) on the basis of delivery reliability and supplier credit terms. Because price and strength differences among compliant brands are small, these operational factors can dominate brand choice without compromising structural performance.
5. For 1st-class brick on plastered load-bearing walls, prefer BB7 as the primary option on value grounds. Where face-brick or exposed masonry is specified, BB2 brick justifies its price premium on dimensional accuracy.
6. Restrict BB9 brick to plastered masonry only, in view of its water-absorption result (22.7%). Do not use BB9 brick for exposed external walls or for walls in sustained wet conditions.
7. For first-time residential clients who rank cost above quality (approximately 25% of the client sample), anticipate substitution pressure on brick more than on cement or rebar. Where substitution is unavoidable, the 2nd-class brick set (BB4, BB1, BB6, BB3, BB8 at NPR 11–13 per piece) is a technically defensible option for plastered internal and secondary walls.
8. Formalize a simple brand-wise quality-cost-preference reporting template on each project. Populating the template early in the procurement cycle, using the summary tables of this study as a starting reference, will make the three-dimensional basis of each material decision visible to the client and to the project team.
9. Apply a Quality-to-Cost Ratio screen before issuing a purchase order for cement or brick. Using the ratio QCR = (Strength ÷ Price) × 1000, the best-value brand in each grade can be identified directly from the summary tables of Chapter 4 (CB1 for OPC 43 and OPC 53 cement, CB9 for PPC cement, BB7 for 1st-class brick, RB3 or RB4 for Fe500 rebar in the uniform-price band). Treat any price premium above 10% over the grade mean as requiring an independent quality justification, with the exception of CB5 OPC 53 where the premium is broadly justified by tested strength.

5.3 Recommendations for Further Study

1. Expand the sample frame by repeating the quality and cost surveys in at least three further survey cycles across different seasons and import windows, so that batch-to-batch and seasonal variation within brands can be quantified.
2. Add durability and lifecycle-cost indicators -for cement, sulphate and chloride resistance; for rebar, corrosion rate in uncoated state; for brick, freeze–thaw and efflorescence behavior -to give a broader performance view.
3. Extend the geographical scope beyond Kathmandu Valley to a comparable set of suppliers in other urban centers (Pokhara, Biratnagar, Birgunj, Butwal), so that the findings can be generalized to the wider Nepalese construction market.
4. Enlarge the stakeholder sample and stratify by project type (residential, commercial, institutional, public infrastructure) to identify whether procurement behaviors vary systematically with project category.

REFERENCES

Acharya, K., & Sharma, P. (2020). Quality assessment of selected brick types used in Kathmandu Valley construction. *IOE Graduate Conference*, (pp. 78-85).

Bista, N., & Karki, R. (2023). Contractor decision-making in material procurement: Evidence from Kathmandu projects. *Construction Management and Economics Nepal*, 5–14.

Bureau of Indian Standards. (1966). *IS 1139: Specification for hot rolled mild steel bars for concrete reinforcement.* New Delhi: BIS.

Bureau of Indian Standards. (2007). *IS 1077: Common burnt clay building bricks-Specification.* New Delhi: BIS.

Bureau of Indian Standards. (2008). *IS 1786: High strength deformed steel bars for concrete reinforcement.* New Delhi: BIS.

Central Bureau of Statistics. (2020). *National economic census 2018/19.* Kathmandu: Government of Nepal.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.).* SAGE Publications.

Durdyev, S., & Hosseini, M. R. (2020). Causes of delays on construction projects: A comprehensive list. *International Journal of Managing Projects in Business*, 20–46.

Joshi, P., & Bajracharya, A. (2022). Supply chain and availability of construction materials in Kathmandy Valley. *Nepal Civil Engineering Journal*, 58–66.

Kothari, C. R. (2014). *Research methodology: Methods and techniques (3rd ed.).* New Age International.

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, 607–610.

Maharjan, S., & Shakya, R. (2023). Client preferences in material selection for urban housing: A survey-based study in Kathmandu. *Proceedings of IOE Graduate Conference*, (pp. 112–120).

Nepal Bureau of Standards and Metrology. (2014). *NS 104: Pozzolana Portland cement specification.* Kathmandu: NBSM.

Nepal Bureau of Standards and Metrology. (2014). *NS 49: Ordinary Portland cement specification.* Kathmandu: NBSM.

Nepal Bureau of Standards and Metrology. (2019). *NS 191: Hot-rolled deformed steel bars for concrete reinforcement.* Kathmandu: NBSM.

Paudel, S., & Subedi, K. (2022). Cement market dynamics and price variation in urban Nepal. *Himalayan Journal of Engineering*, 20–29.

Pradhan, B., & Thapa, M. (2021). Brand perception and procurement behaviour in Nepal's building materials market. *Nepal Engineering College Journal*, 34–42.

Risal, T., & Ghimire, S. (2021). Comparative strength analysis of Fe500 deformed rebar brands in Nepal. *Proceedings of IOE Graduate Conference*, (pp. 45–52).

Shrestha, A., & Manandhar, D. (2021). Seismic risk of plain mild steel reinforcement in Kathmandu Valley buildings. *Journal of Earthquake Engineering Nepal*, 44–53.

Shrestha, S., & Bhattarai, R. (2022). Construction material demand and urban growth in Kathmandu Valley. *Journal of Construction Engineering Nepal*, 11–19.

Thapa, B., & Dahal, K. (2023). Contractor loyalty to established brands: Implications for material procurement efficiency in Nepal. *Journal of Engineering Management*, 15–24.

Tuladhar, R., & Rajbhandari, S. (2019). Integrated framework for construction material selection in developing economies. *Asian Journal of Civil Engineering*, 881–892.

ANNEX I: LIST OF SURVEYED SUPPLIERS

Table A.1 lists the 30 hardware and construction-material suppliers from which the cost-survey data were collected during 2025–2026.

Table I.0.1 Surveyed hardware suppliers (n = 30)

S.N.	Supplier Name	Location	District
1	New Lotus Hardware	Maitidevi	Kathmandu
2	Bhakta Hardware	Maitidevi	Kathmandu
3	New Shiva Shakti Hardware	Kalanki	Kathmandu
4	Manakamana Hardware and Suppliers	Sitapaila	Kathmandu
5	Shankha Hardware	Sankhamul	Lalitpur
6	Sotang Hardware and Suppliers	Kageshwori	Kathmandu
7	Sishir Hardware	Kageshwori	Kathmandu
8	Organ Hardware	Maharajgunj	Kathmandu
9	CB4 Gauri Ganesh Hardware	Maharajgunj	Kathmandu
10	Everest Hardware and Suppliers	Madhyapur Thimi	Bhaktapur
11	Agni Hardware and Construction	Madhyapur Thimi	Bhaktapur
12	Pal Hardware	Kamalbinayak	Bhaktapur
13	Kumari Hardware Center	Nagarkot Road	Bhaktapur
14	BB1 Bricks Factory	New Baneshwor	Kathmandu
15	BB7 Itta Udhyog	Madhyapur Thimi	Bhaktapur
16	Bramhayani Suppliers	Kathmandu	Kathmandu
17	Upakar Fix Chimney Itah Udhyog	Panchkhal	Kavre*
18	NB Brick	Panchkhal	Kavre*
19	BB5 Brick Office	Kathmandu	Kathmandu
20	Jay CB4 Itta Udhyog	Bhaktapur	Bhaktapur
21	Samyam Enterprises	Imadol	Lalitpur
22	NA Brick Udhyog	Panchkhal	Kavre*
23–30	Additional hardware suppliers	Various	Valley-wide

** Suppliers in Panchkhal (Kavre) included because they are the main source of brick stock for Kathmandu and Lalitpur retailers.*

ANNEX II: CLIENT QUESTIONNAIRE

Section 1 -Overall Priority

1.1 Respondent ID: ______________________

1.2 Date: ______________________ Location: ______________________

1.3 When you must choose between COST and QUALITY/STRENGTH on construction materials overall, which do you prioritise? (Tick one)

- Cost
- Quality / Strength
- Both equally

1.4 Please give approximate percentage weights that sum to 100.

Quality: ______ % Cost: ______ %

1.5 Remarks: ______________________

ANNEX III: CONTRACTOR / ENGINEER QUESTIONNAIRE

Respondent Information

Respondent ID: ______________________

Position: [Contractor / Site Engineer / Civil Engineer] ______________________

Date: ______________________ Location: ______________________

Section 1 -Cement

Please indicate the cement brand(s) most commonly used on your current project(s), together with type/grade and your reason for selecting them.

Table III.1 Contractor questionnaire -cement details

Cement Brand	Type / Grade	Reason / Remark

Section 2 -Steel

Please indicate the steel brand(s), sizes, and grade(s) most commonly used on your current project(s).

Table III.2 Contractor questionnaire -steel details

Steel Brand	Size (mm)	Grade (Fe500 / Fe500D / Other)	Reason / Remark

Section 3 -Brick

Please indicate the brick type(s), grade/class, usage area, and your reason for selecting them.

Table III.3 Contractor questionnaire -brick details

Brick Type	Grade / Class	Usage Area	Reason / Remark

ANNEX IV: LABORATORY QUALITY -DETAILED BRAND STATISTICS

Tables IV.1 to IV.3 reproduce the detailed descriptive statistics (mean and standard deviation) for the laboratory quality tests, corresponding to the summaries in Chapter 4.

IV.1 Cement -Detailed brand statistics

Table IV.1 Cement -OPC 43 grade, 28-day compressive strength: mean ± SD by brand

Brand	Mean (MPa)	SD (MPa)	3-day Mean	7-day Mean
CB1	54.50	7.11	34.95	44.64
CB2	47.16	3.07	32.61	39.40
CB3	49.85	4.37	32.16	39.53
CB4	45.33	3.44	30.41	37.83
CB5	46.71	4.34	27.95	36.69
CB6	51.65	4.98	33.16	40.82
CB10	53.41	5.49	33.22	41.48
CB8	52.44	3.81	36.57	42.44
CB9	49.00	3.48	34.85	39.94
CB7	46.26	4.21	32.49	43.97
CB11	48.38	5.30	30.07	37.88

Table IV.2 Cement -OPC 53 grade, 28-day compressive strength: mean ± SD by brand

Brand	Mean (MPa)	SD (MPa)	3-day Mean	7-day Mean
CB1	70.88	3.79	42.74	58.32
CB2	54.42	3.88	38.29	46.03
CB3	57.09	5.02	34.72	43.31
CB4	51.03	2.43	34.37	39.10
CB5	59.90	4.09	40.10	48.16
CB6	54.38	5.18	34.44	42.69
CB10	55.56	5.89	34.06	41.77
CB8	49.41	3.59	34.39	38.85
CB9	46.98	4.95	32.85	37.21

Brand	Mean (MPa)	SD (MPa)	3-day Mean	7-day Mean
CB7	50.41	5.47	31.69	37.76
CB11	55.71	7.18	33.54	43.36

Table IV.3 Cement -PPC, 28-day compressive strength: mean ± SD by brand

Brand	Mean (MPa)	SD (MPa)
CB1	35.78	3.67
CB2	33.24	3.26
CB3	35.90	3.52
CB4	34.11	3.81
CB5	33.43	4.11
CB6	33.09	4.44
CB10	45.23	4.52
CB8	38.71	3.07
CB9	45.71	3.31
CB7	36.11	3.18
CB11	35.41	3.62

IV.2 Rebar -Detailed brand statistics

Table IV.4 Rebar -Yield strength (MPa) mean by brand and diameter

Brand	8 mm	10 mm	12 mm	16 mm	20 mm	25 mm	28 mm	32 mm
RB1	588.2	533.4	564.5	545.2	554.7	546.7	556.3	542.2
RB2	455.1	379.0	371.2	358.3	402.4	374.3	379.6	372.0
RB3	598.1	588.7	568.2	563.4	576.2	559.0	540.2	537.9
RB4	605.2	583.9	575.3	568.9	570.5	554.2	566.4	518.7
RB7	556.9	570.4	558.9	554.2	527.7	535.6	548.3	527.9
RB5	554.2	595.6	565.6	548.1	572.7	584.5	613.4	577.9
RB6	586.1	585.5	573.8	559.3	556.9	569.2	556.8	555.7
RB8	602.1	577.1	575.3	562.9	550.4	542.9	555.7	541.6

Table IV.5 Rebar -Average elongation (%) by brand (across diameters)

Brand	Avg. Elongation (%)	Pass/Fail (≥ 12%)
RB1	21.1	Pass

Brand	Avg. Elongation (%)	Pass/Fail (≥ 12%)
RB2	34.0	Pass
RB3	20.1	Pass
RB4	20.4	Pass
RB7	20.5	Pass
RB5	19.3	Pass
RB6	20.2	Pass
RB8	20.9	Pass

IV.3 Brick -Detailed brand statistics

Table IV.6 Brick -Breaking strength and water absorption: mean ± SD

Brand	Strength Mean (MPa)	Strength SD	Absorption Mean (%)	Absorption SD	Class
BB1	8.72	2.59	17.55	2.29	2nd
BB2	11.56	1.07	13.11	2.84	1st
BB3	8.35	3.76	16.81	4.21	2nd
BB4	9.27	0.76	15.42	0.93	2nd
BB5	10.66	1.47	11.55	3.72	1st
BB6	8.64	2.46	13.90	4.85	2nd
BB7	14.84	0.75	11.94	1.20	1st
BB8	7.85	2.04	18.02	1.73	2nd
BB9	7.58	1.72	22.67	4.34	2nd*

** BB9 brick assigned 2nd class on strength (≥ 7.5 MPa) with caveat that water absorption exceeds the 22% maximum; use restricted to plastered masonry.*

ANNEX V: SUPPLIER-LEVEL COST SURVEY -EXTRACT

Table V reproduces a representative extract from the cost-survey raw data, showing retail price records (NPR/bag for cement, NPR/kg for rebar, NPR per piece for brick) for a subset of suppliers. The full supplier list is given in Annex I.

Table V.1 Cement price extract (NPR/bag) -OPC 43 grade

Supplier	CB1	CB2	CB3	CB4	CB5	CB6	CB10	CB8	CB9	CB7
New Lotus	850	825	825	825	950	850	825	850	825	850
Bhakta	840	840	840	840	950	840	840	840	840	840
New Shiva Shakti	850	850	850	850	960	830	830	850	830	850
Manakamana	845	845	845	845	920	845	845	845	845	845
Shankha	825	825	825	800	900	800	800	825	825	825
Sotang	850	850	850	850	950	850	850	900	850	900
Sishir	800	800	800	800	900	800	800	800	800	800
Organ	800	800	800	840	950	840	800	840	840	800
Mean	842	835	842	836	934	837	834	844	838	842

Table V.2 Rebar price extract (NPR/kg, 8 mm and 10 mm) by supplier

Supplier	RB1 8 mm	RB1 10 mm	RB3 8 mm	RB4 8 mm	RB7 8 mm	RB5 8 mm	RB6 8 mm
Sotang	108	104	108	108	108	108	108
Everest	112	109	112	110	110	110	112
Agni	113.5	110	113.5	113.5	115.5	115.5	115.5
Kumari	111.5	108	111.5	111.5	111.5	111.5	111.5
Pal	112	109	112	112	112	112	112
Mean	112.45	109.13	112.05	112.05	112.35	112.38	112.38

Table V.3 Brick price extract (NPR per piece) by supplier and class

Supplier	Class	Brand	Price (NPR)
Hira Bricks Factory	Single	BB1	16

Supplier	Class	Brand	Price (NPR)
Laxmi Itta Udhyog	1st	BB7	13.5
Laxmi Itta Udhyog	2nd	BB7	11
Bramhayani	1st	BB6	16
Bramhayani	2nd	BB6	13
Upakar Fix Chimney	1st	BB9	16
Upakar Fix Chimney	2nd	BB9	13.5
NB Brick	1st	BB8	14.5
NB Brick	2nd	BB8	12
GOOD Brick Office	Single	BB5	15
Jay Bricks	1st	BB4	15
Jay Bricks	2nd	BB4	12
Samyam	Single	BB2	19
Trishakti Brick Udhyog	1st	NA	16
Trishakti Brick Udhyog	2nd	NA	13

ANNEX VI: QUESTIONNAIRE RESPONSES -SUMMARY

Tables VI.1 and VI.2 reproduce the compiled response summaries from the client and contractor/engineer questionnaires, corresponding to the Section 4.4.

Table VI.1 Client questionnaire -individual responses (extract, n = 32)

S.N.	Respondent ID	Priority	Quality %	Cost %
1	Suwarn Sagar Jung KC	Cost	40	60
2	Robinson Bhandari	Cost	45	55
3	Krisha Karki	Quality/Strength	60	40
4	Kamal Sapkota	Cost	20	80
5	Basu Gautam	Quality/Strength	60	40
6	Kshitiz Puri	Both	50	50
7	Samundra Koirala	Quality/Strength	80	20
8	Suyash Subedi	Cost	45	55
9	Kabita Adhikari	Quality/Strength	65	35
10	Sagar Kharel	Quality/Strength	80	20
11	Anish Dhakal	Both	50	50
12	Rk Dahal	Quality/Strength	55	45
13	Soniya Maharjan	Quality/Strength	70	30
14	Jyotie k.c.	Quality/Strength	90	10
15	Mandip Dhuingana	Cost	35	65
16	Tapesh Khadka	Quality/Strength	60	40
17	Yogendra Raj Joshi	Quality/Strength	65	35
18	Prajwol Raut	Both	50	50
19	Saroj Shrestha	Quality/Strength	60	40
20	Roshan Bam	Quality/Strength	60	40
21	Dipendra Paneru	Quality/Strength	70	30
22	Ishowr Mahara	Quality/Strength	60	40
23	Alisha Joshi	Both	50	50
24	Ramesh Thapa	Cost	30	70
25	Suman Luitel	Quality/Strength	70	30
26	Dikshya Karki	Quality/Strength	60	40

S.N.	Respondent ID	Priority	Quality %	Cost %
27	Prakash Manandhar	Quality/Strength	55	45
28	Usha Bista	Cost	40	60
29	Milan Shakya	Quality/Strength	65	35
30	Deepak Poudel	Quality/Strength	70	30
31	Rajan Lama	Cost	45	55
32	Binita Adhikari	Quality/Strength	60	40

Table VI.2 Contractor/engineer questionnaire -compiled preference frequencies

Category	Item	Count	Percent	Rank
Position	Site Engineer	14	46.7%	1
Position	Civil Engineer	9	30.0%	2
Position	Contractor	7	23.3%	3
Cement	CB1	8	26.7%	1
Cement	CB8	6	20.0%	2
Cement	CB3	5	16.7%	3
Cement	CB2	4	13.3%	4
Cement	CB5	3	10.0%	5
Cement	CB4	2	6.7%	6
Cement	CB7	1	3.3%	7
Cement	CB6	1	3.3%	8
Steel	RB1	9	30.0%	1
Steel	RB7	7	23.3%	2
Steel	RB5	5	16.7%	3
Steel	RB4	4	13.3%	4
Steel	RB3	3	10.0%	5
Steel	RB6	2	6.7%	6
Brick	BB7	8	26.7%	1
Brick	BB5	7	23.3%	2
Brick	BB6	5	16.7%	3
Brick	BB2	4	13.3%	4
Brick	BB1	3	10.0%	5
Brick	BB4	2	6.7%	6
Brick	BB8	1	3.3%	7

ANNEX VII: MATERIAL BRAND IDENTIFICATION

Table VIII.1 Cement Brand Identification Used in the Study

Brand Code	Brand Name
CB1	Hongshi
CB2	Riddhisiddhi
CB3	Sarbottam
CB4	United
CB5	Shivam
CB6	Sagarmatha
CB10	Arghakanchi
CB8	Huaxin
CB9	Maruti
CB7	Jagdamba
CB11	Others

Table VIII.2 Rebar Brand Identification Used in the Study

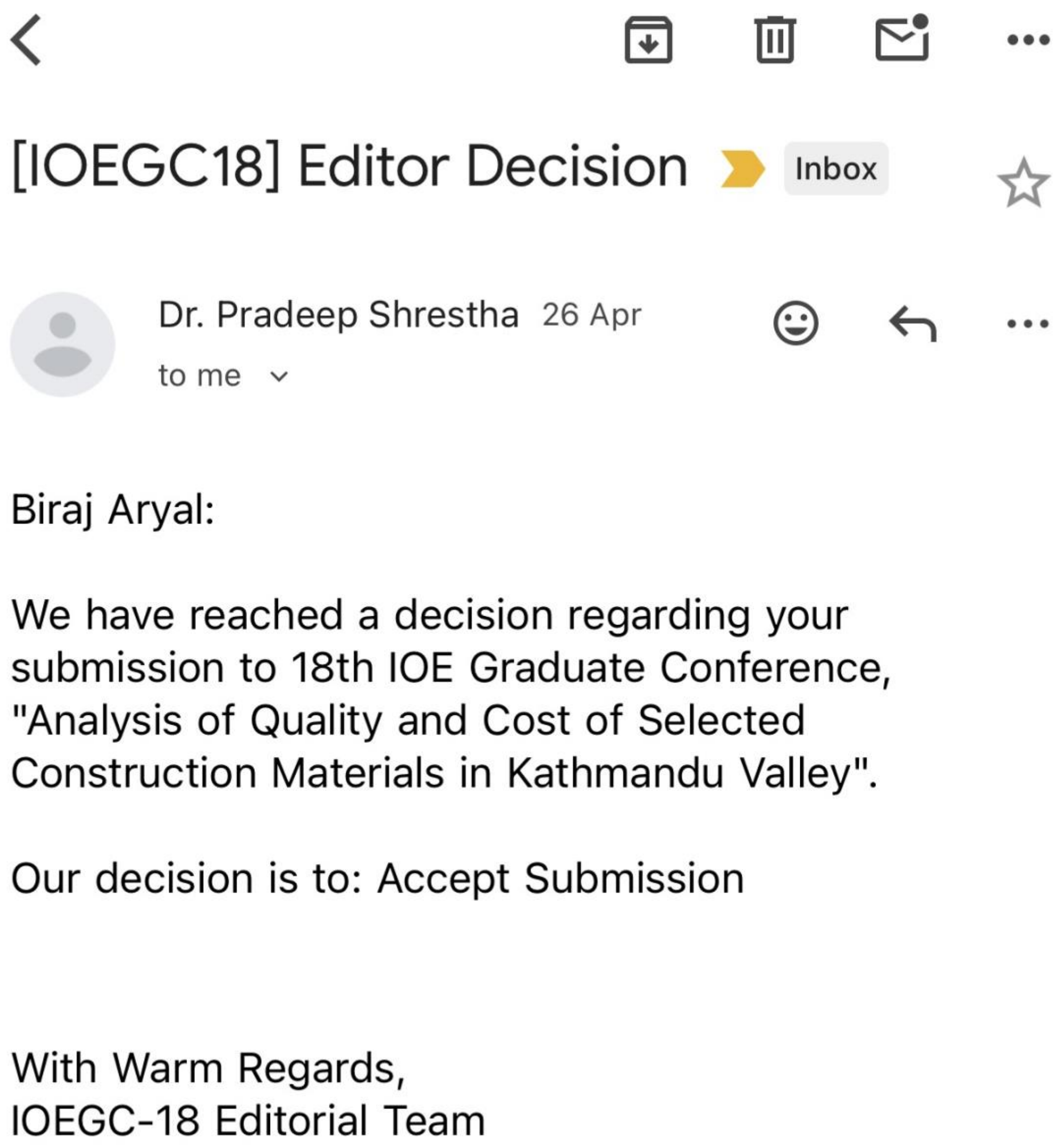
Brand Code	Brand Name
RB1	Ambe
RB2	Plain Mild-Steel Rod
RB3	Sarbottam
RB4	Shree
RB5	Jagshakti
RB6	Premier
RB7	Jagdamba
RB8	Others

Table VIII.3 Brick Brand Identification Used in the Study

Brand Code	Brand Name
BB1	Hira
BB2	NB
BB3	Trishakti
BB4	1H1
BB5	GOOD

Brand Code	Brand Name
BB6	HTT
BB7	LAXMI
BB8	NTB
BB9	UK

ANNEX IX – ACCEPTANCE LETTER & PLAGARISM TEST



[IOEGC18] Editor Decision Inbox

Dr. Pradeep Shrestha 26 Apr

to me

Biraj Aryal:

We have reached a decision regarding your submission to 18th IOE Graduate Conference, "Analysis of Quality and Cost of Selected Construction Materials in Kathmandu Valley".

Our decision is to: Accept Submission

With Warm Regards,
IOEGC-18 Editorial Team

iThenticate

Similarity Report ID: oid:3117:584978346

PAPER NAME	AUTHOR
Analysis of Quality and Cost of Major Construction Materials in Kathmandu Valley	Biraj Aryal

WORD COUNT	CHARACTER COUNT
19500 Words	100532 Characters
PAGE COUNT	**FILE SIZE**
60 Pages	502.1KB
SUBMISSION DATE	**REPORT DATE**
Apr 30, 2026 10:49 PM GMT+5:45	Apr 30, 2026 10:50 PM GMT+5:45

2% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

- 2% Internet database
- 1% Publications database
- Crossref database
- Crossref Posted Content database
- 0% Submitted Works database

Excluded from Similarity Report

- Bibliographic material
- Quoted material
- Cited material
- Small Matches (Less then 10 words)

iThenticate — **Similarity Report ID:** oid:3117:584978346

2% Overall Similarity

Top sources found in the following databases:

- 2% Internet database
- 1% Publications database
- Crossref database
- Crossref Posted Content database
- 0% Submitted Works database

TOP SOURCES

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	elibrary.tucl.edu.np:8080 Internet	<1%
2	assets-eu.researchsquare.com Internet	<1%
3	mdpi.com Internet	<1%
4	link.springer.com Internet	<1%
5	Anna Dreber, Magnus Johannesson. "The Credibility Gap - Evaluating a... Publication	<1%
6	causeweb.org Internet	<1%
7	supercivilcd.com Internet	<1%
8	itspoa.com Internet	<1%

Sources overview

iThenticate

Similarity Report ID: oid:3117:584978346

9	eprajournals.com	Internet	<1%
10	doczz.net	Internet	<1%
11	met.readthedocs.io	Internet	<1%
12	coursehero.com	Internet	<1%
13	nature.com	Internet	<1%
14	tribuneindia.com	Internet	<1%
15	rps.wku.edu.et	Internet	<1%
16	nap.nationalacademies.org	Internet	<1%
17	oulurepo.oulu.fi	Internet	<1%
18	rosap.ntl.bts.gov	Internet	<1%
19	salachar.com	Internet	<1%
20	vinsights.co.uk	Internet	<1%

Sources overview

21 researchgate.net
Internet
<1%