

## Characterisation of Uses and Choice of Building Materials in Greater Lomé (Togo): Sustainability Issues.

GOUTSOP Leopold Carios<sup>1</sup>, MAGNE Marie Rosette<sup>2</sup>, AGBALIN Florentin<sup>3</sup>,  
BOUDOU Mintre<sup>4</sup>, SOKEMAWU Koudzo<sup>5</sup>

### Abstract

The built environment of Greater Lomé has undergone rapid expansion for decades, resulting in a sharp increase in the consumption of a wide range of construction materials. However, the types of construction materials used have a considerable influence on the sustainability of the city. The study aims to characterise the use of building materials in Greater Lomé from a sustainability perspective. This involves distributing the rates of material use by trade in construction and analysing the factors that lead to the choice of these materials in Greater Lomé. Data on the distribution of materials was collected from a total of 714 structures, and data on usage factors was collected from 20 stakeholders in the construction sector, particularly professionals and materials suppliers. It appears that the majority of materials used in structural work and finishing work are not sustainable. This predominance is linked to a number of factors, including technical requirements, material availability and the low consideration given to environmental factors when choosing materials. By highlighting the use of materials in Greater Lomé, the study highlights the need to implement policies promoting the use of local and sustainable materials.

**Keywords:** *Building materials, Sustainable construction, Built environment, Greater Lomé, Sustainability.*

### Introduction

Building materials play a structuring role in urban dynamics and, in particular, in the production of the built environment of cities. This urban built environment encompasses all the buildings and networks constructed to accommodate various human activities [1]. It includes buildings, plots of land, roads, and organised structures [2], as well as networks (transport, energy, sewage, etc.) and various amenities [1]. It is the result of a slow and gradual accumulation of buildings in urban areas [1],[3]. The production of this built environment requires a diverse influx of construction materials of various types and from multiple sources, which may be local or imported. These flows, volumes and types of materials mobilised therefore have an impact on urban dynamics. Their use in the construction of the built environment contributes to economic and socio-cultural development.

Globally, construction materials represent the main solid flow in urban metabolism [4]. It is defined by Sabine Barles (2017) as: “*the totality of energy and material flows involved in the functioning of a given territory*” [5]. The concept assimilates the territory to a living organism whose dynamics are based on the exchange of matter and energy flows. [6], [7]. For example, a study conducted in 2017 in the Paris metropolitan area shows that construction accounts for 40% of materials consumed and 75% of waste volume in metropolitan areas [8]. Since 2017, global consumption of materials has reached 100 billion tonnes per year, half of which consists of sand, gravel, cement and clay, the main construction materials used worldwide [9].

---

<sup>1</sup>Regional Centre of Excellence on Sustainable Cities in Africa (CERVIDA-DOUNEDON), University of Lomé, Lomé 01 BP 1515, Togo; [lgoutsoparchitecte@gmail.com](mailto:lgoutsoparchitecte@gmail.com) (corresponding author).

<sup>2</sup> Regional Centre of Excellence on Sustainable Cities in Africa (CERVIDA-DOUNEDON), University of Lomé, Lomé 01 BP 1515, Togo; [rosette1magne@gmail.com](mailto:rosette1magne@gmail.com).

<sup>3</sup> African School of Architecture and Urban Planning (EAMAU), 422, rue des Balises, Tokoin Doumasséssé (Lomé-Adewi)

<sup>4</sup> LARDYMES Laboratory: Research laboratory on the dynamics of environments and societies, University of Lomé, Lomé 01 BP 1515, [mintreboudou10@gmail.com](mailto:mintreboudou10@gmail.com)

<sup>5</sup> LARDYMES Laboratory: Research laboratory on the dynamics of environments and societies, University of Lomé, Lomé 01 BP 1515, [yves.soke@yahoo.fr](mailto:yves.soke@yahoo.fr)

Several factors explain the growth in consumption of construction materials, including the dynamism of the construction industry and the increase of cities size. Overall, cities continue to grow in size in line with the increase in the global urban population. In 1950, the urbanisation rate was estimated at 41.86% worldwide. It rose to 57% in 2022 and is estimated to reach 68% in 2050 [5]. These figures reflect the fact that demand for materials for urban construction will continue to grow in the coming decades. While cities around the world have undergone rapid urbanisation in recent decades, this trend has been even more pronounced in African cities.

In 1950, the global urbanisation rate was around 41.86%, while in Africa it stood at 14.3%, reflecting a clear discrepancy between urban dynamics on the continent and those observed globally. Decades later, in 2022, the global average was 57%, while in Africa it was 44.2%. According to projections, this proportion will reach 68% globally, compared to 60% in Africa in 2050 [10],[11]. In Togo in particular, INSEED (the National Institute of Economic and Demographic Statistics) indicates that 43% of the Togolese population in 2022 will live in urban areas and projects that by 2028, 50% of the population will live in urban areas [12]. According to the United Nations report on the state of urbanisation, this proportion will rise to 58% in 2050 [13]. African cities are therefore in line with this global growth dynamic, with a more marked acceleration.

The Greater Lomé area, the country's main urban centre, for example, has an annual growth rate of 2.7% [12]. This demographic expansion is accompanied by fairly significant horizontal spatial sprawl. In 1890, the city of Lomé had nearly 3,000 inhabitants and covered an area of 160 hectares [14]. Since 2022, it has covered an area of approximately 42,560 hectares and has a population of 2,168,376 inhabitants [12]. This spatial expansion is justified not only by urban population growth but also by socio-cultural factors. As Guézéré (2011) pointed out, the "*obsession in Lomé with living in one's own home*" contributes to favouring a model of expansion based on individual home ownership rather than vertical densification [15]. This sprawl of the built environment is therefore accompanied by strong pressure on natural resources and increased dependence on imported materials (steel and manufactured goods) due to the weakness of the local industrial fabric. The types of materials used have a major impact on sustainability because materials have different carbon footprints. They can cause an increase in heat by creating urban heat islands [1],[16].

A quick review of the scientific literature shows that the field of building materials is a fairly important area of study, with several studies focusing on economic [17], environmental [18], [19], [20]; social, cultural and technical aspects. This consideration of materials is also central to research related to sustainable construction [16], [19], [20], [21], [22],[18]. Sustainable construction is based on the formalisation of sustainable development, drawing on the same principles [19]. Sustainable construction relies on building materials (sustainable, local, recyclable), energy efficiency and the contribution to the comfort of users' lives [21]. Research trends for sustainable construction through materials increasingly favour earthen materials such as stabilised earth bricks, adobe or raw earth [22]. Recycled materials and alternative materials for reinforcing concrete, such as bamboo, are also gaining ground [23].

Two specific studies focusing on the use of building materials in the city of Lomé, the earliest of which was conducted in 1976 by the REXCOOP programme on the construction economy in Lomé, indicate that 88% of cement is used in the structural work of buildings in Lomé [24]. Subsequently, the study conducted by Tossim et al (2024) found that concrete was used in 78% of masonry and 85% of building structures [16]. This shows that concrete is the dominant material in the city in terms of usage rates. In addition, several materials are used in the construction of the built environment, such as traditional materials (earth, straw, wood, stone) and modern materials (cement, steel, aluminium, etc.), which are manufactured products. The latter, due to their use at local and international level, have an impact on the sustainability of the built environment.

The issues related to the use of materials are environmental (degradation of ecosystems due to quarrying, carbon emissions) [22], [23],[25],[26]; economic (high cost of imported materials, job creation); social (accessibility and inequalities in housing); and cultural (changes in construction practices that distort local identity). However, despite the importance of these issues, few studies have sought to systematically characterise the uses of construction materials in Greater Lomé. It should be noted that the importance of building materials led the Togolese government to establish the CCL (Centre de Construction et de Logement) in 1967. Its main mission was to improve housing in Togo by researching locally available materials. The aim was to assess the sustainability of these materials and the economic approaches related to their production and use [27], [28]. However, the CCL has since

focused mainly on materials such as compressed earth bricks and lime, neglecting a wide range of research and implementation of various materials necessary for construction.

Although the debate on sustainable construction in urban areas highlights the use of appropriate materials as a solution for sustainability[18] ; Few studies have sought to characterise in detail the use of materials in construction in Lomé and the underlying factors influencing the choice of these materials, which in turn determine sustainability. Existing studies, although insufficient, generally focus on technical or environmental aspects, without always linking these dimensions to an integrated analysis of urban sustainability. This scientific gap limits our understanding of the determinants of material choice and their long-term implications.

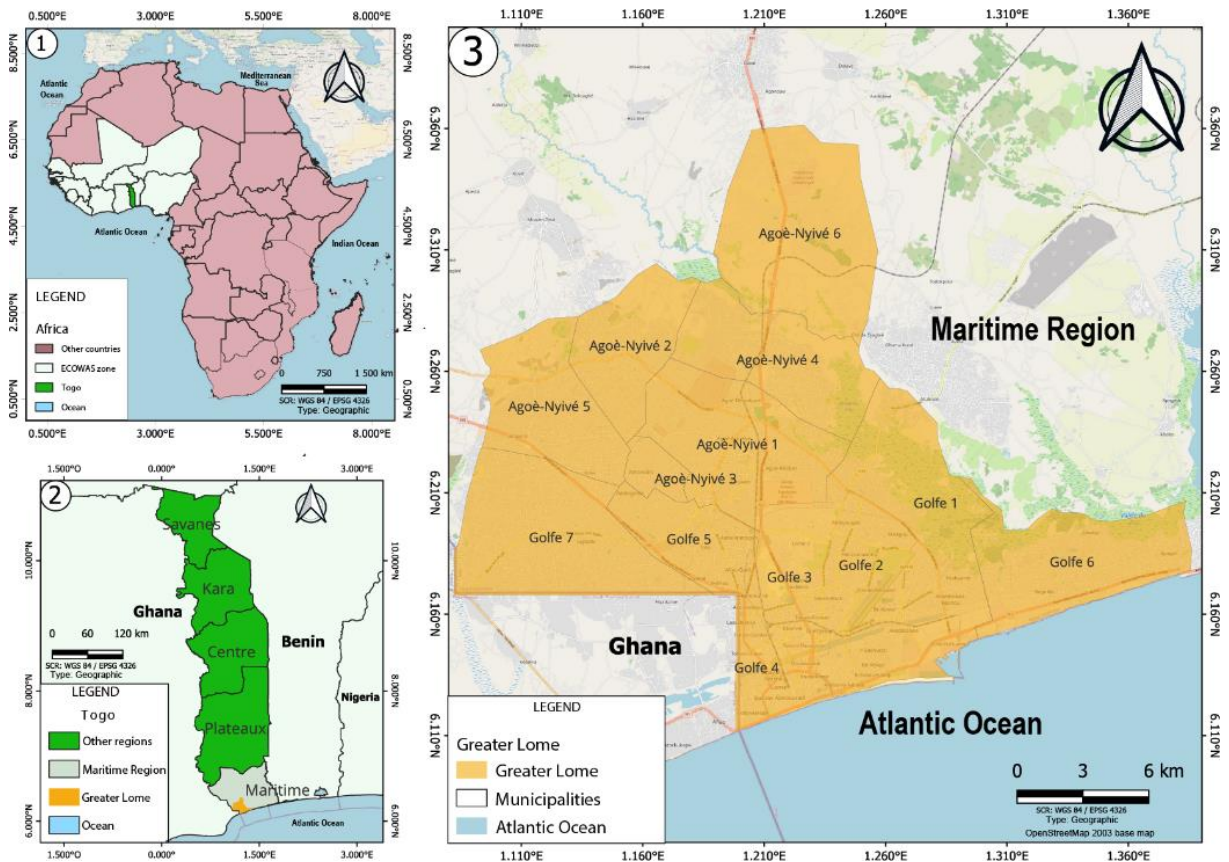
The aim of this article is therefore (i) to characterise the materials used in the built environment of Greater Lomé, (ii) to analyse the determinants of their use and (iii) to assess their implications in terms of sustainability, in order to shed scientific light on local construction practices and their prospects for development.

**Methodology**

**Overview of the study area**

The site chosen for the study is Greater Lomé, as it is Togo's main metropolitan and home to nearly a quarter of the Togolese population. It is also the main point of entry and exit for construction materials in Togo and is home to the main construction and building materials production companies. The site covers the entire city in order to ensure a homogeneous distribution of samples.

Greater Lomé consists of two prefectures (Golfe and Agoè-Nyivé) divided into 13 municipalities, including seven municipalities in Golfe and six municipalities in Agoe-Nyive[12]. The city was chosen during the German colonial period as the capital due to its strategic location near the coast[14], [15]. It still occupies a strategic position today for the transit of goods to the Sahel countries [13]. This map illustrates the spatial layout of the city and its administrative subdivisions.



**Figure 1.** Location map of the study area.

Since 2022, Greater Lomé has covered an area of approximately 425.6 km<sup>2</sup> [27], bordered by nearly 50 km of coastline to the south by the Atlantic Ocean, to the west by the Avé Prefecture and the

border with Ghana at Aflao-Gakli [32], to the east by the Lacs Prefecture, and to the north by the Zio Prefecture [27]. The city is currently only expanding to the north and east due to natural obstacles, namely the sea to the south and the border with Ghana to the west [33]. The table below summarises the spatial, temporal and demographic evolution of the city of Lomé from 1900 to 2022.

**Table 1.** Table summarising the spatial, temporal and demographic evolution of the city.

Period	1900[15]	1960[15]	2010[29]	2022[30]
Population (hbts)	3 000	85 000	1 571 508	2 168 376
Area (Ha)	160	1 400	35 000	42 560

### Data collection and analysis methodology

The study is based on an exploratory and explanatory methodology that aims to identify, classify and quantitatively distribute the rates of material use in construction. It then seeks to explain the data obtained through qualitative research with various stakeholders in the construction sector. The methodology focused on usage rates rather than quantities due to the lack of statistics on materials used and a database linked to the consumption of construction materials in Greater Lomé. There is no database linked to the consumption of materials in construction. The data from the National Institute of Statistics (INSEED) is aggregated and insufficient. The complexity and large number of buildings make it impossible to obtain accurate figures based on existing buildings. However, observing usage trends makes it possible to characterise usage, understand the dynamics of choice and characterise sustainability without numerical indicators. The table below summarises the data collection methods.

**Table 2.** Table summarising data collection methods.

Variable	Method	Data collect
Characterisation of buildings (usage rate by category)	Quantitative	Field surveys, documentary research.
Determinants of usage	Qualitative	Interviews and surveys with construction industry stakeholders, documentary research.

The population considered in the study for the characterisation of buildings in terms of materials is buildings in Greater Lomé. The buildings were chosen at random from the population of buildings to be surveyed. According to the RGPH-5 conducted in November 2022, the Greater Lomé region has 549,050 dwellings, the distribution of which is shown in the table below[12].

**Table 3.** table showing the distribution of building types in Lomé.

Region	Habitat	Infrastructure	Total
Great-Lomé	549 050	18 668	567 718
percentage	96,71	3,29	100

Housing is divided into three groups: modern housing, which accounts for 51.6%; semi-modern housing, which accounts for 37.3%; and traditional housing, which accounts for 11.1%. Infrastructure consists of buildings used for services and work[12]. Sampling was carried out using buildings as the study population. The number of buildings to be surveyed was estimated using Daniel Schwartz's formula, which is as follows:

$$n = z^2 \times p (1 - p) / m^2[31]; \quad (1)$$

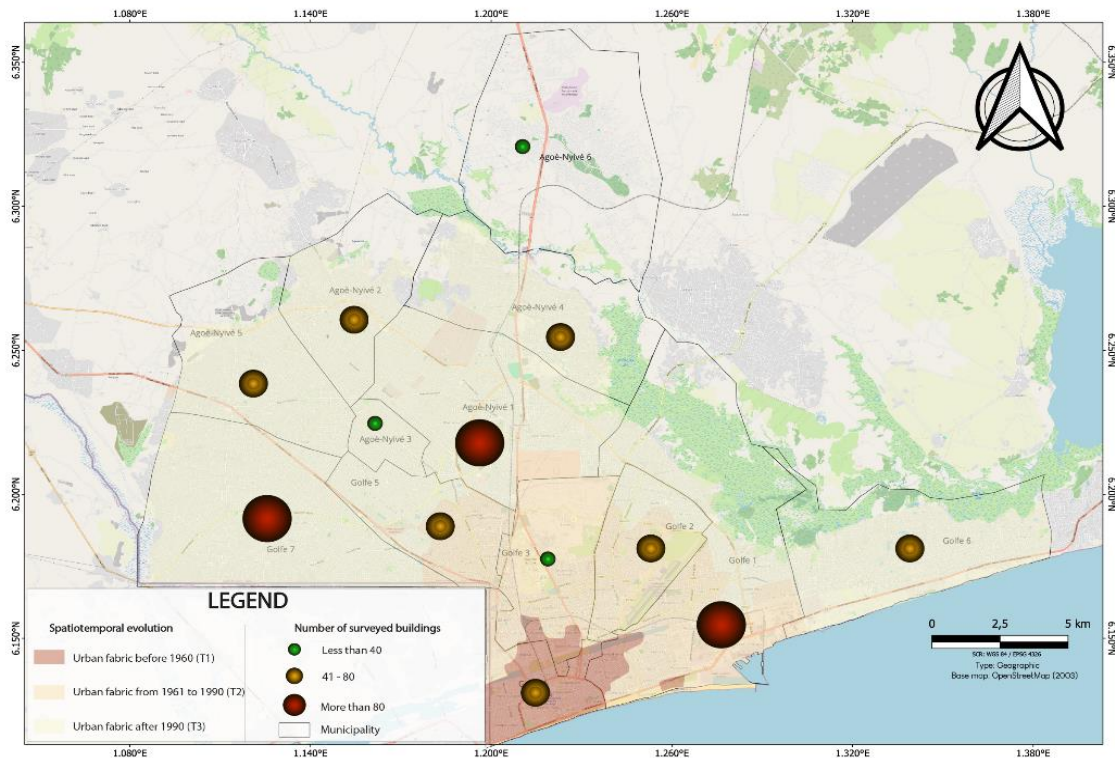
n represents the sample size; z represents the confidence level according to the centred normal distribution (the confidence level is 95%, z = 1.96); p is the estimated proportion of the population that presents the characteristic (each building is unique in terms of variations in material types, so in this case we chose 0.5); m = tolerated margin of error (the actual proportion is within 3.5%). In this case, the sample size is as follows:  $n = (1.96)^2 \times (0.35)(1-0.35) / (0.035)^2 = 714$  buildings.

The number of buildings was distributed by municipality according to the following formula:  $NBE = n * NEC / Pop$ . Where NBE is the number of buildings to be surveyed, n is the sample size, NEC is the estimated number of buildings, and Pop is the population. The table below summarises the distribution of buildings surveyed by municipality.

**Table 4.** Table showing the distribution of sample buildings by municipality.

Municipality	Area(Km2)	Population (2022)	Nb of estimate construction ( NEC)	NBE
Golfe1- Amoutiévé	60.15	351 550	91 201	114
Golfe2-Bè centre	17.82	136 153	35 321	45
Golfe 3-	22.86	52 769	13 690	17
Golfe 4 Amoutivé	13.57	155 842	40 429	51
Golfe5-Agoè-Nyivé	19.43	169 993	44 100	55
Golfe 6 Baguida	38.55	181 561	47 101	59
Golfe7- Vakpossito	48.97	257 813	66 883	84
Agoè-Nyivé 1	42.37	317 255	82 304	104
Agoè-Nyivé 2	25.43	128 164	33 249	42
Agoè-Nyivé 3	5.85	47 554	12 337	16
Agoè-Nyivé 4	34.36	154 431	40 063	50
Agoè-Nyivé 5	30.88	125 097	32 453	41
Agoè-Nyivé 6	54.40	110 194	28 587	36
<b>Total</b>	<b>411,37</b>	<b>2,188,376</b>	<b>567 718</b>	<b>714</b>

All field data was collected using KoboCollect software version 2023.2.4, and the collection areas are distributed across the following maps created using Arcmap software. The map below shows the areas surveyed and the number of buildings surveyed per municipality..



**Figure 2:** Map showing the distribution of survey areas.

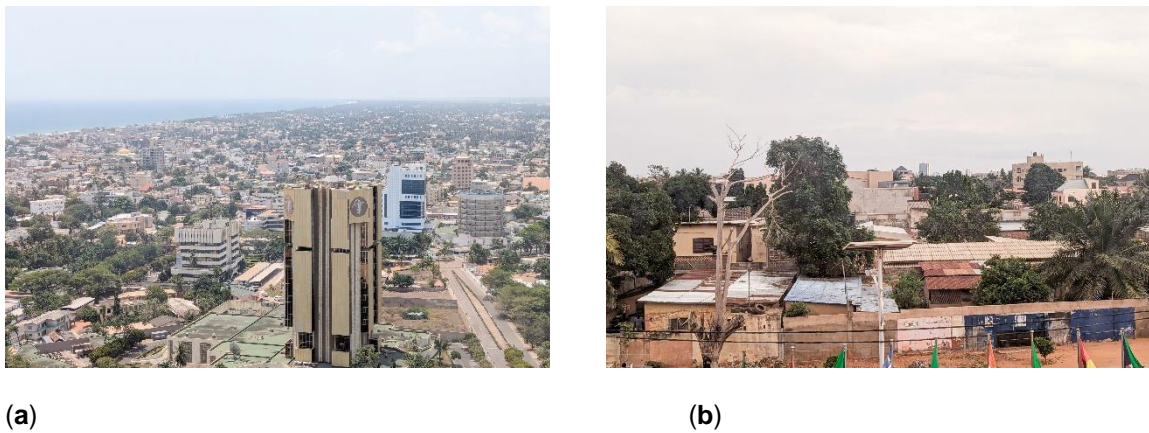
Data on usage factors was collected through semi-structured questionnaires administered to 10 building material retailers, 10 construction professionals, and 10 project owners in order to obtain a range of perspectives.

**Typology and components of the buildings surveyed**

According to interministerial decree No.115-MVUHSP-MIT-MATDCL-MSPC-MEDDPN of 2020 on the classification of buildings and facilities in Togo, there are four main types of structures: residential buildings, high-rise buildings, public access buildings and establishments receiving workers [36]. These classifications contain other sub-classes that depend on the use and size of the building.

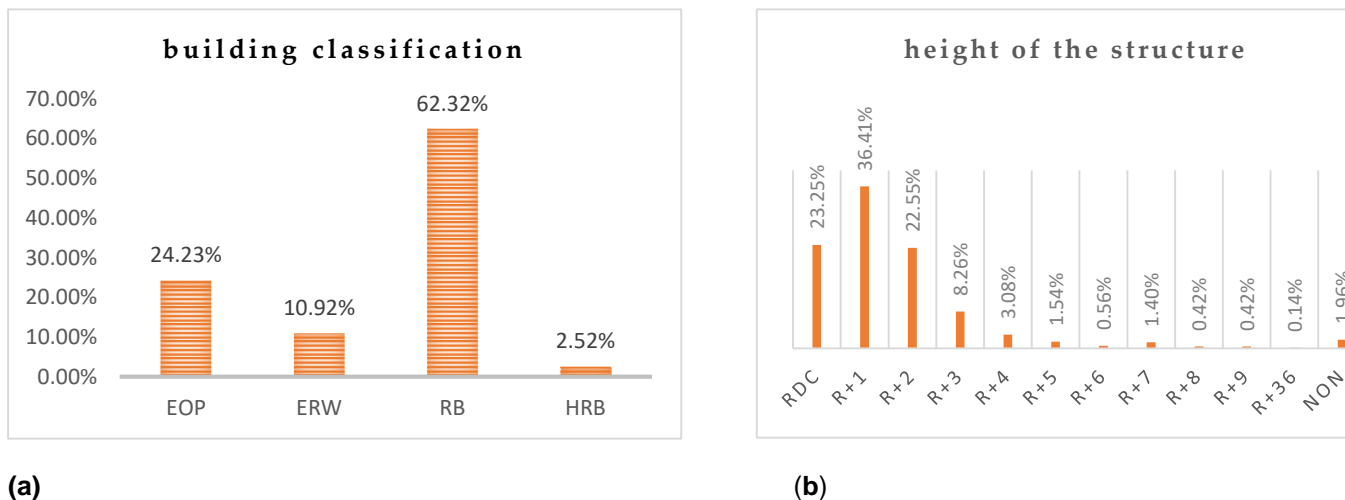
**- Survey typology**

The city of Lomé is relatively flat with few high-rise buildings; the average building height is around ground floor and first floor. The images below illustrate this with aerial views of Greater Lomé from the city centre and from the Adewi district in the Gulf 3 municipality.



**Figure 3.** Figure show Great-Lomé city: (a) image of Greater Lomé city centre.; (b) Image on the outskirts of the Gulf 3 district in Greater Lomé.

In the case of the study, among the 714 buildings surveyed, 62.32% were residential buildings(RB), 2.52% were high-rise buildings(HRB), 23.39% were public buildings(EOP) and 10.92% were industrial buildings(ERW). Based on this categorisation, a classification according to height gives 23.25% of buildings with one storey, 36.41% with two storeys, 22.55% with three storeys, and 8.26 with four storeys. The graphs below summarise the percentages of samples by type of building surveyed.



**Figure 4.** Figure show the building surveys repartition: (a) image of Greater Lomé city centre.; (b) Image on the outskirts of the Gulf 3 district in Greater Lomé.

These rates enable a sample to be obtained that aligns with the types of buildings in the city based on height.

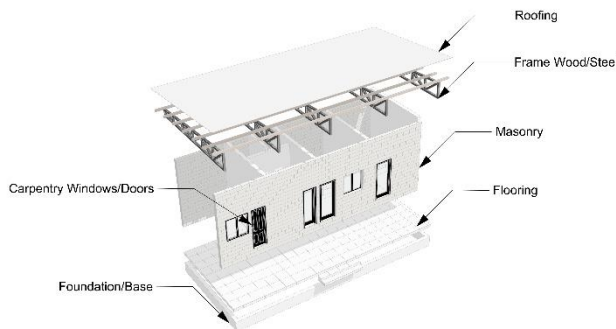
**Decomposition of structures**

With a few exceptions, buildings in urban areas have retained the same structure for centuries: foundations, masonry, doors and windows, roofs, supply and drainage systems[1]. However, there are less common components that can vary from one building to another, such as insulation and waterproofing. The structures studied can be broken down into several trades grouped into the following three components:

**Table 5.** Table showing the distribution of lots by building trade

Category	Structural work	Finishing work	Technical package
Function	Foundation, masonry, structure (posts, beams), paving and flooring, crossing structures (stairs and ramps), roofing (framework and covering).	Door and window frames, wall and floor coverings, ceilings, waterproofing, insulation.	Electrical systems (high and low voltage), plumbing, air conditioning, equipment (fire safety, crossing).

The figures below illustrate that sub-components in a single-storey building and a multi-storey building.



**Figure 5.** figures showing the trades in buildings. axonometric projection of a ground floor building;



**Figure 6.** axonometric projection of a multi-floor building.

**Data Processing and Analysis**

The data collected in the Koobocollect survey software was then extracted and analysed using Excel 2016 software. Thanks to Koobocollect, a precise map of the areas surveyed was extracted and processed using Illustrator software with an Open Street Map background. The data was analysed using descriptive statistical methods [37]. The data from the interviews was analysed using discourse analysis.

**Results**

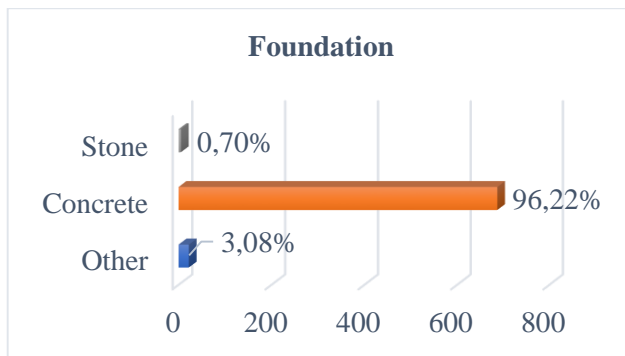
**Distribution of materials in buildings**

**Distribution in structural work**

Structural work refers to all work that ensures the solidity and stability of the building. It includes foundation work, masonry, structural work, paving and flooring, crossing structures (stairs and ramps), and roofing (framework and covering). The graph below illustrates the proportions of use across all 714 buildings surveyed in the 13 municipalities of Greater Lomé.

- **Foundation;**

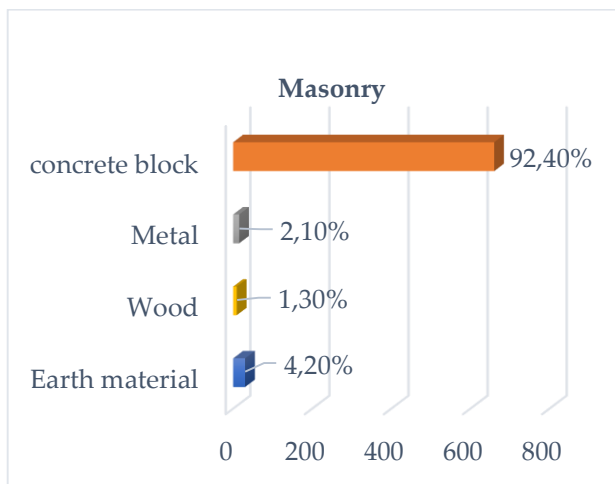
Of all the buildings surveyed, 96.22% have reinforced concrete foundations and 0.70% are made of stone. 3.08% for other type of foundation; these are generally temporary structures made of metal containers or wood. The figure 7 below summarises this data :



**Figure 7.** graph showing the distribution of materials at foundation level.

**Masonry or elevation ;**

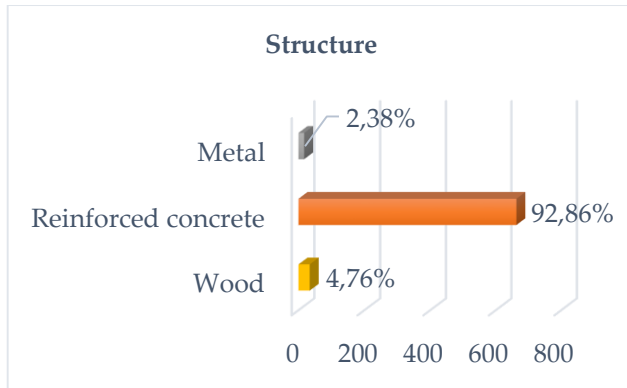
Masonry refers to all exterior and interior partition walls. The survey focused on external walls. The field data illustrated in the figure 8 below show that, in the case of masonry, 92.40% of buildings are constructed of cement blocks, 4.20% of earth bricks, 2.10% of metal cladding and 1.30% of wood. Metal cladding is used in buildings constructed from recycled materials that are over a hundred years old, or in industrial buildings. In the cases observed, earthen brick masonry includes compressed earth bricks stabilised with cement and terracotta bricks.



**Figure 8.** graph showing the distribution rate of materials in the masonry.

### Structure (columns and beams)

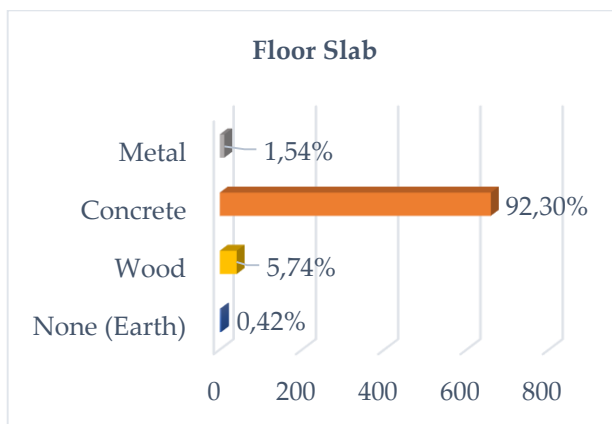
The structure represents all the columns and beams. The figure 9 below illustrates the distribution of material usage rates. The survey data indicates that 92.86% of the structure is concrete, 4.76% is metal and 2.38% is wood.



**Figure 9.** graph showing the distribution rate of materials within the structure.

### Floor Slab

Field data indicate that 92.30% of floors in Greater Lomé are made of reinforced concrete, 5.74% are made of wood, and 1.54% are made of metal. In 0.42% of cases, ground floors have no flooring and are made of earth. It should be noted that the floor level has an impact on the composition of floor materials. 92.30% combine reinforced and non-reinforced floors. Reinforced floors are found on upper floors, while non-reinforced floors are used on ground floors. Wooden slab floors are used on upper floors, as are floors with metal frames. These floors have been observed in industrial buildings and wooden floors in restaurants. The figure 10 below summarises the data :



**Figure 10.** graph showing the distribution of materials at the level of the flooring.

### Roofing

We observed two main types of roofs in the urban area of Lomé: sloping roofs and flat roofs. According to data collected in the field, sloping roofs covered with corrugated iron account for 42.72% of buildings, while concrete flat roofs account for 56.44% of buildings. Thatched roofs account for 0.84% of buildings. The figure 11 below illustrates these data:

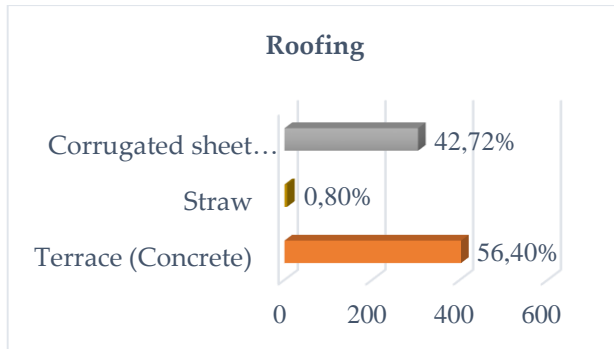


Figure 11. graph showing the distribution of materials on roofs.

**Distribution in Finishing work**

Finishing work refers to all work that does not affect the structural integrity of the building but makes it habitable and comfortable. It includes door and window frames, wall and floor coverings, insulation, false ceilings and waterproofing. These are generally referred to as protective materials. The study focused on these trades, excluding insulation and waterproofing.

**Carpentry**

Carpentry is the trade that encompasses windows, doors, railings and cupboards, if the latter are integrated into buildings. The study focused on doors and windows. It should be noted that a door consists of two parts: the frame and the leaves. This also applies to windows. This construction complicates the determination of material usage rates. Of the buildings surveyed, 47.76% have metal and glass joinery. Metal is used for the frame and glass for the sash. Next, 7% are glass-metal-wood, which are constructions that use several different types of doors and windows, 7.42% are metal and wood joinery, 3.22% are wood and glass, 15.13% are wood only, and 19.47% are metal. Nevertheless, there is a strong combination of three main materials used in construction. These are glass, wood and metal (aluminium and iron). Glass is used more for windows and wood for doors. The figure 12 below shows the results from the field.

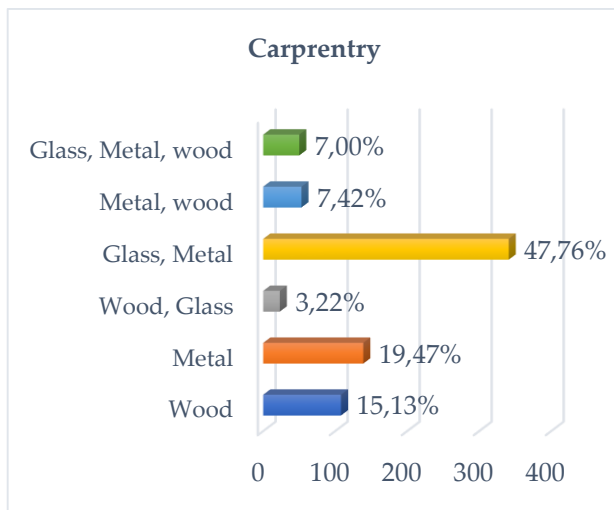
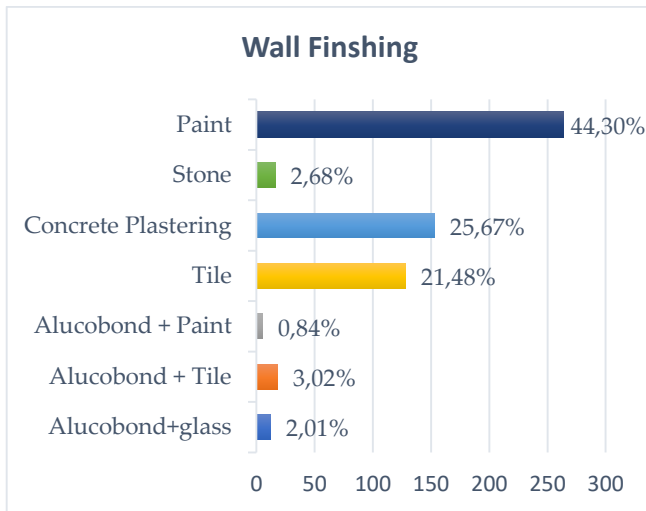


Figure 12. Graph showing the distribution rate of materials in carpentry

**Exterior wall covering**

Wall coverings are complex because interior wall coverings are generally different from exterior wall coverings. The study focused on exterior wall coverings because they are less varied than interior wall coverings, which depend on the functions of each room. The study on exterior walls noted the combination of several materials on exterior walls. The results show that 44.30% of the buildings surveyed have paint cladding, 21.48% have tiles as their main material, 25.67% have cement (unplastered and plastered), 2.68% have decorative stone cladding and 5.87% have Alucobond cladding, which is sometimes combined with glass, paint or tiles. These results show that paint and tiles are the most commonly used materials for wall cladding.

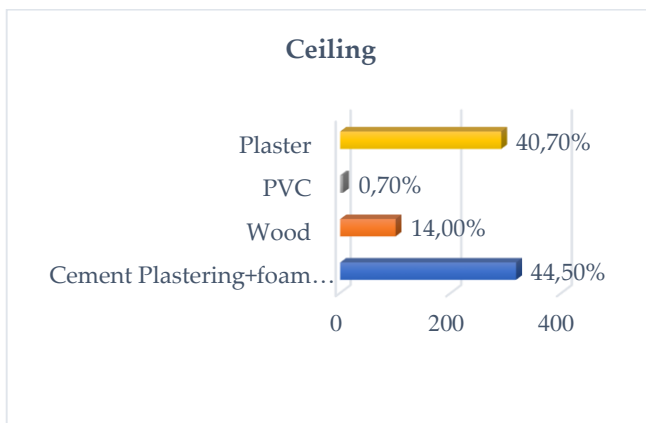
The figure 13 below shows the data collected in the field:



**Figure 13.** Graph showing the distribution rate of materials in external cladding.

### Ceiling

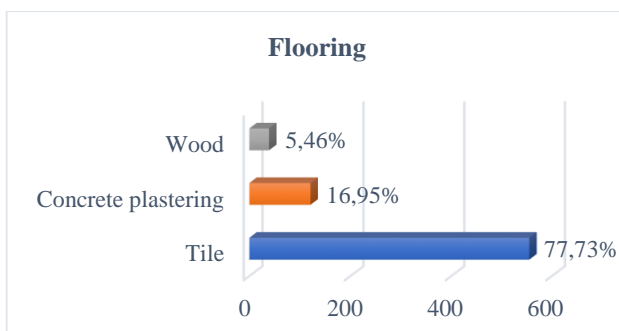
The use of ceilings is not systematic in all buildings. Surveys have shown that 44.50% have no false ceilings, 40.70% are made of plaster, 14.00% are made of wood (plywood and wood panelling) and 0.70% are made of other materials such as PVC.



**Figure 14.** This is a figure. Schemes follow the same formatting.

### Floor covering

The figure 15 below summarises the data relating to floor coverings. We have a rate of 5.46% for wood, 16.80% for cement plastering, 77.73% for tiling. Tiles are the predominant material used for floor coverings in the buildings observed. In the case of floors, these are ceramic stoneware tiles, glass paste tiles in toilets and, to a lesser extent, marble. Cement-based coatings include terrazzo and polished cement. The latter is found in low-income households in the city, while terrazzo is found in public facilities and industrial floors in the city.



**Figure 15.** graph showing the distribution rate of materials at floor covering level.

**Distribution within the technical batch**

The study did not focus on technical aspects such as plumbing, electricity, air conditioning, fire safety equipment and access facilities (lifts), as these are relatively complex technological products that are added to the building to facilitate its use. The above data thus shows the trend in the use of building materials in Greater Lomé. These trends are the result of several factors that influence the choice of materials used in construction.

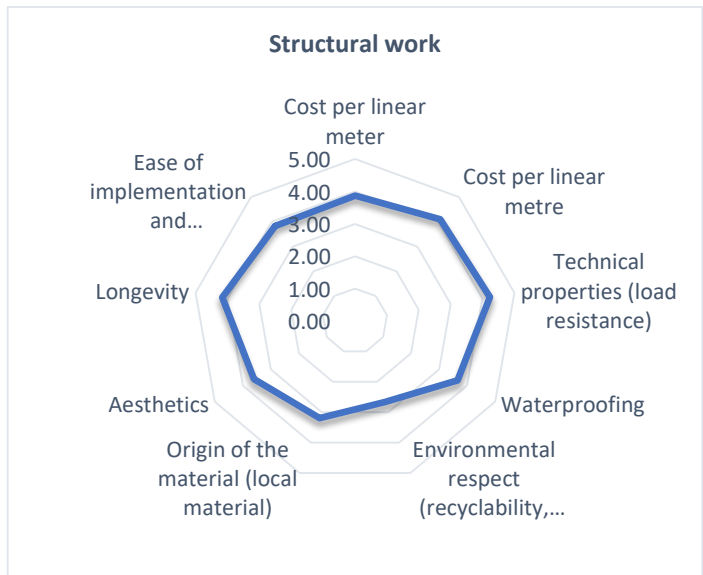
**Analysis of the determinants of construction material usage in Greater Lomé**

The use of building materials is a synergy between several factors (historical, social, cultural, economic, technical, environmental, political, etc.) and several players (material producers, material sellers, building professionals, project managers). These underlying factors help shape the character of the city through the use of materials. The survey was conducted among building professionals using a Likert scale rating from 0 to 5. A low score was considered to indicate that the factor was not taken into account, while a high score indicated that the factor was strongly taken into account in the choice of materials.

**Overall factors influencing material selection among construction professionals according to trade.**

**Structural work**

According to data from a field survey of construction professionals on the factors influencing the choice of building materials for structural work in Greater Lomé, the top three factors influencing the choice of materials are: technical factors, particularly load resistance, with an average score of 4.3, followed by durability (4.17) and availability of materials (4.10). Environmental friendliness (2.67), origin of materials (local materials) with a score of 3.20, and aesthetics (3.60) are the factors least taken into account in the choice of materials in the building trade. The cost of the material (3.87) is an intermediate factor that helps to validate the final choice of material. The diagram below summarizes the trends in choices related to the factor of material selection.



**Figure 16.** Diagram illustrating the factors influencing the choice of building materials.

It should be noted that these criteria vary depending on the trade. For example, in the case of masonry, the criteria of material origin (4.33), aesthetics (4.00), and technical properties (4.00) take precedence over the other criteria. The table and graph below summarize this data.

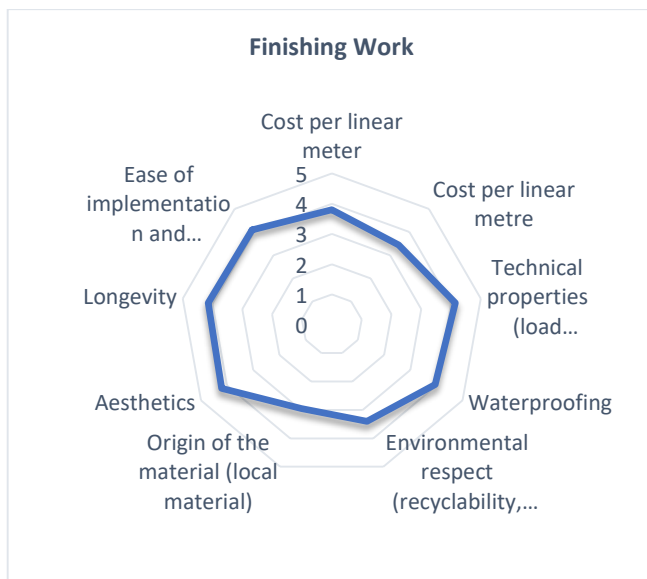
**Table 6.** Table summarising the scores for material selection factors by batch for structural work.

	Foundation	Structure	Floor slab	Maconry	Roofing	Average
Cost per linear meter	4,17	3,67	3,83	3,67	4,00	3,87

Cost per linear metre	4,50	4,33	4,00	3,67	4,00	4,10
Technical properties (load resistance)	4,50	4,17	4,33	4,00	4,17	4,23
Waterproofing	3,50	3,67	3,67	3,33	4,17	3,67
Environmental respect (recyclability, carbon footprint)	2,33	2,67	2,50	2,67	3,20	2,67
Origin of the material (local material)	3,17	2,67	2,67	4,33	3,17	3,20
Aesthetics	3,33	3,33	3,67	4,00	3,67	3,60
Longevity	4,50	4,33	4,33	3,50	4,17	4,17
Ease of implementation and maintenance	4,17	4,00	4,17	2,50	4,33	3,83

**Finishing work**

In the case of finishing work as a whole, the factors with the highest scores are: aesthetics, with a score of 4.2, followed by the durability of the material and technical properties, which have a combined score of 4.15, and finally ease of installation and maintenance, with a combined score of 4.1. Although the cost of the material is a determining factor in the choice of material, it has an intermediate score of 3.8. Environmental criteria and the origin of the material are the criteria with the lowest scores, at 3.4 and 2.95 respectively. The diagram below summarises trends in the choice of construction materials according to the factors mentioned above:



**Figure 17.** Diagram illustrating the factors influencing the choice of materials in finishing work.

It should be noted that there are variations in the factors depending on the different lots comprising the finishing work. The table below details the scores for the selection factors for each lot of finishing work.

**Table 7.** table summarising the scores for material selection factors by batch for finishing work.

Factors influencing the choice of materials	Wall Finishing	Flooring	Carpentry	Ceiling	Average
Cost per linear meter	3,4	3,8	3,8	4,2	3,8
Cost per linear metre	3,8	3,8	3,2	3	3,45
Technical properties (load resistance)	4,2	4,2	4,2	4	4,15
Waterproofing	4,2	4,4	4	3,2	3,95

Environmental respect (recyclability, carbon footprint)	3,2	3,8	3,2	3,4	3,4
Origin of the material (local material)	3,2	2,4	3	3,2	2,95
Aesthetics	4,2	4,4	4,2	4	4,2
Longevity	4,2	4,4	4,2	3,8	4,15
Ease of implementation and maintenance	4,4	4,2	4	3,8	4,1

**Overall factors influencing material selection among building material retailers.**

According to data from interviews with construction stores, availability at the time of supply, quality and cost are the main factors influencing the choice of construction materials to be sold in retail stores. According to the salespeople interviewed, the cost and quality of materials are essentially the determining factors in their customers' choice of construction materials. The quality of materials refers to their durability, ease of use and compliance with technical requirements. This assertion by materials suppliers is in line with the main factors influencing professionals' choices. A comparison of material costs and usage rates shows that the most affordable materials are not always the most widely used. Examples include foundations, structures, roofing, wall and floor finishing, and ceilings.

For example, in the case of foundations, a cubic metre of concrete costs 268,58 (\$US) while a cubic metre of stone costs 125,34(\$US). However, stone is still rarely used due to factors such as material availability, technical properties (ability to bear heavy loads) and consumer habits. When these data are combined with the factors mentioned above, the technical factor and the availability and ease of implementation justify the widespread use of concrete as a foundation material. The table below summarises the comparative costs of construction materials in Lome according to the different trades, with usage rate data from the survey on usage rates in Greater Lome.

**Table 8.** Table summarising material costs and usage rates in Greater Lome[32]

Designation	Unity	Price (\$US)	Usage rate in the city
<b>Structural Work</b>			
Foundation			
Reinforced concrete with 350 kg of cement, including steel and formwork	(m <sup>3</sup> )	268,58	96,22 %
Stone	(m <sup>3</sup> )	125,34	3%
Masonry			
Stone	(m <sup>2</sup> )	41,18	0%
Compressed and stabilised earth brick	(m <sup>2</sup> )	27,75	4,20%
Cement brick 15	(m <sup>2</sup> )	13,43	92,40 %
Structure			
Concrete	(m <sup>3</sup> )	268,58	92,86%
Wood	(m <sup>3</sup> )	-	1,30%
Steel* (volume ratio equivalent to m3 of concrete for the same load to be supported) coefficient: 16.2	(m <sup>3</sup> ) eq/concrete	376,11	2,38%
Roofing			
Roofing Hollow block slab thickness: 20	m <sup>2</sup>	44,76	56,44%
Corrugated sheet metal Wooden frame	m <sup>2</sup>	18,98	42,72%
Corrugated sheet metal Steel frame	m <sup>2</sup>	27,31	
Straw thickness 25	m <sup>2</sup>	44,76	0,84%
Tiles including wooden frame	m <sup>2</sup>	18,98	-

<b>Finishing work</b>			
Flooring			
Porcelain stoneware tiles	m <sup>2</sup>	26,86	77,73%
Wooden flooring	m <sup>2</sup>	-	5,46%
Plastered flooring	m <sup>2</sup>	4,66	16,80%
Marble	m <sup>2</sup>	116,38- 358,1	-
Granito	m <sup>2</sup>	11,64	0,1%
Terrazzo	m <sup>2</sup>	21,49	-
Wall Coverings			
Faience tiles (mid-range) including installation	m <sup>2</sup>	17,91- 26,86	21,48%
Painting	m <sup>2</sup>	9,85	44,30%
Cement plastering	m <sup>2</sup>	3,94	25,67%
Kpalime stone	m <sup>2</sup>	-	2,68%
Alucobond	m <sup>2</sup>	-	5,87%
Ceilings			
4mm plywood ceilings including treated hardwood joists	m <sup>2</sup>	11,37	14%
Plaster	m <sup>2</sup>	20,59	40,70 %
Foam under slabs	m <sup>2</sup>	4,48	44,50%
Carpentry	m <sup>2</sup>	83,44	-
Wood carpentry	m <sup>2</sup>	170,1	-
Aluminium carpentry	m <sup>2</sup>	170,1	-

### Analysis of the determinants of construction material usage in Greater Lomé

Sustainable materials generally meet three criteria: they must be produced locally in order to limit transport-related emissions and promote the local economy; they must have low energy consumption during production and use; and finally, they must be recyclable and reusable at the end of their life.

A cross-analysis of material sustainability based on the criteria mentioned above shows that, in the case of structural work, 96.22% of structures have foundations made from non-sustainable resources (reinforced concrete) and 3.08% from sustainable resources (stone). 92.86% of structures have non-sustainable structures (reinforced concrete) and 7.14% have sustainable structures (steel, wood). 92.30% of structures have non-sustainable floors and 7.70% have sustainable floors. 92.40% of structures have masonry made from sustainable resources (cement blocks) and 7.60% (BTC, stone) from non-sustainable resources. 56.44% of structures have roofs made from non-sustainable materials (reinforced concrete) and 43.56% from sustainable materials (corrugated sheet metal on wooden and steel frames).

In the case of finishing works, 97.32% of buildings have wall coverings made of non-sustainable materials (industrial paint, tiles, cement plaster) and 2.68% (stone). 94.5% of buildings have floor coverings made of non-sustainable materials (tiles, cement plaster) and 5.5% made of sustainable resources (granite, wood). 86% of buildings have false ceilings made of non-sustainable materials (plaster, plaster and foam paint) and 14% made of sustainable materials (wood). The table below summarises the above results, showing the distribution of sustainable and non-sustainable materials in Greater Lomé based on the criteria set out above.

**Table 9.** Table summarising the distribution of sustainable and non-sustainable materials.

Building trade	Sustainable material	Unsustainable material
<b>Structural work</b>		
Foundation	stone (3,08%), earth, wood	reinforced concrete ( 96,22 %)
Structure ( coloumn, beam)	stone (0%), wood(4,76%), Steel (2,38%)	reinforced concrete (92,86%)
Floor slab	stone(0%), earth (0,40%), steel (1,54%)	reinforced concrete (92,30%)
Masonry	compressed and stabilised earth brick (4,20%), stone(0%), wood(1,30%), steel (2,40%)	concrete (92,40%)
Roofing	corrugated aluminium sheet (42,72%), straw (0,84%)	concrete (56,44%)
<b>Finishnig work</b>		
Wall finishing	stone(2,68%), wood (0%)	industrial paint(44,30%), tile(21,48%), cement plastering (25,67%), agglomeration (alucobond, glass, tiles) (5,87%)
Flooring	wood(5,46%)	tile*(77,73%), resin, concrete plaster (16,80%)
Ceiling	wood(14%),	plaster(40,70%), PVC(0.70%), concrete plaster+foam( 44,50%)
Carpentry	wood, aluminium, metal (aggregated data)	PVC, fibre resin, glass*(aggregate data)

**Discussion**

The results of this study show that the city of Lomé is generally unsustainable. Indeed, it is mainly used in structural work for buildings, with concrete and reinforced concrete composed of sand, cement, water, gravel and iron. It should be noted that cement has considerable environmental impacts, particularly during its production and use. It is widely used in foundations, structures, floors and roofs. In addition to concrete, there is nevertheless limited use of traditional materials such as BTC in masonry and stone for foundations, even though these are significantly more durable [22]. Finishing work involves a greater variety of materials, most of which are industrially processed. These results indicate that Greater Lomé is characterised by the abundant use of so-called modern materials, non-sustainable materials derived from a combination of industrial and extracted materials.

It should be noted that the use of these materials is due to multiple underlying factors that have gradually fuelled this trend. The choice of materials, whether by professionals or private individuals, is the result of a set of socio-political, economic and empirical considerations rooted in the period and the times[33]. The analysis of material selection factors in the study revealed varying criteria depending on the trade. The choice of concrete as a structural material is based on its economic performance, ease of use and technical performance[34]. Add to this the hegemony of cement production industries, which compete through advertising to make the material accessible. Tossim et al (2024) also note that training in building and civil engineering schools is based on this material and leaves very little room for other materials[16]. Mastery of alternative materials such as earth bricks and stone has become rare among labourers, who play a fairly important role in the choice of materials, as noted by Gam (1991) [17].

Finishing materials are often overlooked in analyses of urban materiality, yet they have a significant economic impact, accounting for between 30% and 60% of construction costs. Finishing work involves a wider variety of building materials, with the main factors influencing choice being aesthetics, cost and longevity. These factors steer choices towards manufactured materials that are mostly imported, such as tiles, which account for 77.73% of floor coverings and 21.40% of wall coverings. Materials such as Alucobond, aluminium, stainless steel and glass are symbols of modernism and are becoming

increasingly important in building construction compared to traditional materials such as wood, straw and stone.

The issue of material selection raises questions about construction practices and brings two approaches into debate. The first is that of colonial somatic markers, which suggests that the choice of materials, particularly concrete, is due to a colonial reflex and a perception of local materials as poor-quality materials. The second approach is that of objective choices based on the efficiency, availability, quality and ease of implementation of the material. It is by considering this second interpretation that the trend in material choices becomes clearer, even though colonial heritage was an initial factor in influencing material choices during the colonial era and in the early years of independence in Lomé.

The results of this study are consistent with those of Tossim et al (2024), which show the predominance of cement-based materials in the city of Lomé. The present study aims to be more comprehensive by analysing the factors influencing choice by trade and by lot. The study highlights the low consideration given to environmental factors and local sourcing (local materials) in the choice of materials. Némoz (2011) observes that eco-construction approaches using local materials are still quite distant from the concerns of residents, who do not take these issues into account when choosing materials[35]. This assertion by Némoz (2011) in the French case is valid for Greater Lomé based on the results observed. In a study in Central Africa, Fizez (2024) observed a dichotomy between the reality of professionals' discourse on the use of eco-materials and the reality of their practices[33]. This highlights a real gap between scientific research and actual practice in the field.

These findings have important implications because they provide insight into the dynamics of construction material use and the role of materials in the built environment from a built environment perspective. By showing the trajectory of the city and the factors that support it, they highlight the urgent need to implement construction policies that promote the use of sustainable materials. These policies must place environmental parameters at the heart of material selection approaches, in particular the recyclability of the material and its contribution to carbon and GHG (greenhouse gas) emissions. It should be remembered that the building sector is responsible for 38% of global CO<sub>2</sub> emissions[36]. As a result, decarbonisation of the construction sector is now a real challenge. The choice of low-carbon building materials is crucial, and we will need to move towards more environmentally friendly materials[36].

Nevertheless, several limitations must be highlighted in the study. The issue of sustainability varies depending on parameters related to extraction, production, means of transporting the material and the method of implementing the materials. For example, earth, which is generally considered sustainable if extracted in China and used in Lomé, may be less sustainable than concrete produced and used locally. Conversely, a locally produced material may be less sustainable than an imported material. This nuance must therefore be taken into account when interpreting the results showing the rates of use of sustainable and non-sustainable materials. The study did not analyse the origin of the materials. However, these variations do not exclude the effects of these materials, as several previous studies have already established their contribution to GHG emissions. The size of the samples did not allow us to cover all possible uses of the materials, as some materials available on the market were not included in our samples. It should be noted that these are materials with limited use.

It should also be noted that there is no detailed database on the quantities of construction materials entering and leaving the Greater Lomé area available to institutions in the construction sector. The lack of reliable quantitative data on the weight of materials consumed per year in buildings in Lomé prevented the study from conducting a more in-depth analysis of the weight of materials consumed by trade. This could have revealed trends in terms of consumption weight and, in addition to quantitatively identifying the socio-economic and environmental effects, enabled.

Nevertheless, the study, through an overview of usage rates, provides an understanding of the use of materials from a sustainability perspective. Further studies will provide a more in-depth analysis of the issue of building materials in the city of Lomé. Among other things, additional research will be conducted on the origins of building materials, the forms of material production and policy guidance on the use of materials from a sustainability perspective[6]. Other quantitative methodologies based on the weight distribution of different materials may be considered, as well as more detailed environmental analyses based on the life cycle of construction materials in buildings in Greater Lomé. Finally, comparative studies with other contexts, whether rural or urban, can provide a better understanding of the dynamics of material use in built environments.

## Conclusions

The study aimed to characterise the built environment of Greater Lomé by the types of materials used in construction, revealing the complexity of trends in material use. The results obtained made it possible to characterise the city of Lomé through the materials used, showing an abundant use of non-sustainable materials in the structural and finishing work of buildings. These results show that the city's built environment is not sustainable. Analysis of the factors influencing material selection has provided insight into the mechanisms behind the materiality of the built environment in Greater Lomé. Survey results among professionals have shown that the factors influencing selection vary by trade. The choice of these materials is based on technical requirements, availability of materials and ease of implementation in structural work. In finishing work, aesthetic factors, followed by technical factors and availability, are the determining factors in the choice of materials. The results show that environmental issues and the local origin of materials are still marginal factors in the choice of building materials in Greater Lomé. However, certain scientific limitations and gaps can be identified in the field of study, in particular limitations related to the quantification of materials mobilised in the Greater Lomé area and the socio-economic and environmental effects linked to the dynamics of material use. The study therefore opens up the field of research on the environmental effects linked to trends in material use, socio-economic analysis and the contribution of local industry to the supply of building materials in the city. These studies will enable precise action to be taken to reorient the construction industry towards a sustainable approach.

**Author Contributions:** Conceptualization, G.L.C. and M.M.R, B.M; methodology, G.L.C., and A.F ; software, A.F; formal analysis, G.L.C, M.M.R and A.F.; investigation, G.L.C. and A.F; data curation, G.L.C. B.M and S.K; writing—original draft preparation, G.L.C.; writing—review and editing, G.L.C., M.M.R, B.M and S.K. All authors have read and agreed to the published version of the manuscript.

**Funding:** This work was supported by the World Bank through the Regional Center of Excellence on Sustainable Cities in Africa (CERViDA-DOUNEDON), funding number IDA 5360 TG.

Institutional Review Board Statement: Not applicable.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the Study.

**Data Availability Statement:** The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

**Acknowledgments:** The authors would like to thank the World Bank and the University of Lomé (UL) via the Regional Center of Excellence for Sustainable Cities in Africa (CERViDA-DOUNEDON) for their financial contributions and scientific supervision.

**Conflicts of Interest:** The authors declare no conflict of interests.

## References

- [1] J.-L. Salagnac, "Adaptation of the built environment to current and future climatic conditions: the case of heatwaves," [Adaptation du cadre bâti aux conditions climatiques actuelles et futures : le cas des canicules] report, CSTB - Scientific and Technical Centre for Building, 2015. Accessed: 31 January 2025. [Online]. Available at: <https://cstb.hal.science/hal-01232773>
- [2] Gauthiez, "Vocabulary of morphological analysis", in Village and city in the Middle Ages: Morphological dynamics, [« Vocabulaire de l'analyse morphologique », in Village et ville au Moyen Âge : Les dynamiques morphologiques] E. Zadora-Rio et H. Galinié, Éd., in Perspectives Villes et Territoires. , Tours: Presses universitaires François-Rabelais, 2003, p. 479-485-Vol. 1. doi: 10.4000/books.pufr.6418.
- [3] Baumont, H. Beguin, and J.-M. Huriot, "Defining the city" [« Définir la ville »], Laboratoire d'analyse et de techniques économiques (LATEC), Research Report 9611, 1996. Accessed: 26 September 2024. [Online]. Available at: <https://hal.science/hal-01527276/document>
- [4] Fernandez, C. Blanquart, and E. Verdeil, "Earth and concrete: the urban project considered from the perspective of territorial metabolism" [La terre et le béton : le projet d'urbanisme considéré sous l'angle du métabolisme territorial], Vertigo - Rev. Electronics In Sci. Environ., no Volume 18 Number 3, Art. no Volume 18 Number 3, dec. 2018, doi: 10.4000/vertigo.23302.
- [5] Vialleix, A. Bastin, and V. Augiseau, "Towards a circular model for building materials" [Vers un modèle circulaire pour les matériaux de construction], HALSHS Arch. Open In Sci. Society Man - Not. Integrated Text, May 2020.
- [6] J.-B. Bahers and M. Durand, "What materiality for city-countryside relations ? The challenges of the circular economy" [Quelle matérialité pour les relations ville-campagne ? : Les enjeux de l'économie circulaire], For, vol. 236, no 4, p. 135-151, 2018, doi: 10.3917/pour.236.0133.

- [7] Dillenseger, " Territorial metabolism, urban metabolism "[Métabolisme territorial, métabolisme urbain], Geoconfluences. Accessed: September 28, 2024. [Online]. Available at: <https://geoconfluences.ens-lyon.fr/glossaire/metabolisme>
- [8] GrandPariscirculaire, "Metabolism of the Greater Paris Metropolis and EPTs in 2017"[ Métabolisme de la Métropole du Grand Paris et des EPT en 2017], grandpariscirculaire.org. Accessed on: September 27, 2024. [Online]. Available at: <https://www.grandpariscirculaire.org/static/h/metabolisme-urbain-cartographies-materiaux-de-construction.html>
- [9] Duraabl.com ". Accessed: 28 August 2025. [Online]. Available at: <https://www.duraabl.com/la-consommation-humaine-mondiale-de-materiaux-depasse-le-niveau-record-de-100-milliards-de-tonnes-par-an/>
- [10] Gaudiaut, " Infographic: The Urban Explosion in the World "[Infographie: L'explosion urbaine dans le monde], Statista Daily Data. Retrieved on: 25 September 2024. [Online]. Available at: <https://fr.statista.com/infographie/26877/urbanisation-monde-evolution-part-de-la-population-urbaine-par-continent>
- [11] E. O. Nkoa and J. S. Song, "Urbanization and inequalities in Africa: a study based on disaggregated indices"[Urbanisation et inégalités en Afrique : une étude à partir des indices désagrégés], *Urban Regional Economy Rev.* 3, p. 447-484, June 2019, doi: 10.3917/reru.193.0447.
- [12] INSEED, " 5th General Census of Population and Housing (RGPH-5) of November 2022 "[5e Recensement Général de la Population et de l'Habitat (RGPH-5) de novembre 2022]. Central Census Office, April 2023.
- [13] Ministry of Promotion and Investment, "Economic Report TOGO-2022-2023, vision 2030"[ Rapport Economique TOGO-2022-2023, vision 2030]. Accessed on: September 25, 2024. [Online]. Available on: <https://investissement.gouv.tg/wp-content/uploads/2022/08/Rapport-Economique-YEARBOOK-TOGO-2022-2023.pdf>
- [14] K. Nyassogbo, "Urbanization and its evolution in Togo"[L'urbanisation et son évolution au Togo], *Cah. O.-m.*, vol. 37, no 146, p. 135-158, 1984, doi: 10.3406/caoum.1984.3100.
- [15] Guézéré, " The obsession of living in one's own house in Lomé: what impact on spatial dynamics?[L'obsession d'habiter sa propre maison à Lomé : quel impact sur la dynamique spatiale ?]", *Cah. D'Outre-Mer Rev. Géographie Bordx.*, vol. 64, no 256, Art. no 256, oct. 2011, doi: 10.4000/com.6443.
- [16] M. J. Tossim et al., « Analysis of the Choice of Cement in Construction and Its Impact on Comfort in Togo », *Sustainability*, vol. 16, no 17, Art. no 17, janv. 2024, doi: 10.3390/su16177359.
- [17] Adjavou and Plan construction et architecture (France), Ed., *Economy of construction in Lomé*. in Collection « Villes et entreprises ». Paris: L'Harmattan, 1987.
- [18] M. Y. Awoussi, E. K. A. Domtse, D. K. Gake, P. V. Genovese, et Y. Dziwonou, « Analysis of the Sustainability Elements of Vernacular Architecture in Northern Togo: The Case of the Kara Region », *Sustainability*, vol. 17, no 6, p. 2450, mars 2025, doi: 10.3390/su17062450.
- [19] E. Prud'Homme, " Valorization of alternative raw materials in materials for sustainable construction "[Valorisation de matières premières alternatives dans les matériaux pour la construction durable]. *Materials*. Institut National des Sciences Appliquées de Lyon; Université Lyon, 2022. [En ligne]. available on <https://hal.science/tel-03829130>
- [20] M. Safi, "Valorization of geo- and bio-sourced materials for sustainable construction"[ Valorisation de matériaux géo- et bio-sourcés pour la construction durable], Thesis, Mohamed BOUDIAF University of M'Sila, 2019. Accessed: August 12, 2023. [En ligne]. available on <http://localhost:8080/xmlui/handle/123456789/14602>
- [21] Sustainable construction: definition, benefits, labels, Youmatter. Accessed: December 6, 2023. [Online]. Available on: <https://youmatter.world/fr/definition/construction-durable-definition-benefices-labels/>
- [22] S. Sinha et J. S. Sudarsan, « Building a Greener Future: How Earth Blocks Are Reshaping Sustainability and Circular Economy in Construction », *Architecture*, vol. 5, no 2, p. 25, juin 2025, doi: 10.3390/architecture5020025.
- [23] Y. A. Abera, « Sustainable building materials: A comprehensive study on eco-friendly alternatives for construction », *Compos. Adv. Mater.*, vol. 33, p. 26349833241255957, août 2024, doi: 10.1177/26349833241255957.
- [24] A. Adjavou, Éd., *Construction economy in Lomé*[Économie de la construction à Lomé]. in Collection 'Cities and enterprises'. Paris: L'Harmattan, 1987.
- [25] A. F. Fresnet, « From material to book: some methodological contributions related to the Life Cycle Analysis "[Du matériau à l'ouvrage : quelques apports méthodologiques relatifs à l'Analyse de Cycle de Vie], thesis, Université Paris Est - Marne-la-Vallée, 2016. Accessed: January 22, 2025. [Online]. Available on: <https://hal.science/tel-01591409>
- [26] D. G. Sahlol, E. Elbeltagi, M. Elzoughiby, et M. Abd Elrahman, « Sustainable building materials assessment and selection using system dynamics », *J. Build. Eng.*, vol. 35, p. 101978, mars 2021, doi: 10.1016/j.jobe.2020.101978.
- [27] « AFRIBAT 2019 Edition: Focus on the Center for Construction and Housing CCL - Ministry of Urban Planning, Housing and Land Reform "[AFRIBAT édition 2019: Zoom sur le Centre de la Construction et du Logement CCL – Ministère de l'Urbanisme, de l'Habitat et de la Reforme Foncière]. Accessed: May 28, 2025. [Online]. Available on: <https://urbanisme.gouv.tg/afribat-edition-2019-zoom-sur-le-centre-de-la-construction-et-du-logement-ccl/>

- [28] Economic Commission for Africa (ECA), " Establishment of a Subregional Centre for Building and Construction Materials Research in the West African Sub-region: ECA project proposal for transformation into a subregional institution, from the center of construction and housing (CCL) cacabelli of Lomé (Togo)[ « Création d'un centre sous-régional pour la recherche sur les matériaux de construction et le bâtiment dans la sous-région de l'afrique de l'ouest: proposition de projet de la CEA concernant la transformation, en institution sous-régionale, du centre de la construction et du logement ( CCL) cacavelli de lomé ( Togo)]. " 1981.
- [29] Guézéré, "Two motorized wheels and urban sprawl in Lomé, what is the link with the theory of the 'three ages' of the city? »[Deux roues motorisées et étalement urbain à Lomé, quel lien avec la théorie des « trois âges » de la ville ? ], *Norois Environ. Aménagement. Société*, no 226, Art. no 226, mars 2013, doi: 10.4000/norois.4549.
- [30] A. K. Yaovi, Presentation of the Grand Lomé "[ Présentation du Grand Lomé]. Accessed on: September 20, 2024. [Online]. Available on: <https://dagl.tg/1-presentation>
- [31] F. Lafont, "Determine Sample Size - Questio's Blog "[Déterminer la taille de l'échantillon - le blog de Questio], *Questio's Blog*. Accessed: December 21, 2024. [Online]. Available at: <https://blog.questio.fr/determiner-taille-echantillon>
- [32] Ministry of the Economy and Finance, " Reference price directory"[Répertoire des prix de références]. 2024.
- [33] R. Fivez, « Resisting Material Binaries: Unpacking persisting dichotomies of building materials in Central Africa », *Cah. Rech. Archit. Urbaine Paysagère*, no 20, Art. no 20, mai 2024, doi: 10.4000/11pax.
- [34] A. Choplin, *Gray matter of the urban*[Matière grise de l'urbain]. MetisPresses Sàrl, 2020. doi: 10.37866/0563-74-6.
- [35] S. Némoz, "The imperative construction of sustainable habitat ", *Emul. - Rev. Jeunes Cherch. En Sci. Soc.*, 2011, [Online]. Available on: [www.revue-emulations.net](http://www.revue-emulations.net)
- [36] C. Guerniou, "Carbon in the building, the building in decarbonation "[La construction impérative de l'habitat durable], *Constructive*, vol. 64, no 1, p. 68-72, mars 2023, doi: 10.3917/const.064.0068.