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Investigation of Factors Influencing the Use of Concrete Flat Roofs in Kakamega Municipality, Kenya

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Abstract: The use of concrete flat roofs has potential benefits such as durability, space efficiency and suitability for urban settings, but they remain underutilised. This study investigated factors that influence the use of concrete flat roofs in Kakamega Municipality, Kenya. The specific research objective was to analyse the influence of cost on the use of concrete flat roofs on residential buildings in Kakamega Municipality, Kenya. This was a descriptive survey that adopted a mixed method approach where both quantitative and qualitative techniques were used for data collection and analysis. Population of the study included homeowners with concrete flat roofs on their residential buildings. This was supported by secondary information gathered from contractors, consultants and government officials in Kakamega Municipality, Kenya. Using Yamane's formula for sample size determination, the study drew a representative sample of 65 homeowners with concrete flat roofs on their residential buildings selected through a stratified random technique. Interviews were also conducted with three contractors, three consultants and two government officials. All questionnaires were distributed to homeowners with concrete flat roofs on their residential buildings but only 64 were returned fully completed, yielding a high response rate of 98.5%. The data gathered through the use of questionnaires was analysed using both descriptive and inferential statistics. Secondary data was transcribed and subjected to thematic analysis to get into the in depth of the study. It was discovered that construction cost had a significance influence on the use of concrete flat roofs on residential buildings in Kakamega Municipality, Kenya. While the use of concrete flat roofs was supported by labor in the Municipality, cost constraints remained the barrier to adoption.

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I. INTRODUCTION

Roof is the main protection component of a building. It's the uppermost covering of a building. There are two types of roofs namely, pitched roof and flat roof. Pitched roofs are characterised by their inclination and are utilised in regions with high rainfall due to their efficient water shedding capabilities. Conversely, flat roofs are defined as those whose maximum pitch is 10 degrees to the horizontal plane (GoK, 2022).

The evolution of roofing designs has been marked by significant transformations, shaped by climatic factors, cultural norms, material availability and advancements in construction technology. Flat roof designs emerged significantly during the modernist movement of the 20th century, championed by influential architects like Le Corbusier, who emphasised on form, function and minimalist design (UN-Habitat, 2018).

Roofs serves as the primary protective barrier against weather elements namely rain, sunlight and wind. Beyond its protective function, a roof significantly influences a structure's thermal performance, structural integrity and aesthetic quality (Chudley & Greeno, 2016). Among their most significant advantages is space efficiency platforms for green roof installations, solar energy systems and recreational space. From a construction perspective, they typically simplify building processes and require reduced material inputs compared to pitched alternatives, potentially enhancing cost-effectiveness in appropriate applications (Gok ,2021). Furthermore, their compatibility with environmentally responsive technologies for instance integrated rainwater management systems and photovoltaic

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installations positions them as advantageous options for ecologically conscious architectural design (NCA, 2021). From an aesthetic perspective, concrete flat roofs complement contemporary minimalist architectural expressions and offer design flexibility aligned with modern urban design principles (AAK, 2020).

➢ *Statement of Problem*

Concrete flat roofs are governed by various regulatory frameworks in Kenya. The Kenya National Building Code (2024) provides the standards for concrete flat roofs, requiring a maximum slope of 10 degrees to prevent water ponding, the use of durable waterproofing systems and properly designed drainage components like gutters and downpipes. It emphasises the use of high-quality, low-permeability concrete and admixtures to enhance durability. The Code also mandates a structured construction process from substrate preparation to membrane application and insists on routine inspections and quality assurance measures to maintain structural integrity and ensure long-term performance of the roofing system. Routine on-site inspections and post-construction quality assurance protocols are also essential to detect and address potential defects early. These specifications are essential in maintaining structural integrity and extending the lifespan of roofing systems (NCA, 2021).

The Architectural Association of Kenya (2020) notes frequent deviations from best practices, leading to challenges particularly poor water runoff, membrane failures and accelerated deterioration of building components. AAK (2020) notes that many roofs are constructed completely level or with an insufficient gradient causing water to stagnate (Habitat for Humanity Kenya, 2019). Another prevalent issue is membrane failure (Nzeyimana et al., 2020). However, cost-cutting tendencies among contractors often result in the use of substandard materials or omission of membranes altogether (Munyiri & Otieno, 2020). Studies show that many homeowners in Western Kenya associate flat roofs with maintenance headaches and premature structural failure (Wafula, 2020).

It is for this reason that this study sought to investigate factors that influence the use of concrete flat roofs in Kakamega Municipality, Kenya.

➢ *Objectives of the Study*

The main objective of this study was to investigate factors that influence the use of concrete flat roofs in Kakamega Municipality, Kenya. This was guided by the following specific objective:

- To analyse the influence of cost on the use of concrete flat roofs on residential buildings in Kakamega Municipality, Kenya.

➢ *Research Questions*

- Does cost have a significant influence on the use of concrete flat roofs on residential buildings in Kakamega Municipality, Kenya?

➢ *Significance of the Study*

This study seek to analyse the influence of cost on the use of concrete flat roofs on residential buildings in Kakamega Municipality, Kenya.

➢ *Scope of the Study*

The research was confined to Kakamega Municipality, Kenya, which represents a rapidly urbanising town characterised by increasing demand for modern housing and commercial structures. The area was selected due to its growing real estate market, changing urban landscape, and diverse socio-economic population, making it an appropriate case for examining the adoption of flat roofing solutions.

➢ *Limitations of the Study*

This study was limited to homeowners with concrete flat roofs on their residential buildings in Kakamega Municipality approved in the course of 2015 -2025.

II. LITERATURE REVIEW

➢ *Expenses Associated with Concrete Flat Roofs on Buildings*

Flat roofs have had been gaining in popularity in several countries, and the roof is one of the building envelope elements where most thermal exchanges with the exterior occur, and this considerably influences the thermal performance of buildings (Marrana et al,.2017). The cost of constructing and maintaining concrete flat roofs has been identified as one of the major factors influencing their adoption in both urban and peri-urban contexts. In low and middle-income communities, affordability often matters more than long-term benefits when choosing building materials. Gichuki (2019) notes that the high initial cost of building concrete flat roofs especially with necessary parts like waterproofing materials, reinforced concrete and proper drainage systems puts off low-income earners. This reality forces homeowners to choose between immediate affordability and long-term durability. The situation becomes more difficult when considering that many people have fluctuating incomes. Small-scale farmers, market vendors and casual laborers often find it difficult to secure the large upfront investment needed for concrete flat roofs.

Farah (2022) studied on the waterproofing process of reinforced concrete flat roof on terrace house at teluk intan, perak in Malaysia. Results showed that building and installing to the materials commonly used for flat roofs, they are relatively cheap. It makes a flat roof very affordable for both installation and upkeep and maintenance. Labor is cheaper due to less risk while installing a flat roof. Installation of flat roofs is quicker and easier.

Marrana et al, (2017) conducted a study on Lifecycle Cost Analysis of Flat Roofs of Buildings. It was revealed that material acquisition and execution costs are the most determinant; inverted flat roofs with limited accessibility are more economical; lightweight concrete with expanded polystyrene granules used as shaping layer and atactic polypropylene polymer bituminous or polyvinyl chloride thermoplastic membranes are the most economical solutions.

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One of the critical building elements that requires immediate attention for maintainability is reinforced concrete flat roofs. They are often subjected to alternate drying and wetting cycles under tropical conditions, causing many defects and subsequent deterioration when proper detailing related to design, construction and maintenance actions are lacking. De Silva and (Malik, 2010)

De Silva and Malik (2010) studied on Maintainability of reinforced concrete flat roofs in Sri Lanka, findings revealed that the level of maintainability of a typical flat roof is only 51 percent.

Azman and Norazura (2023) Investigated issues that arise in concrete flat roof in Perak in Malaysia. Findings were that; over time, problems like leaks and fractures emerge, requiring maintenance. Similarly, the majority of respondents expressed satisfaction with their buildings.

Kot et al, (2024) studied the application of electromagnetic waves in monitoring water infiltration on concrete flat roof: the case of Malaysia. The study determined that microwave technology can be used to identify moisture content in concrete flat roofs by analysing properties of the concrete roof and water.

Arthur et al, (2023) studied roofing economics: analysing the impact of design and materials on construction costs. It was found out that flat roofs are a cost-effective option, costing only 47.69% of the price of gable roofs. This makes them appealing for projects with limited budgets.

Flat concrete roofs are generally low maintenance, meaning it is easy to clean and aren't too difficult to access. Like any other roofing, debris and dirt can pile up over time. However, roofers can easily remove these from the surface without damaging the roof itself (Farar, 2022).

University of Nairobi study by Mwangi (2018) noted that even when homeowners were presented with evidence of lower lifecycle costs of flat roofs, most still opted for cheaper pitched alternatives due to limited access to credit. Globally, research in Latin America and South Asia also confirms that liquidity constraints often outweigh lifecycle savings in material selection (Chowdhury & Kabir, 2020; UN-Habitat, 2021).

While flat roofs offer significant long-term benefits such as lower maintenance costs, space for future expansion and potential for solar installation; these advantages are not always clear or accessible to families with limited money (Alvarado & Moreno, 2020). Low-income households are often forced to make cheaper short-term decisions that prove more expensive over time. However, immediate financial pressure often makes this long-term thinking difficult. Research by Wanjiku and Otieno (2021) in Kenyan municipalities found that households with monthly incomes below KSh 20,000 were 70% less likely to consider concrete flat roofs, regardless of their knowledge of long-term benefits. This shows that cost play a major role in roofing material choices.

In smaller municipalities such as Kakamega, limited access waterproofing technologies can inflate construction costs compared to major urban centers (Integrum, 2022). Moreover, poorly executed flat roofs increase the risk of leaks and drainage failures, thereby raising long-term maintenance costs and reinforcing perceptions of unaffordability (Nyangena, 2017). Thus, while concrete flat roofs provide clear benefits in terms of durability, space utilization, and modern aesthetics, the high initial investment remain critical barrier to adoption.

- *Theoretical Framework*

The theoretical framework provides the foundation for understanding the factors that influence the use of concrete flat roofs in Kakamega County. By integrating the Diffusion of Innovations Theory (Rogers, 2003) and Cost-Benefit Analysis Theory (Brealey, 2011), this study aimed to explore the use process from socio-economic and technological perspectives. These theories provide insight into how innovation spreads, the acceptance of new technologies and the role of economic considerations in use decisions.

- *Diffusion of Innovations Theory*

The Diffusion of Innovations Theory, introduced by Everett Rogers (2003), is a key framework for understanding how new technologies, ideas or practices spread within a population. According to Rogers, innovations do not become universally adopted at once, but rather diffuse over time through different categories of adopters (early adopters, early majority, late majority and laggards). Rogers identifies several factors that influence the use process, including relative advantage, compatibility, complexity, trialability and observability.

- *Cost- Benefit Analysis Theory*

Cost–Benefit Analysis (CBA) is an economic evaluation framework used to assess the feasibility of projects or investments by systematically comparing the total expected costs against the anticipated benefits. The central premise of the theory is that a rational decision is achieved when the benefits derived from a project outweigh the costs incurred (Boardman et al., 2018).

In construction, and particularly in the context of roofing, CBA provides an objective lens for evaluating alternatives such as pitched versus flat roofs. Costs considered in the analysis typically include initial construction costs, operation and maintenance expenses, repair and replacement costs, and opportunity costs of land or space. Benefits, on the other hand, may include functional utility, space optimisation, durability, aesthetic appeal, energy efficiency, and potential for multi-functional use such as roof gardens, water harvesting systems, or additional usable floor space (Pearce, 2015).

Applying the theory to concrete flat roofs in developing contexts such as Kakamega Municipality, the evaluation extends beyond immediate construction costs. While the upfront costs of concrete flat roofs may be relatively higher due to material and technical requirements, the long-term benefits such as additional usable space, resilience,

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adaptability to solar installations, and alignment with sustainable construction practices may outweigh the short-term financial burden. Moreover, non-monetary benefits, such as environmental sustainability, improved urban land use, and compliance with evolving building codes, are also increasingly recognised within CBA frameworks (Gramlich, 1990).

The relevance of CBA in this study lies in its ability to provide a rational basis for explaining why certain stakeholders adopt or resist the use of concrete flat roofs. Homeowners may focus on immediate affordability, while contractors and consultants consider long-term performance and compliance. Policymakers, in turn, can use CBA insights to design incentives and regulatory frameworks that promote sustainable roofing choices.

Thus, CBA theory provides both a decision-making tool and a conceptual framework for analysing the cost implications, perceived value, and broader socio-economic benefits associated with the adoption of concrete flat roofs in Kakamega Municipality.

➢ *Conceptual Framework*

The conceptual framework for this study provides a visual and narrative representation of the key variables influencing the use of concrete flat roofs in Kakamega Municipality. It demonstrates the interaction between economic, and technical factors and how these shape decisions and practices in roofing design.

Independent Variables included Cost of concrete flat roofs for homeowner and benefits and challenges associated with the use of concrete flat roofs. Costs directly affects homeowners ability to afford the construction of concrete flat roofs. Low construction and maintenance costs often correlate with more willingness and capacity to invest in durable and innovative construction technologies.

Intervening Variables; Improvement on the use of concrete flat roofs; Awareness of the long-term benefits of concrete flat roofs (for example, durability, space utilisation, energy efficiency) can influence acceptance. Access to Financing; Availability of affordable credit or government subsidies can ease the initial financial burden, particularly for low-income groups. Training Programs; Initiatives aimed at enhancing technical expertise among contractors can positively mediate the effects of limited skills.

Dependent Variable; Uptake and Effective Use of Concrete Flat Roofs; This refers to the extent to which concrete flat roofs are adopted in Kakamega Municipality and whether they are constructed and maintained to meet technical and sustainability standards.

➢ *Research Gaps*

Despite increasing interest in sustainable building designs, the adoption of concrete flat roofs in regions like Kakamega Municipality remains underexplored in current literature. Most existing studies and policy discussions concentrate on urban centers like Nairobi, with little attention given to smaller, fast-growing municipalities (Alvarado & Moreno, 2020). As a result, the unique economic realities, climatic conditions and technical capacities within areas like Kakamega are not well represented in academic or professional discourse. For example, while the Government of Kenya (GOK, 2022) and the National Construction Authority (NCA, 2021) provide technical standards and construction guidelines, little has been documented on how effectively these are followed in smaller towns. Furthermore, the influence of factors like cost, access to materials and public awareness on the choice of roofing systems remains largely undocumented at the county level.

Additionally, many previous studies focus heavily on technical design without considering the lived experiences of local contractors, homeowners and developers (Mohammed et al., 2018; Nyakundi & Gicheru, 2017). This creates a disconnect between policy and practice, especially in regions with limited access to training and professional expertise. The lack of localised data also hinders efforts to promote cost-effective and sustainable roofing choices tailored to local conditions. Moreover, there is minimal research on how knowledge gaps, public perception and available training influence the adoption of flat roofs. By zeroing in on Kakamega Municipality, this study sought to close these knowledge gaps and offer grounded, practical recommendations. Ultimately, it aimed to connect policy with on-the-ground realities and support more inclusive decision-making in Kenya's built environment.

III. RESEARCH METHODOLOGY

➢ *Research Design*

The research design for the study was non-experimental. It was a descriptive survey that adopted a mixed method approach where both quantitative and qualitative techniques were used for data collection and analysis.

Kakamega Municipality is located in Kakamega County, Western Kenya, approximately 380 km northwest of Nairobi. The municipality lies within latitude 0°17′N and longitude 34°45′E and sits at an average altitude of about 1,535 metres above sea level (Kakamega County Government, 2022).

As a result of urbanization in Kakamega county, many people prefer to live within Kakamega Municipality where land for development of residential buildings is scarce. In recent years, concrete flat roofs have started appearing in multi-storey commercial buildings and high-end residential developments due to their significant advantages such as space efficiency for solar installation and recreational activities among others. The uptake remains limited due to perceptions about water leakage, higher construction and maintenance costs, and the availability of skilled labor (Wafula, 2020; NCA, 2022).

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➢ *Population of the Study*

Population of the study included homeowners with concrete flat roofs on their residential buildings, contractors, consultants and government officials.

➢ *Sampling*

- *Sample Size*

Yamane formula;

$$n = \frac{N}{(1 + N(e)^2)}$$

= 182/ [1 + 182(0.10)²]

= 182/ (1+1.82) = 65

Yamane, (Y, Adzani et al., 2021)

By taking N =population size, n =sample size and e =error, a sample size of 65 homeowners was obtained from a population of 182 homeowners with concrete flat roofs on their residential buildings.

➢ *Sampling Techniques*

Both probability and non-probability sampling techniques were used. Stratified random sampling technique allowed the total population to be divided into smaller non-overlapping groups and homeowners picked randomly from each group. Purposive sampling technique was used by contractors, consultants and government officials. By using non-probability research method, participants were picked intentionally basing on their specific traits, expertise, or goals rather than random chance.

➢ *Sampling Method*

A sampling frame for the study was formed as follows; Yamane formulae was applied on a population size of 182 homeowner with concrete flat roofs on their residential buildings to obtain a sample size of 65. This sample for the study was achieved using stratified random sampling technique.

Table 1 Concrete Flat Roof Sampling Frame

POPULATION UNIT	POPULATION SIZE	SAMPLE SIZE	SAMPLING TECHNIQUE
Homeowners	182	65	Stratified random

Source; Author, 2026.

➢ *Data Collection*

Data was collected in four different ways

➢ *Table survey*

Various literature review that had information on research topic were studied. At this point, the research revealed the information that was under the study. It formed the basis for formulation and orientation of research objectives and research questions.

➢ *Survey*

Questionnaires were distributed to homeowners with concrete flat roofs on their residential buildings for data collection as guided by research objectives and research questions.

➢ *Key Informant Interview*

Interview guides were used to capture data from contractors, consultants and government officials as guided by the research objectives and research questions.

➢ *Data Analysis*

The quantitative and qualitative data collected was coded for convenience in use.

➢ *Quantitative Data Analysis*

Both descriptive and inferential statistics were used in data analysis. Descriptive statistics was used to summarise and describe the characteristics of collected data without making inference beyond the dataset itself. They provided a quick overview of the data allowing researcher to identify patterns, detect errors, and understand trends before conducting more advanced anlysis. It focused on the observed data only. Frequency distribution presented tables, percentages, bar graphs and pie charts. Inferential statistics involved hypothesis testing. Both Null (Ho) and Alternative (Ha) hypotheses were formulated, sample data collected and tested using statistical tests to determine whether there was enough evidence to reject the Null hypothesis in favor of the Alternative hypothesis. These techniques were applied on construction and maintenance costs of concrete flat roofs.

➢ *Qualitative Data Analysis*

Qualitative data from contractors, consultants and government officials was first coded into categories reflecting major themes like; self-introduction, construction cost implications, construction cost relationship and maintenance cost of concrete flat roofs, and role played by government in support of concrete flat roofs. Direct quotes from respondents were selectively used to illustrate key points and provide context to the numerical data. This was transcribed and subjected to thematic analysis in order to get to the insights.

➢ *Validity and Reliability*

Prior to fieldwork, google forms were used to collect data from a small group of respondents who shared similar characteristics with the target population within Kakamega Municipality, Kenya. Feedback on clarity, wording, and comprehensiveness was used to refine the instruments thus ensuring validity and reliability.

➢ *Ethical Considerations*

This study was deeply committed to upholding high ethical standards to protect the rights, dignity and safety of all participants while ensuring the accuracy and credibility of the research. Ethical research practices were central to every stage of the study from data collection to reporting of results. In the context of exploring the use of concrete flat roofs in

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Kakamega Municipality, the following ethical principles guided the research process:

➢ *Informed Consent*

Participants were fully informed about the nature and purpose of the research before they agree to take part. This involved clearly explaining the study's objectives, how data was collected, any potential risks and the expected benefits. Each participant was given ample opportunity to ask questions and only proceeded once they voluntarily signed a written consent form. No one was coerced, misled, or forced to participate, ensuring their autonomy and comfort throughout the process.

➢ *Privacy and Confidentiality*

To protect the identity and personal information of participants, all data was handled with the highest level of confidentiality. Names and identifying details were removed or coded using anonymisation techniques. Sensitive information was only accessed by the researcher and stored securely using password-protected and encrypted files. In all presentations and reports, data was presented in aggregate form to prevent tracing any information back to individual respondents.

➢ *Voluntary Participation*

Participation in this study was entirely voluntary. Respondents including homeowners, contractors, consultants and government officials were reminded that they can withdraw at any point, without facing any form of penalty or discrimination. The study prioritised an environment where participants feel respected, safe and free to express their honest views without fear of repercussion.

➢ *Data Fabrication and Falsification*

This research strictly opposed any form of data manipulation. All findings were based on authentic data collected from the field and analysis followed an honest and rigorous process. The study did not tolerate the invention of data or the alteration of outcomes to match preconceived conclusions. Upholding the credibility and integrity of the research is of utmost importance.

➢ *Plagiarism*

All secondary sources used to support this research including books, articles and government publications were correctly cited using appropriate academic referencing styles (for example, APA 7th edition). Proper attribution was given to original authors to acknowledge their intellectual contributions and avoid plagiarism. This not only respects the work of others but also enhances the academic integrity of the study.

IV. FINDINGS

A total of 65 questionnaires for homeowners with concrete flat roofs on residential buildings were distributed but only 64 were collected when fully completed, yielding a high response rate of 98.5%. This high return rate signified a strong respondent engagement and provided reliable foundation for drawing meaningful conclusions. Majority of the respondents were male gender as compared to their female gender counterparts in the four locations of Kakamega Municipality, Kenya.

➢ *Construction Cost of Concrete Flat Roof*

Construction cost was shared among homeowners in the four locations as follows; Much lower; Northern =7, Western =0, Southern =15 and Eastern =0. Much higher; Northern = 9, Western =7, Southern =14 and Eastern = 12. Much lower construction opinion was 34.34% and much higher was 65.62%.

➢ *A Pie Chart Showing Construction Cost of Concrete Flat Roof Feedback in Four Locations of Kakamega Municipality, Kenya.*

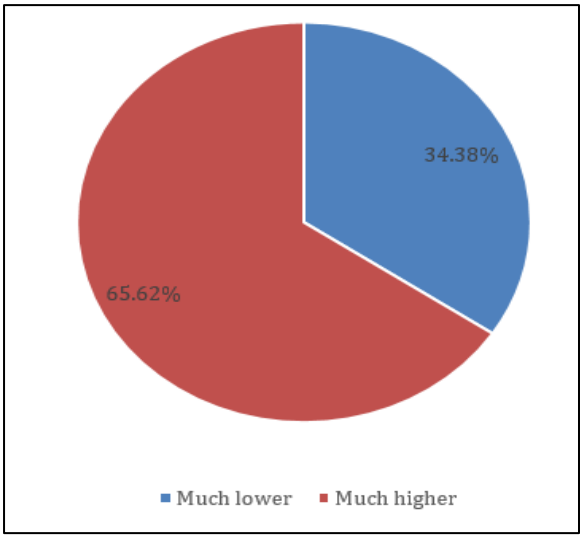

Fig 1 Construction Cost of Concrete Flat Roof (Buildings Approved 2015 -2025).
Source; Author, 2026.

➢ *Influence of Construction Cost on the Use of Concrete Flat Roofs Construction Cost of Concrete Flat Roof*

From the collected data, the researcher carried out a test to know whether cost had a significant influence on the use of concrete flat roofs in Kakamega Municipality, Kenya. A response rate of 64 achieved was analysed using chi-square statistics at a confidence level of 90% through the following Steps:

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- *Step 1: The Data Was Arranged in a Contingency Table as Shown Below*

Table 2 Contingency Table for Comparing Two Variables of Cost Opinion.

CONSTRUCTION COST	LOCATION			
	Norther	Western	Southern	Eastern
Much higher.	9	7	14	12
Much lower.	7	0	15	0

Source; Author, 2026.

- *Step 2: The Expected Values were Obtained from the Observed Values as Shown in Table 2; Using the Following Procedure;*

✓ Record all the observed values in rows and columns as shown in table 4.10.
✓ Add values in columns and obtain column totals.
✓ Add values in rows and obtain row totals
✓ Record all cells (ij) in every row and column thus, i=row and j=column.
✓ Compute the expected values and record them in brackets below the observed values using;

$$E_{ij} = \frac{r_i \times c_j}{T.}$$

Where:

- Eij = Expected Value for cell ij
- ri = Totals of observation rows for cell [ij]
- cj = Totals of observation column [ij]
- T.= Grand total of all observations.

✓ Row 1.

- Cell [1,1]

$$E = \frac{42}{64} \times 16$$

= 10.5 (to 1dp).

- Cell [1,2]

$$E = \frac{42}{64} \times 7$$

= 4.6 (to 1dp)

- Cell [1,3]

$$E = \frac{42}{64} \times 29$$

=19.0 (to l d p)

- Cell [1,4]

$$E = \frac{42}{64} \times 12$$

= 7.9 (to l d p)

✓ Row 2.

- Cell [2,1]

$$E = \frac{22}{64} \times 16$$

= 5.5 (to 1dp).

- Cell [2,2]

$$E = \frac{22}{64} \times 7$$

= 2.4 (to 1dp)

- Cell [2,3]

$$E = \frac{22}{64} \times 29$$

= 10.0 (to l d p)

- Cell [2,4]

$$E = \frac{22}{64} \times 12$$

= 4.1 (to l d p)

✓ Row 1; Σ expected value = Σ observed Value

(10.5+ 4.6+19+7.9) = (9+7+14+12)

42 = 42 hence okay.

Row 2; Σ expected value = Σ observed Value

(5.5+ 2.4+ 10+4.1) = (7+0+15+0)

22 = 22 hence okay

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Table 3 Chi-Square Calculations Showing Observed and Expected Values of Construction Cost

COST	LOCATION				
	Northern	Western	Southern	Eastern	TOTAL
High construction cost	9 [1,1] (10.5)	7 [1,2] (4.6)	14 [1,3] (19.0)	12 [1,4] (7.9)	42
Low construction cost	7 [2,1] (5.5)	0 [2,2] (2.4)	15 [2,3] (10.0)	0 [2,4] (4.1)	22
TOTAL	16	7	29	12	64

Source; (Author, 2026).

- *Step 3: The Null and Alternative Hypothesis were Framed as Follows;*

✓ [H_0/ Construction cost of concrete flat roof is much lower than that of a pitched iron sheets roof in Kakamega municipality, Kenya].
✓ [H_a/ Construction cost of concrete flat roof is much higher than that of a pitched iron sheets roof in Kakamega municipality, Kenya.

- *Step 4: The Field Date was Manipulated Giving the Chi-Squared Value Results Abbreviated as X^2 cal as Shown in Table 4 Below.*

Table 4 Computation of Chi-square statistics steps for construction cost influence on the use of Concrete flat roofs in Kakamega Municipality, Kenya

CELL NUMBER	Oi	Ei	Oi -Ei	$[Oi-Ei]^2$	$\frac{[Oi-Ei]2}{Ei}$
1,1	9	10.5	-1.5	2.25	0.21
1,2	7	4.6	2.4	5.76	1.25
1,3	14	19	-5	25	1.32
1,4	12	7.9	4.1	16.81	2.13
2,1	7	5.5	1.5	2.25	0.41
2,2	0	2.4	-2.4	5.76	2.40
2,3	15	10	5	25	2.50
2,4	0	4.1	-4.1	16.81	4.1
TOTALS	64	64.0	0.0		14.32

Source; Author, 2026.

- *Step 5: From Chi-Square Tables, the Researcher Obtained a Critical Value Beyond Which, the Null Hypothesis was Rejected as Follows-*

$x^2_{s=[a,(r-1)(c-1)]}$

Where a=1-95%

=1-0.95

=0·05

r-1=2-1 =1

c-1=4-1 =3

$x^2_{s=[0.05,(1)(3)]}$

= [0.05,3]

=7.815

- *Step 6: Decision Making*

Chi-square obtained from observed and expected values (14.32) was greater than that obtained from chi-square tables (7.815). The null hypothesis was rejected.

Cost was found to be a major determinant in roofing choices. These findings are consistent with Wanjiku and Otieno (2021), who reported a similar trend in other Kenyan municipalities, where cost considerations heavily influence the choice of roofing systems.

➢ *Maintenance Cost of Concrete Flat Roof;*

The maintenance cost for the sample in the four locations was as follows; Much lower; Northern =5, Western =2, Southern =13 and Eastern =0 while for Much higher; Northern =11, Western =5, Southern =16 and Eastern =12. Much lower maintenance cost was 31.25% and much higher was 68.75%.

➢ *A Pie Chart Showing Maintenance Cost of Concrete Flat Roof Feedback in Kakamega Municipality, Kenya.*

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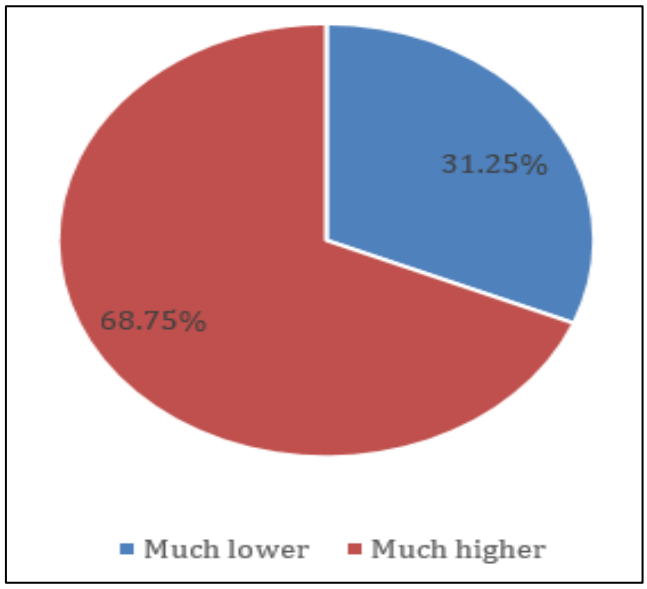

Fig 2 Maintenance Cost of Concrete Flat Roof (Buildings Approved 2015 -2025).
Source; Author, 2026.

V. ANALYSIS OF INTERVIEW INSIGHT

This section discusses findings from both quantitative and qualitative data, integrating them with existing literature and key informant insights. The discussion is structured according to thematic areas that emerged from interviews and aligns with the study's objectives.

➢ *Common Roofing Styles and Their Popularity*

The majority of informants noted that pitched iron-sheet roofs remain dominant, especially in single-family homes. This trend is influenced by; rain water harvesting, affordability, accessibility of materials, and cultural familiarity. However, flat roofs are gaining ground in urban zones and multi-family buildings, where land scarcity and vertical expansion require space-maximizing solutions. This is consistent with Wekesa & Obonyo (2021), who observed that urban areas in Western Kenya increasingly adopt flat roofs for apartment blocks and commercial centers. *"In estates like Busoga and Maraba, we're seeing flats go up with flat concrete roofs, it's mostly a space issue."— Real Estate Developer*

➢ *Financial Considerations and Constraints*

High initial construction cost emerged as a key barrier. Interviewees pointed out that while concrete flat roofs have long-term benefits, their upfront expense deters average homeowners. Most informants stated that concrete flat roofs have significantly higher initial costs compared to alternatives like iron-sheet pitched roofs. This cost includes, reinforcement steel, formwork, concrete mix and waterproofing materials.

➢ *Material and Technological Limitations*

Respondents highlighted the need for modern waterproofing materials, better insulation, and precast technologies. However, these innovations are either costly or unavailable locally, making them impractical for mass adoption.

➢ *Regulatory Support for Urban Expansion*

County building regulations are said to be increasingly supportive of multi-storey developments, indirectly favoring concrete flat roofs. Urban zoning requirements often require engineered slab roofing for building approval, especially in town centers. However, no policy specifically promotes flat roofing systems. Most regulations focus on compliance and structural safety, not roof type preference.

➢ *Capacity-Building and Training Needs*

Participants strongly recommended practical workshops for masons, enhanced TVET curriculum content on flat roofing or demo projects to showcase proper execution. These recommendations reflect the training gaps highlighted by the National Construction Authority (2022), which found only 35% of Western Kenya's building contractors certified in concrete roofing systems.

VI. SUMMARY

➢ *Summary of Key Findings*

- *Objective1: To Analyse the Influence of Cost on the Uptake of Concrete Flat Roofs in Kakamega Municipality, Kenya.*

The study established that cost significantly influence the adoption of concrete flat roofs. This was achieved through analysis contacted on concrete flat roofs in the four locations of Kakamega Municipality, Kenya. From the likert scale used, homeowners who chose much lower were 22 thus; Northern =7, Western =0, Southern =15 and Eastern =0 while those who chose much higher were 42 thus; Northern = 9, Western = 7, Southern =14 and Eastern =12. From the sample above, both the Null and Alternative hypothesis were tested. It was discovered that CHI-SQUARE calculated (14.32) was much higher than the one obtained from CHI-SQURE tables (7.815). The NULL hypothesis was rejected ALTERNATIVE hypothesis accepted.

Maintenance cost also had an influence on the use of concrete flat roofs in Kakamega Municipality. Homeowners who commended on the maintenance cost being much lower were =20 thus; Northern =5, Western =2, Southern =13 and Eastern =0 while those who selected much higher were =44 thus; Northern = 11, Western =5, Southern = 16 and Eastern =12. Many people commended on maintenance costs being much higher as opposed to smaller number who chose on it being much lower.

VII. CONCLUSION

This study investigated the key factors influencing the use of concrete flat roofs in Kakamega Municipality, Kenya. Construction cost was found to be a major determinant in roofing choices. These findings are consistent with Wanjiku and Otieno (2021), who reported a similar trend in other Kenyan municipalities, where cost considerations heavily influence the choice of roofing systems.

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In summary, while the use of concrete flat roofs is technically feasible and supported by skilled labor in Kakamega Municipality, cost constraints and inadequate public awareness remain the primary barriers to wider adoption.

➢ *Contribution to Knowledge*

This study makes several important contributions to the academic and practical understanding of use of concrete flat roofs in Kakamega Municipality, Kenya:

The study empirically demonstrates how cost significantly influence the adoption of concrete flat roofs in urbanising municipalities. It also provides new insights on how gaps in training, workmanship, and adherence to standards directly affect the longevity and acceptance of modern roofing technologies.

The study positions concrete flat roofs within the broader framework of sustainable urban development by linking them to space optimization and renewable energy installations. This expands the academic conversation by situating flat roofs not only as architectural choices but as tools for achieving Sustainable Development Goals (SDGs) in rapidly urbanising towns.

At a local level, the study provides the first documented evidence on the factors influencing flat roof adoption in Kakamega Municipality. This knowledge is directly relevant to local authorities, practitioners, and homeowners, and also offers comparative insights for other mid-sized urban centers in Kenya.

RECOMMENDATIONS

Based on the study findings, the following recommendations are proposed for various stakeholders to promote the safe, affordable and sustainable adoption of concrete flat roofs in Kakamega Municipality:

➢ *Homeowners*

Adopt bulk procurement strategies to reduce the cost of roofing materials for concrete slab systems. However, some challenges like rain water down pipe blockages affected most of flat roofs causing damages to internal finishes. Most of the homeowners fail to make regular inspections on their flat roofs enabling leaves and other debris to block water drainage. These challenges align with Mohammed et al. (2018), who highlighted similar issues in flat roofing systems within tropical regions.

➢ *Contractors*

- Embrace precast slab technologies and modular construction systems to reduce construction time and costs.
- Implement roof utilization plans including rooftop gardens, water tanks, or solar panels, to increase the value and usability of flat roofs.

➢ *Consultants and Policy Makers*

- Develop targeted subsidies or tax relief on construction materials specifically for reinforced concrete roofing systems.
- Incorporate flat roof technologies in urban housing policies, especially in high-density areas.
- Simplify and decentralize building approval processes for concrete flat roof projects to encourage uptake at the community level.
- Ensure that the due building plans approval process is followed through proper documentations. Indemnity forms must be signed by all the project stakeholders and the drawings to be well certified before circulation for approval.

➢ *Recommendations for Future Studies*

To expand the scope and depth of this research, the following areas are recommended for future investigation:

- Comparative Study of Roofing Systems. Future research could compare concrete flat roofs with other roofing systems (e.g., pitched iron-sheet roofs) in terms of cost, performance, and user satisfaction across various income groups.
- Climate Impact and Roof Performance. A study assessing the long-term performance of concrete flat roofs under tropical weather conditions, particularly rainfall patterns in Western Kenya, would offer insights into durability and maintenance needs.
- Policy Impact Assessment. Evaluate the effectiveness of current housing policies and subsidies, if any, in promoting modern and sustainable roofing technologies in rural and urban settings.
- Gender and Housing Decisions. Investigate the role of gender dynamics in housing construction decisions, including roofing preferences, to understand whether income disparities and household priorities differ between men and women.
- Energy Efficiency and Flat Roofs. Explore how concrete flat roofs can be leveraged for green building practices, including installation of solar panels, rooftop gardens, and rainwater harvesting systems.

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