UNIVERSITY OF EDUCATION, KUMASI CAMPUS

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

ASSESSING THE EFFECTIVENESS OF GLASS IN BUILDING AND ITS SECURITY IMPLICATIONS: CASE STUDY OF BUILDING IN WA MUNICIPALITY

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BY

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OCTOBER, 2018

DECLARATION

STUDENT'S DECLARATION

I, PETER DONG GANDAA, declare that this Dissertation with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: ……..

DATE: ……

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidance for supervision of Dissertation as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: ENG. MICHAEL K. TSORGALI

SIGNATURE: …….....

DATE: ….....

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DEDICATION

I dedicate this work to my children; Gloria and Prosper

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ABSTRACT

Glass is one of the very used and favored building materials with multiple applications, such as a building construction material, use in construction industries as material, use in containers and vessels, as windows in the automobile industry. Glasses in buildings are the weakest element of a house with regard to prevention of burglaries. The study aimed at assessing the effectiveness of glass in building and its security implication of buildings using Wa Municipality as a case study. The specific objectives of the study were: to examine the use of glass in building construction in the Wa Municipality, to identify the effectiveness of glass in building construction in the Wa Municipality, and to identify the security implications of using glass in building in the Wa Municipality. The study was carried out using a survey designed. The study drew one hundred and twenty four (124) residents and ten (10) contractors in the Wa Municipality. The study adopted purposive sampling technique in selecting respondents for the study. Data collection instrument involved questionnaire, interviews and observation. The study found that in Wa Municipality, glasses in building are mostly used for architectural features like doors, windows, and partitions. Furthermore, it appeared that glasses are used for reinforcement structures, and in the form of block walls. The result indicated that glass in building construction is effective as it resists corrosion, makes structure look more stunning, sophisticated and adds beauty to the building. The study further revealed that glass has a smooth, glossy surface so it is dust proof and can be easily cleaned, and also absorb, refracts or transmits light. The study indicated that glass in building construction have serious implication on the live and property in the building. Based on this, conclusions were made and it was recommended that the government through its agencies should develop by-laws to control the type of glass building materials to be used to avoid any serious implication on the live and property in the building.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Glass is one of the very used and favored building materials with multiple applications, such as a building construction material, use in construction industries as material, use in containers and vessels, as windows in the automobile industry, in nanotechnology applications such as optical objects and among others (Knaack, 2008). Many qualities and appearances make glass attractive and admired by many construction industries and users, as it is transparent, chemically inert as a result of its composition and colorations, environmentally friendly, sustainable, strong, easily available and relatively cheap in some parts of the country. Glass is arguably the most remarkable material ever discovered by man (Wigginton, 1996). Glass as used in construction is a compound of elements of silica, lime, soda, magnesia and aluminium. No other building system combines as significant an impact to both a building's performance and aesthetics (Wigginton, 1996).

According to Mocibob (2008), glass has traditionally been used as window panes in buildings, but the use of glass as a main building material has become increasingly popular during the past 25 years. The recent advances in glass technology and the architectural, sustainability and environmental considerations promote the use of glass in buildings. It is hard to envisage any modern building without glass windows/ facades. The use of glass to build well-lit and spacious buildings has become more prominent and widely gaining ground across the global setting.

Glass blowing currently referred to as glass building was discovered in the 1st century in Europe, this revolutionized the glass making industry. The technique spread throughout the Roman Empire. Production of Clear glass, by introduction of manganese dioxide, saw glass being used for architectural purposes. Cast glass windows began to appear in the most important buildings and villas in Rome and Pompeii (Haldimann et al., 2008). Over the next 1,000 years glass making spread through all of Europe and Middle East. In 7th century Anglo Saxon glass was used in churches and cathedrals. By the eleventh century, sheet glass was made by the crown glass process. In this process, the glass blower would spin molten glass at the end of a rod until it flattened into a disk (Ciccotti, 2009). The disk would then be cut into panes. By thirteenth century, this technique was perfected in Venice. Stain glass windows were used in gothic renaissance and baroque architecture from the eleventh to the eighteenth century. The examples of stunning patterns created by using colorful glass are immortalized by great artists all over the world. The Crown glass process was used up to the mid-nineteenth century / sheet glass windows were used in making windows (Ciccotti, 2009).

As per Pilkington (2008), there has been this revolution of the use of glazing (aluminium doors and windows, curtain walling), as against the use of traditional doors and window (louvers and timber doors) and sandcrete block walls. Traditional features of tropical buildings like shading devices (awnings, overhangs, and trellises) and courtyards have given way to enclosed high rise buildings with curtain walls. One wonders if these buildings are sustainable in the hot /warm and humid climates developing countries like Ghana where energy efficiency among other factors is supposed to be of paramount importance. Globalization has brought with it the adoption of modern lifestyles by the inhabitants of developing countries which Ghana

is not an exception from developed countries like the United Kingdom and the United States of America. The most glaring global change is in that of buildings worldwide, cultural diversity, environmental climate change called for this practice of using glass in building houses and offices. In respect of Ghana, the climatic seasons is divided into the Southern zone, the Coastal belt and the Northern Zone, with the Northern zone being the hottest zone in the country but for the quest to meet changing trends using glass in building material is not an exception. With features like extensively glazed areas and the use of air-conditioning which is more often than not ignore the use of natural climatic components, thus overlooking sustainability.

Glass when used as cladding material, fulfils a variety of functions from aesthetic point of view, the glass provides transparency and natural light. Functionally, it provides solar, acoustic and heat insulation, whilst having additional self-cleaning property (Hess, 2004; Luible & Crisinel, 2004; Mocibob, 2008; Knaack, 2008). Glass as a material posed considerable challenge to the attainment of climatic comfort to occupants in tropical climates. This requires the use of mechanical ventilation to bring the indoor climate to an acceptable level thus making the issue of energy consumption paramount (Taylor, 2000). According to Garg (2009) developers have now resorted to building their houses with large glass panes, glass roofs, verandas with glass banisters, and even glass staircases. There has been an increasing use of glass in modern residential buildings. This development, according to Viet (2010) is influenced by change of modern lifestyle of people. This certainly causes problems in house design, especially in achieving climatic comfort, which owners as well as architects, have to do.

1.2 Statement of the Problem

In the past few decades, the use of glass in buildings has remarkably increased. As a result, several transparent buildings have been constructed, in which the materials have almost disappeared. In the Wa Municipality, glass in buildings now sprung across the length and breadth of every facet particularly in residential areas and along the major routes notably the banks, supermarkets, boutiques, schools and stores. For most buildings in the Wa Municipality, the glasses are most typically used in architectural features like doors, windows, and partition. The owners of these building enjoy utilizing glass in building designs for a variety of reasons. One of the primary reasons of choosing glass in a design is because it offers a beautiful and unique feel that cannot be achieved using any other material, and to provide natural daylight to illuminate and heat the building.

With the glass wave sweeping across architectural designs in Wa, the high level of solar radiation in the dry season becomes course for concern, considering green-house-effect produced by glass. This brings the problem of trapping heat inside and which required for opening doors and window for natural air, therefore making threat to health and security implication of such buildings. Additionally, the glass surfaces create an annoying and potentially dangerous glare and at time turn the buildings into an unbearably hot and bright mess of the structure.

Glasses in buildings are the weakest element of a house with regard to prevention of burglaries. The threat of injury during glass breakage exists in any place where the users of a building are in direct contact with glass partitions, especially in areas of communication. An incident happened in Wa municipality where glass panels spontaneously cracked and eventually fell down near pedestrians led to immediate suggestions that poor quality imported glass from China is to blame. But the problem

is not Chinese imports. Glasses in building have the tendency to break when expanded with a force that overcomes the internal stress of the material. This has necessitated in assessing the effectiveness of glass in building and its security implication of buildings in Wa Municipality.

1.3 Purpose of the Study

The purpose of the study is to assess the effectiveness of glass in building and its security implication of buildings in Wa Municipality.

1.4 Research Objectives

The specific objectives of the study were to:

1. Examine the use of glass in building construction in the Wa Municipality.
2. Identify the effectiveness of glass in building construction in the Wa Municipality.
3. Identify the security implications of using glass in building in the Wa Municipality.

1.5 Research Questions

The following research questions were developed to guide the study

1. What are the uses of glass in building construction in the Wa Municipality?
2. How effective is glass in building construction in the Wa Municipality?
3. What are the security implications of using glass in building in the Wa Municipality?

1.6 Significance of the Study

The study is significant for the following reasons:

- The findings of the study will be useful to the ministry of finance in formulating a policy action plan to address the factors influencing glass buildings and their security implications in Ghana.
- The study will provide useful suggestions to the contractors to enable them to deal with challenges facing glass buildings in the country.
- The study will also go a long way to outline how effective is glass in buildings for the development of the region and the country at large.
- The outcome of the study may become a very resourceful reference material to various stake holders in the economy and readers who have general interest in gaining more knowledge about the use of glass in building constructions and its security implications in the development of mother Ghana and the world in general. Specifically, financial institution and investors will find the information useful when developing programmes to suit the growth of glass building construction.
- Finally, the study results and recommendation may provide useful information to scholars and prospective contractors and users in the building industry.

1.7 Scope of the Study

The study is geographically limited to residence and building contractors in Wa municipality in the Upper West Region. For the purpose of the study the sample was drawn from four Central Business District thus; Dobile, Kambale, Kpaguri and Kabanye. The study covers the use of glass in building, the effectiveness of glass in building construction, and the security implications of using glass in building in the Wa Municipality.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter looks at the views, opinions, publications, and research works related to the study. The chapter specifically looks at

2.1 Concept of Glass in Building Construction

Glass is a magical material which has so many different properties and uses, that it has presented Architects with many new possibilities and designs (Ciccotti, 2009; Mocibob, 2008; Knaack, 2008). Glass is most typically used as transparent glazing material in construction and also used in architectural features like doors, windows, partition. Glass is a transparent hard substance created by the application of heat to sand or quartz. Glass is an inorganic, transparent or translucent material which can be molded into any shape (Wigginton, 1996).

Glass is made by melting together several minerals at very high temperatures. The main compound of glass is silica (SiO2), which is the primary constituent of sand. Natural glass, which is existing for millions of years, formed when certain types of rocks melted as a result of high-temperature phenomenon such as volcanic eruptions and lightning, and then cooled and solidified rapidly (Le Bourhis, 2008). Stone Age people may have used natural glass as tools owing to its high strength and sharpness. The oldest use of manufactured glass may be in around 3500 BC in Egypt where coloured glass was used as jewellery and as vessels to store liquids (IStructE, 2014).

Manufactured glass contains considerable amounts of various metal oxides, mainly soda (Na2O) and lime (CaO), in addition to the main constituent silica.

Therefore, it is known as ‘soda-lime-silica glass’ or ‘soda-lime glass’. Soda-lime glass is the most widely used silica-glass type in the world. Typically, soda-lime glass contains 69–74% silica, 5–14% lime, 10–16% soda and other minor ingredients such as magnesia (MgO) and alumina (Al2O3) (Haldimann et al., 2008). The function of soda is to lower the melting point of soda-lime glass to a value between 400 and 600 oC from that of 1723ºC of silica (Le Bourhis, 2008). This low melting point enables the bulk production of soda-lime glass. Glass containing only silica and soda will have poor durability, and it is often water soluble; the addition of lime makes glass more durable. Pure silica-glass is still used in special applications, for instance, in windows of spacecraft where glass is exposed to temperatures up to 1200ºC.

Glass has been used in construction since approximately 2000 years ago (Knaack, 2008; Mocibob, 2008). In recent decades, the application of this environment-friendly material has been developed in the field of construction because of the following characteristics of glass: very high compressive strength (Hess, 2004; Luible & Crisinel, 2004); resistance to corrosion (Hess, 2004; Wilson and Vasilchenko-Malishev, 2005); recyclability (Nijsse, 2003; Siebert, 2002); reduction of energy consumption (Siebert, 2002; Tückmantel, 2009); recent advancements in glass coatings (Bostick, 2009; Tückmantel, 2009); development of computers and programs; growth of the demand for the architecture of thinner and more transparent structures (Bostick, 2009; Luible & Crisinel, 2004).

Glass building is the most typically used as transparent glazing material in building envelope, including windows in the external walls. Glass is also used for external partitions and as an architectural feature. When used in buildings, glass is often of a safety type, which includes reinforced, toughened and laminated glasses (Yeang, 1996). According to Cetiner and Ozkan (2005), glass is used extensively in

most buildings, in both exterior and interior applications; as a construction material for function ability for decoration and for interior fittings.

2.2 Uses of glass in building construction

Glass in buildings was brought about due to certain needs that designers, occupants and owners had to meet (Pilkington, 2008). Some of these are the need to make building lighter, the need to have high amount of natural day lighting in order to reduce electricity consumption through the use of artificial lighting, the need to create views and blending interior and exterior views, the need to control the solar and thermal heat in interiors thus maintaining temperatures at comfort levels, the need for designers and architects to have least restriction in capturing desired shapes and forms and the need to control noise.

According to Watson (2000), it is also with a deep understanding of glass science and by using fusion draw manufacturing process to lead the display industry with its superior liquid crystal display (LCD) glass that fueled the electronics gadget screen revolution. The glass is UV stable, Since It is not attacked by ultraviolet radiation and hence cracks, discolouration or disintegration will not occur. Glass is available in varieties of colours and when combined the glass sheet in laminated or insulated units, they change in colour and appearance. Mei and Woolrich (1963) mentioned that glass is an excellent insulator against electricity. It is impossible to conduct an electric current under the influence of an electric field. In order to be able to satisfy the above stated needs however, different types of glass with different characteristics and properties are required; failure to match the correct type of glass with the specific needs may result in the creation of problems in the building (Mocibob, 2008).

According to Bay and Ong (2006), many designers are eager to find innovative glass technologies, such as reflective glass, double skin glass, and low –E glass, to cut down the cooling load of glass skin but still cannot change the basic material performance that bigger solar heat gain comes from bigger glass opening'. This means that the use of glass should be determined by the climate as against the properties of the glass; and should not be used in spite of the climatic conditions or the requirement for sustainability in a region.

It is established that building construction involves the provision of built developments that are efficient and affordable, socially acceptable and less damaging to the environment. 'Sustainable construction not only refers to the buildings and spaces themselves but also the processes or activities used to construct them. It also includes the infrastructural elements such as waste management, transportation, and utility transmission systems put in place to serve this building space (Presley & Meade, 2010). Ballast (2007) affirmed that interior designers make use of the glass in partitions, walls and staircases.

As per Halliday (2008), glass can be used in a variety of commercial and residential applications, including doors, windows, roof-lights, glass facades, conservatories and orangeries. Its self-cleaning properties make it ideal for use in hard-to-reach places that are difficult to clean. Over the past decade the increase in popularity of glass roofs in conservatories and orangeries has led to glass being the ideal solution to create an additional living area that can be utilised all year round. The unique colour helps to keep internal temperatures cooler whilst still maintaining excellent light transmittance, low light reflection and high energy absorption. Glass can be blown, drawn and pressed to any shape and hence it is used for general glazing purposes in building, shop fronts, building doors and windows and workshops. It is

also used for furniture after being laminated with plywood or metal sheet (Narelle, 2005).

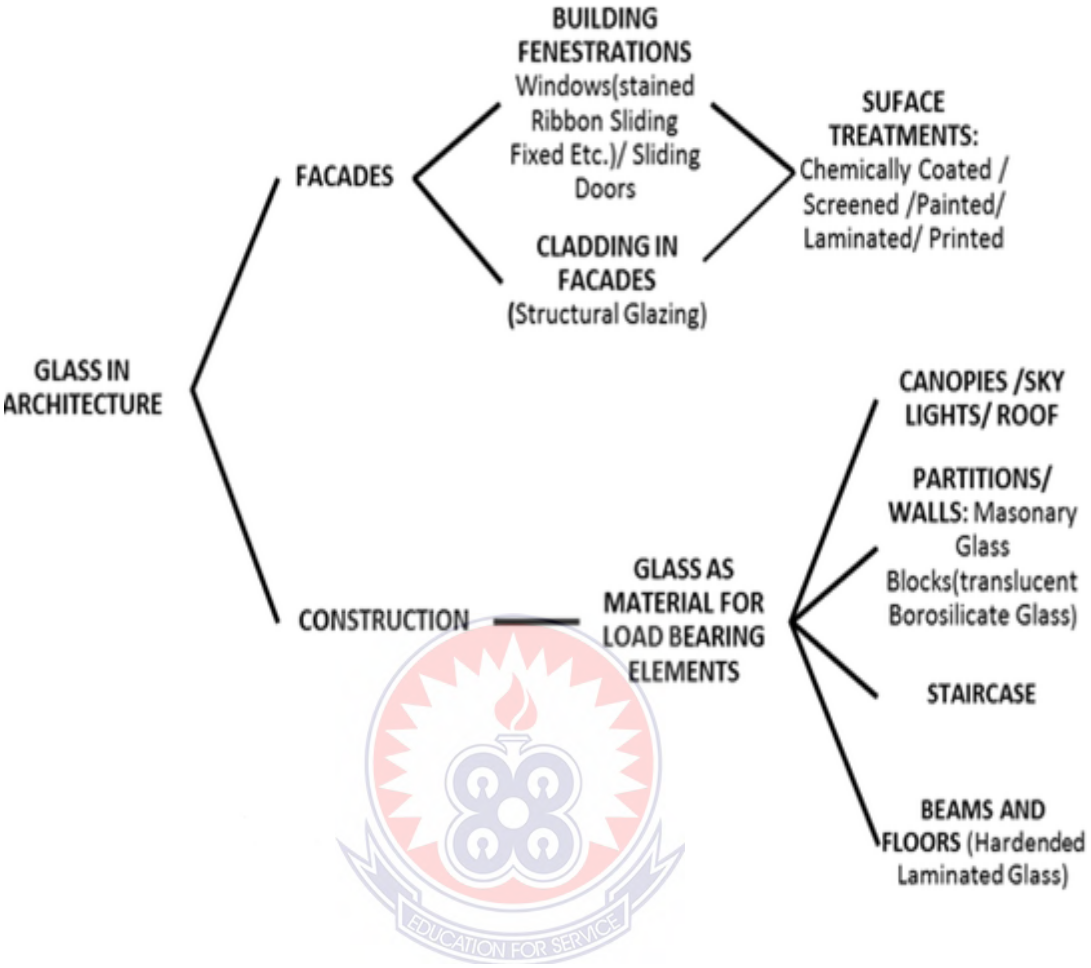

Figure 2. 1: Different use of Glass in building
Source: Modified Conceptual framework of Wurms (2007).

2.2.1 Window and Door

Glass is one of the most sophisticated and versatile materials used in the construction industry. With the advent of technology glass is now available in toughened form and is a crucial material in the world of Architects and Interior Designers (Bilgen, 1994). The main feature of glass is its capability to provide a wide range of inventive solutions of interior and exterior beautification. Glass is no longer a filler material but is a crucially used for supporting and enveloping purposes.

According to Ballast (2007), interior designers make use of the glass in doors and windows.

As per Stagno (2001), glass is a magical material which has so many different properties and uses, that it has presented Architects with many new possibilities and designs. Glass is most typically used as transparent glazing material in construction and also used in architectural features like doors, and windows. Glass is a transparent hard substance created by the application of heat to sand or quartz. Glass is an inorganic, transparent or translucent material which can be molded into any shape. Glass is a mixture of raw materials like Silica, sodium potassium carbonate, lime or lead oxide, Manganese oxide which is ground, sieved and mixed in specific proportion and melted in furnace.

Taylor (2000) indicated that glass is the most common material used in windows and doors. In addition to ordinary clear glass, most manufacturers offer a variety of high-performance and decorative options. Recent introductions to the market are low-maintenance and self-cleaning glasses. Glass manufacturers have recently introduced new coatings that can limit dirt build-up on the exterior and reduce the need for cleaning windows on the outside. Glass pieces are fixed in door panels to admit light inside the room. Large openings in doors fitted with thick glass panels impart a beautiful appearance. The glass may be of various types - frosted glass , beaded glass , ribbed glass. Glass-paneled doors need to be well built, especially if they are exterior doors. Individual glass panes are often referred to as "lights" (or "lites"). Be sure to get gas-filled thermal glass panes for an exterior door, and make sure the glass is well sealed against the stiles and rails (Smith, 2006).

2.2.2 Internal Partitions

Glass is one of the most remarkable building materials in the world. With the many benefits it brings to a project, it is little surprise that it is used in the construction of almost every home, office, and public building worldwide. Providing access to natural light, options for colour customisation, and the ability to blend interiors with exteriors, this wonder material can be used to transform a building into a thing of natural and elegant beauty (Kurniawan, 2006). Glass is used for internal partitions and as an architectural feature (Calgarian, 2007).

According to Yeang (1996), glass is used extensively in construction industry in interior partitions, balustrades, railings for stairs and balconies, etc. There are many different types of glass with different appearance and properties, which can be used in various applications. In many of its application glass can help to save energy. It is most obvious in the case for insulating glass for windows and facades but also for less known products such as weight-lightening reinforcement glass fibre used in automotive, aviation and other transport modes to reduce the weight of vehicle and their fuel consumption (Guarracino, 2005). Ballast (2007), interior designers make use of the glass in partitions, walls and counter tops.

2.4.2 Reinforcement structures

In construction, architects not only use large glazed areas for their energy-saving properties but also because they provide natural light into buildings which enhance living and working conditions of occupants. Studies show that glass in buildings, through all these benefits, contribute to people's well-being and improved health conditions (Corgnati, Perino, & Serra, 2007). Glass has found a wide range of applications in building structures as reinforcement. Creative architects are building

structures ranging from arching canopies and rising facades to delicate cubes and footbridges entirely of glass**.** Architects can make use of the strength of modern glass for structural purposes and can use it in creative way (Chikaher & Hirst, 2007). A more creative designer also creates transparent staircases, translucent floors, designer ceilings and colorful bookshelves.

2.4.3 Glass as Conservatory

According to Luible and Crisinel (2004), the pleasure of enjoying conservatory need not be confined to the warmer months. Adding a conservatory is now an extremely popular means to increase the available space as well as add value to your home. A conservatory can be beneficial for a wide range of reasons; providing an extra room such as a playroom, enabling to enjoy being close to the garden, adding a light spacious area for dining or resting or just enjoying the sun for the whole of the year. Hess (2004) emphasized that nowadays glass is used not only for the walls but also for the roof of the conservatory and it can enhance the performance of new space in more ways than one might imagine.

2.3 Properties having influence on choice of glass as a construction material

A unique combination of fascinating physical, optical, chemical, and thermal properties makes glass the most preferred construction material in modern buildings. The appropriate use of glass windows, doors, roofs, staircases, partitions, etc. makes buildings bright, airy, energy efficient, and it also enhances comfort of the occupants.

2.3.1 Physical and optical properties

The most striking feature that contributes to the widespread use of glass in buildings is its transparency to visible light. Owing to the absence of internal

subdivisions such as grain boundaries in the microstructure, glass does not scatter light, and as a result, it is transparent. Glass also has smooth surfaces, since during the formation the molecules of the super-cooled liquid are not forced to dispose in rigid crystal geometries and can follow surface tension (Haldimann et al., 2008). The recent developments of high-tech glass products expand the range of applications of glass beyond the merely decorative, to functional and structural roles. Light, comfort, well-being, style, safety, security, and sustainability are among the benefits that can be achieved from the appropriate use of modern glass products in buildings.

2.3.2 Chemical and thermal properties

One of the key properties of glass is its chemical inertness and general resistance to exposed environment. Glass is one of the most durable materials used in the construction industry. The chemical inertness is attributed to its microstructure: an irregular network of silicon and oxygen atoms with alkaline parts in between. Glass is also an electric insulator, since there are no charged particles such as free electrons in metals or ions in an electrolyte fluid that can move creating an electric current. The thermal expansion coefficient of soda-lime glass is 8–9x10-6 K-1, and this is of similar magnitude as that of the two most widely used construction materials, concrete (12x10-6 K-1) and steel (11–13x10-6 K-1). The specific heat of glass (the amount of heat required to raise the temperature of unit mass of glass by 1 K) is -0.8 Jg-1K-1. The thermal conductivity of glass (the amount of heat transmitted through a unit thickness – in a direction normal to a surface of unit area – due to unit temperature gradient under steady state conditions) is -1 Wm-1K-1. The relatively low specific heat, high thermal conductivity, and the use of less volumes of the

material mean glass members have lower thermal mass than that of equivalent concrete/steel/masonry structures.

2.3.3 Stress corrosion cracking

Despite its well-known chemical inertness characteristics, glass is susceptible to stress corrosion cracking: small flaws grow slowly when exposed to crack-opening stresses in the presence of water or water vapour. This phenomenon is also known as ‘static fatigue’ or ‘slow crack growth’. Typically, under moderate tensile stresses, subcritical cracks in silica-glass can propagate at velocities of 10-12 to 10-5 ms-1 (Lechenault et al., 2011). The mechanism of stress corrosion cracking is complex, and despite the problem has been studied since 1960s (Wiederhorn, 1968; 1969), the process is not yet fully understood. One of the most acknowledged mechanisms was proposed by Michalske and Bunker (1984): water molecules break the Si-O bonds located at the crack tip as a result of a hydrolysis reaction. Under modest applied tensile stresses, the crack velocity is governed by the rate of the chemical reaction, which depends on both the degree of humidity and the applied tensile stress. Because of stress corrosion cracking, the strength of glass depends on the rate of the applied loadings. In-depth discussions of stress corrosion cracking in glass may be found in elsewhere (Ciccotti, 2009).

2.3.4 Surface Coatings

Properties such as visual appearance, optical, and thermal properties of float glass may be modified by applying surface coatings. For instance, coatings can regulate certain wavelengths of visible and non-visible light which are reflected and/or transmitted through glass, and thereby able to control solar energy passing

through the glass or to reflect the heat energy back inside the building. The coatings may be applied either offline or online. Offline coatings are applied after the glass is manufactured and cut, usually by dipping glass panes into chemical solutions or by the evaporation of metals onto surfaces in a vacuum. Coatings which give different colours, reflectivity and thermal properties are applied in this way. Online coatings are applied whilst the glass is hot and still in the lehr, and as a result, they form a strong bond to the glass and are usually more durable than offline coatings. Solar control and low emissivity (low-e) coatings are mostly applied online. Multifunctional coatings are used in modern high-tech glass products, the coatings do not adversely affect the desired properties of the original glass. The coatings are durable and usually last as long as the glass member.

2.4 Features and Effectiveness of glass in buildings

Energy required for heating, cooling, lighting, and ventilating of conventional buildings contributes to a major portion of the total carbon footprint. By combining the knowledge of 'Building Engineering Physics' (iexploitation of natural science that relates to the performance of buildings and their indoor and outdoor designs) together with the creative use of glass in building envelops, it is possible to reduce the demand for artificial energy.

2.4.1 Day lighting

The most striking property of soda-lime glass is its transparency to visible light. Glass has a refractive index of 1.5, and the reflection of visual light is about 4% per surface; hence, the transmissivity of one glass sheet (ie, two surfaces) is more than 90% (Haldimann et al., 2008). By applying special surface coatings, the transmissivity of glass can be further improved and such high-transmissivity glass are

available in the market. Because of transparency of glass, whether a window or a fully glazed facade, can provide invaluable day lighting into buildings.

Glass absorbs, refracts or transmits light. It can be made transparent or translucent so it adds extraordinary beauty to the building. Glass transmits up to 80% of available natural day light in both directions without any yellowing, clouding or weathering (Brookes & Grech, 1996). Glass allows natural light to enter the house even if doors/windows are closed so thus it saves energy and also lowers the electricity bills, brightens up the room and brings out the beauty of the home, and most importantly it boosts the mood of occupant. Day lighting is essential for the function of the buildings, and it also helps to improve the health and productivity and to regulate the biological clock of the occupants (Aboulnaga, 2006).

According to Aboulnaga (2006), proper day lighting designs can avoid the need for artificial lighting for a majority of the day/year, and consequently, can lead to 30–50% savings in the total energy bill of certain buildings. Although daylighting can easily be provided through glass windows/facades, it is necessary to monitor the intensity, distribution, glare, colour rendering, etc., to create stimulating high quality interior environments. To achieve a good lighting design, many factors must be taken into account: characteristics of glazing and its orientation, solar control elements such as blinds and louvers, the geometry and the space organisation of the building, surface properties of internal partitions, and distance and orientation with respect to windows/glazing.

Inefficient designs could lead not only to poor day lighting, but could also adversely affect the comfort and the productivity of the occupants. Day lighting systems should be free from too much solar gain, brightness, glare, non-uniform lighting, etc. Solar control can be achieved by using specially designed solar control

glass. It is possible to offset glare interfering with work tasks such as computer screens by the use of exterior shading, window blinds, reflective louvers, low-transmission glass, and optimal placement of windows/glazing. The provision of high windows with sloped celling together with light shelves that redirect light brings daylight deep into interior spaces without overheating and glare. Readers interested in in-depth discussions of day lighting designs should refer to subject specific text (Baker & Steemers, 2014).

2.4.2 Solar control glass

Visual light passes through glass, and heats up the interior. The emitted long-wave thermal radiation is unable to escape through glass because it is absorbed by Si-O groups; this origins the greenhouse effect. In winter, the fact that glass allows solar gain as well as light into the building is beneficial, but in summer months, without solar control, it can become uncomfortably warm. Glass building envelops should be able to ensure maximum comfort, aesthetic appearance whilst minimising the energy consumption throughout the year irrespective of the climatic conditions. The solar control glass products available in the market can be used to avoid overheating of buildings whilst still maintaining high levels of daylight when exposed to sun. Solar control glass is required in buildings which have large areas of glass facades such as the modern commercial building.

Solar control glass regulates solar radiation by managing reflection, transmittance and absorption. In the past, highly reflective glass was used in windows to control solar gain, but the use of reflective glass also reduces daylight entering the buildings and the mirror-like buildings, as a result of reflection of light, are not architecturally pleasing. Modern solar control glass uses tinted/translucent/opaque/

patterned coatings or interlayers to regulate the passage of solar radiation. Solar control glass with interlayers that blocks UV (ultra violet) light can be used to protect materials which are sensitive to UV (Nitz & Hartwig, 2005). Generally, modern solar control glass products possess multifunctional benefits, such as low-e, thermal insulation, noise/sound control, etc. In-depth discussions of solar-controlling technologies used in modern glass products can be found in subject specific text (eg, Nitz & Hartwig, 2005; Smith et al., 2002).

2.4.3 Thermally-insulated glazing and low-e glass

Thermal insulation is an issue of great interest in colder countries where energy is required for space heating. Depending on the exposed environment, up to 25% of the heat from residential and commercial buildings may escape through the windows (Jelle et al., 2012). To minimise the environmental impacts and the rising energy bills, it is essential to save energy. The United Kingdom and other governments regulate minimum requirement for the energy efficiency. For instance, the 'Green Deal' introduced in the United Kingdom encourages home owners to enhance energy efficiency through the provision of an upfront finance to undertake energy improvement measures, with repayments over time offset by savings on energy bill (Great Britain, 2010). Thermally-insulated glass can stabilise the internal temperature, and consequently be able to reduce the energy need for heating and cooling. Improvements in thermal insulation also allow the incorporation of larger areas of glazing for daylighting and solar gain.

The recent advances in thermally insulated glazing technology include insulating glass units (IGU) and low-e glass along with the improvements in frames and spacing designs (Sadineni et al., 2011). In an IGU unit, two or more glass panes

enclose a sealed air space whilst the whole unit is assembled by a secondary edge seal, usually silicone. IGUs have low heat transfer coefficients (*U*-values) of about 1 Wm 2K-1 and about 0.7 Wm-2K-1 for double glazed and triple glazed units, respectively; the values are significantly lower than the *U* value of 5.8 Wm-2K-1 of conventional single glazing (Haldimann et al., 2008). Low-e glass has an invisible coating (usually tin oxide or a silver-based coating) (Hammarberg & Roos, 2003) that regulates wavelengths of energy, thereby reducing the heat transfer and reflecting the heat back into the interior. Low-e glass is more suitable for rooms/buildings which have high proportions of windows/glass doors. Manufacturers of low-e glass products (Pilkington, 2015b; Dupont, 2015) claim savings up to 75% compared to conventional single glazing. In-depth discussions of thermal insulating technologies used in modern glass products can be found in subject specific text (Sadineni et al., 2011).

2.4.4 Noise control glass

Since the windows is the primary path through which noise enters a building, it is necessary to have sound insulation glass in nosier environments, such as those close to airports, highways, cities, etc. Propagation of sound may be retarded by either reflecting the noise back towards the source, or by absorbing the energy within the glass. Resin-based interlayers, those bonded between the glass sheets of laminated glass, are used to reduce the propagation of sound through glass windows. Damping effects of the interlayer retard the vibrations, thereby suppressing the acoustic noise. The mass of the glass also has a significant effect on the sound attenuation; thick glass laminates usually possess satisfactory acoustic properties. Noise control, laminated glass are available in combination with other special properties such solar control and

low-e. In-depth discussions of noise-controlling technologies used in modern glass products can be found in subject specific text (Zhu et al., 2004).

2.4.5 Vibration control glass

As in noise control glass, dissipation of energy is required to control vibrations. Viscoelastic materials are widely used in many industries to damp vibrations; laminated glass with interlayers, which possess damping properties, are widely used in glass members subject to vibration-induced loadings, for instance, in floor plates and treads for staircases in buildings (Haldimann et al., 2008). A more in-depth discussion of contemporary glass products is beyond the scope of this chapter. Interested readers should refer to detailed text on the subject (Koutsawa and Daya, 2007).

2.4.6 Self-cleaning glass

Build-up of dirt (soiling) and the subsequent decay of optical properties is one of the main problems encountered in high-rise buildings with large glazing. Chabasa (2008) shows a glass window which has lost optical properties as a result of the built-up of dirt. Due to the cost and the challenge associated with cleaning of dirty glass, the use of self-cleaning glazing has become popular in recent years. A special coating (usually, nanostructured TiO2), which has an innovative dual action, is used in modern self-cleaning glass products. Once exposed to sunlight (UV radiation), the coating chemically reacts with oxygen and the water molecules present in the atmosphere, and subsequently breaks down the organic dirt deposits, for example, bird droppings (Haldimann et al., 2008; Chabasa, 2008). The rain water then easily washes away the loosened particles. Self-cleaning glass also functions well in prolonged dry spells and in areas those protected from direct rainfall; it is only

necessary to washes down with water. Similar to other special coatings, self-cleaning glass can be combined with other properties such as solar control. In-depth discussions of modern self-cleaning glass technologies can be found in subject specific text (Chabasa, 2008).

2.3.7 Fire resistance glass

The resistance of glass to high temperatures is low, and glass transmits heat rapidly. Float glass usually breaks due to thermal shock when the temperature difference is about 40 oC, whereas toughened glass can withstand temperature differences up to 200oC (IStructE, 2014). Glass also starts to soften and loses stiffness at temperatures above the glass transition temperature (~500oC). Special fire-resistance glass is required to achieve satisfactory performances against fire. Borosilicate glass has relatively high resistances to thermal shocks as opposed to soda-lime glass, since its thermal expansion coefficient (9x10-6 K-1) is higher than that of soda-silica glass (6 x10-6 K-1). The modern fire-resistance glass products use laminated glass with intumescent interlayers (Haldimann et al., 2008). When one side of the laminate exposes to a fire, the interlayer expands into an insulating foam after absorbing heat from the fire, and subsequently protects the second glass sheet (Haldimann et al., 2008). The modern glass products have potential to withstand moderate fires expected in residential/commercial buildings for up to 3 hours (Pilkington, 2015a). Old technologies of fire-resistance glass include laminated glass with a wire mesh, in which the wire mesh keeps glass in place after it cracks. Although the application of a wire mesh has potential to improve the fire resistance, it weakens the glass due to the surface flaws induced by the wire mesh.

2.5 Security implications of using glass building construction

Bos (2009) reported that glass in building have serious security implication. According to the study majority of the respondents (97%) indicated that glass allow people to see through the building which has serious implication on the lives and property in that building. Also, 89% of them indicated that glass buildings can easily be broken by thieves whereas 73% are of the view that strong winds can break the building giving way to criminal operations. According to the study by Starossek and Haberland (2012) glass can be broken easily and it causes danger to human life and severe economic consequences. This development validates the literature by Calgarian (2007) which revealed that glass in building construction can breaks easily. Calgarian mentioned that this can be prevented, or at least minimized, by using glazing or opening protection systems that have been designed to resist wind and windborne debris forces specified in the building code this in the long run makes glass buildings safer for habitation. Impact-resistant such as debris-resistant systems provides protection through the use of laminated glass or polycarbonate glazing systems which also make them conducive for use. However it appeared that glass buildings are not safer as compared to other buildings (Calgarian, 2007).

In coastal environments, numerous post-disaster investigations conducted by FEMA have shown that windows and glazed portions of doors are vulnerable to impact from windborne debris. This impact force is the principal failure mode for these systems. Debris from the natural environment (e.g., tree limbs) and from the built environment (e.g., roofing material, siding material, sawn lumber, etc.) can become windborne debris and break window and door glazing. Once broken, windows and glazed portions of doors can allow wind, windborne debris, and rain into the interior of the building (Gratia & Herde, 2007). This in effect in the long run

can result in the following: large amounts of water may enter a building and damage its contents and finishes. There is also the possibility that the water could compromise certain structural members. If water intrusion occurs, action will not only be needed to eliminate the water-induced damages on appurtenances (such as carpets, cabinets, and floors), but also to mitigate all potential long-term moisture problems associated with certain construction materials. Wind forces or pressures inside a building are dramatically increased when the building's envelope is breached. It is not uncommon to observe significant damage to structural and nonstructural building elements from this internal pressurization. Such damage may remain isolated to a small area or room or it may result in damage severe enough to initiate the complete structural failure of the building.

According to Alibaba and Ozdeniz (2011), water leakage around windows and doors is also quite common but because the effects of leakage are often subtle, the full effects of leakage are often not readily apparent. Leakage from poor flashing or weather stripping, from improper installation, or from doors or windows being inadequate to resist local conditions can allow water to enter a building's interior even when the structure of the window or door remains intact. Water intrusion can cause rot and fastener corrosion that weaken the window or door frame or the wall framing itself. Leakage can also cause damage to interior finishes and facilitate mold growth (Alibaba & Ozdeniz, 2011).

Wind pressure failure of glazing is also occasionally observed. Windows and doors can fail if they are not strong enough to resist wind pressures from a high-wind event or if forces exerted on the doors or windows exceed the strength of their anchorage. When strength is inadequate, the window or door's glazing or frames fail; when anchorage is inadequate, the entire door or window unit can be torn from its

mounting. Negative pressure (i.e., suction) failures are more common but positive pressure failures can occur as well (Haldimann, Luible & Overend 2008).

2.5.1 Importance of facades

Facade has essential role in performance and presentation of any building, its integral part of any building and bearing different responsibilities at a same time. In presentation aspect, facade plays important role such as clients, sponsors or even road passers position the image of building and organization in their mind and perceive their level of professionalism and how much they care their assets (Billow, 2012). Facade should be strong enough to prevent the forces of nature that act or might influence with change in climate on building such as wind, gravity, seismic loading and extreme temperatures need to be evaluated and resisted. With the responsibility of all functions facade should be smart enough to act in intelligent way such as should possess ability to save energy that can be utilized when needed.

As requested by Divsalar (2010) beside architectural aspect there is another leading responsibility of facade in this 21st century, in this era when security has got first priority, façade should able to protect and prevent any uncertain situation of violent attacks or minimize the damages. According to Ballast (2007), it is necessary to further specialized the components and planning processes of facades to increase differentiation in their functionalities. That is why climate engineering and Facade planning has become an essential part of the planning process and influence the performance of the facades. It is also established in literature that, with adequate installation of facades makes glass buildings difficult to break by thieves and allies thereby protecting such buildings from the activities of stealing, air disturbances/noise etc. (Giord, 2007). The major functionality of building facades are as following:

1. **Buffer and Regulating Functions**

   Buffer zones are created with double glass skins in order to give protection from the sun and to avoid direct exposure of the work space to the sun. It also deters the sound and chaos to reach inside the room of building codes. To control airing in work place it is required to manage substantial amount of inner glass screen. Living Quarters through the shared outdoor corridors (Billow, 2012).

2. **Visual Functions**

   Facade are considered as aesthetic signature of any building, they offer different and important advantages, they are aesthetic as well as responsible for diverse functions, such as main appearance is necessary because it stands out and in term of functionality it works as solar protection. It is linked with climate development. In Hospital Manuela Gonzalez, Torre de Especial utilized his idea and introduced Exquisite embroidery in building construction. Mexico is considered as highly airy city, where a 2500 meter square crystal facade composed of three dimensional architectural modules with photo catalytic pollution-fighting technology is been used in developing high-rise buildings. This decorative architectural module actually decreases the air pollution in urban areas (Hadden & Lee, 2002).

The modules discussed are highly decorative modules use “ornament”, which act as a synergy between design form and molecular technology. The undulating shapes maximize the surface area of active coating to diffuse light, air turbulence and pollution. These modules contain superfine titanium dioxide a pollution-fighting technology that activate through ambient daylight (Hadden & Lee, 2002).

3. **Hygienic Function**

A comparative study of German Federal Ministry of Research and Technology (1998) proved that in offices employees feel more comfortable in naturally ventilated rooms as compared to air conditioned spaces. To work in naturally ventilated room increased their productivity at workplace. So features of room plays significant role in hygiene. If room is naturally ventilated contaminations such as dust, gases, CO2, odors, viruses and bacteria will not stay in room (Chikaher & Hirst, 2007).

4. **Acoustic Functions**

Acoustic function involves protection from noise pollution, and sound can be transmitted from outside, inside the building and can also be self-created sound or their reflections.

2.6 Sustainability of glass building Construction

According to Bolin (2009), Glass is 100% recyclable and it does not degrade during the recycling process, hence it can be recycled again and again without loss of quality or purity. Climatic forces have been an important factor ever since man first constructed shelter. Throughout architectural history, local builders have used great resourcefulness in providing the most comfortable internal conditions possible within the constraints and requirements of the local climates (Jones, 1998). Countries in the tropics have a long history of sustainable buildings in their vernacular architecture. The hot and dry regions for instance, developed over centuries, appropriate materials, a perfect balance of shading and day lighting, natural ventilation and heat storage to suit their climatic conditions. In the hot and humid regions natural ventilation and shading systems were perfectly adapted to the local climate as well (Laar & Grimme,

2002). However a lot have changed with the introduction of air conditioners, extractors, artificial lighting, etc. Design and construction of buildings have become independent from the prevailing climatic conditions. Aesthetics has become the main aim for the design of buildings, overshadowing sustainability (Laar & Grimme, 2002).

According to Koenisberger et al., (1980), buildings have to be opened up to breezes and orientated to catch available air movement in order for heat to be removed from the occupants' body into the environment. Other features that were suggested by Koenisberger et al. (1980) are shading devices to reduce radiation from the sky. According to Jones (1998), some of the important considerations for buildings in tropical regions are 'natural ventilation, mechanical ventilation, night ventilation, artificial cooling, free cooling, light weight construction, day lighting and solar shading/control'. Stagno (2001) also suggests that in order to achieve an acceptable level of habitability and comfort in buildings in the tropics, consideration must be given to variables like 'the problems of excess rainwater disposal, air-cooling, decreasing relative humidity levels and reduction of excessive glare from the sun' and existing environmental factors. According to Bay and Ong (2006), 'shading devices with verandas, sun breaks, and appropriate openings, is always more efficient and cheaper than any glass technology for climatic control in subtropical regions'.

2.6.1 Safety glasses

The following safety glasses were identified by Matteis, Brando and Mazzolani (2012) as some of the precaution glasses that can easily cause injury if not properly handled, glazing material constructed, treated, or combined with other materials so as to reduce, in comparison with ordinary sheet, float or plate glass, the likelihood of injury to persons by objects from exterior sources or by these safety

glasses when they may be cracked or broken. The following are the products in the scope of this research that may be used in safety glazing provided they meet the Bureau of Safety Standards (BSS) conditions and are marked accordingly. Safety glass shall be off our types as follows: 1) Toughened Safety (Tempered) Glass (TS) 2) Toughened Float Safety Glass (TF) 3) Laminated Safety Glass (LS) 4) Laminated Float Safety Glass (LF) Toughened (Tempered) Safety Glass: A single piece of specially heat-treated or chemically treated glass, with a stress pattern such that the piece when fractured reduces to numerous granular fragments, with no large jagged edges. Laminated Safety Glass: Two or more pieces of glass held together by inter leaving layer or layers of plastic materials. The laminated glass will crack and break under sufficient impact, but the pieces of glass tend to adhere to the plastic and do not fly. If a hole is produced, the edges are likely to be less jagged than that would be the case with ordinary glass.

Safety glass can be flat or curved and of any type which includes: Clear, Tinted, Coated, Frosted, Decorative or Mirror. Glasses shall satisfy the relevant resistance to shock test, fragmentation test and warp test for T Sand TF glass and L Sand LF glass hall comply with light stability test, boil test and fracture and adhesion test in accordance with IS.

2.6.2 Application/installation

Many human impact injuries are due to failure to take reasonable safety precautions. Some materials, such as glass, may break under impact and cause injury. Most people are aware of this and treat such materials with due care. However a person's ability to perceive this potential risk and to cope with it can vary. Safety standards are therefore based on a number of factors including the assumption of a

reasonable level of awareness and behavior and also suitable product design and choice of materials (Hong, 2009). Accident statistics show that gazing in some locations in buildings is more vulnerable to human impact than in others. These critical locations are: a) In-and-around doors particularly side panels may be mistaken for doors) At low levels in walls and partitions.

The designer, or specifies, should take precautions to reduce the risk of injuries from accidental human impact in these locations by: a) Selecting glass of a suitable type, thickness and size, primarily with reference to impact behavior and safety characteristics as established by testing in accordance with this guide, b) Providing mechanical protection to glass in critical locations, to prevent fall of glass under impact. c) Enhancing a person's awareness of the presence of glass by incorporating manifestation. Glass in locations other than critical locations is not likely to be subject to human impact and consequently not likely to cause injury. Design of the glazing system should be such that it has the ability to hold glass in place and prevent it from falling out as a whole.

2.6.3 Identification of safety glass

All Safety glasses shall be procured from certified manufacturers and the product shall conform to relevant standards (Watson, 2000). Either a label that cannot be removed and reused or a permanent mark on the glass surface shall mark all the panels of safety glass according to Bureau of Safety Standards (BSS). Each label must contain the ISI mark as prescribed by the BSS, manufacturer’s name, registered trademark or code of the manufacturer or supplier, type of safety glass material, the standard or guidelines to which the safety glass has been tested and the grade of test classification.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter is devoted to the various methods employed in obtaining relevant data for the study. The chapter involved, research design, population of the study, sampling techniques and sample size and data collection instruments.

3.2 Research Design

The study was carried out using a survey designed in which data were collected from a sampled population to determine their current status with respect to various variables. A survey deals with phenomena, as it exists in nature (Mugenda & Mugenda, 2003). Using this design, the researcher attempted to study the use of glass material in building, it health and security implications in the Wa Municipality of the Upper West Region. The advantages of this design were that more extensive and elaborate information was collected facilitating a more realistic analysis.

The survey design allowed for collection of both quantitative and qualitative data at the same time (Borg, Gall & Gall, 1996), it was thought to be suitable to this study. Qualitative data provided detailed information about the phenomenon being studied enabling the researcher to establish patterns, trends, and relationships. Quantitative data on the other hand allowed the researcher to meaningfully describe the distribution of variables using standard statistical procedures (Borg et al., 1996) such as means, frequency distributions and measures of variability.

3.3 Study Population

The population for the study comprised the residence and the building contractors in the Wa Municipality particularly the Central Business District (CBD). Four Major areas were selected. These includes: Dobile, Kambale, Kpaguri and Kabanye. The estimated households and contractors for these areas based on simple random sampling is Five Hundred (500) which constituted the sample population for the study.

3.4 Sampling Techniques and Sample Size

The study adopted purposive sampling technique in selecting respondents for the study. Purposive sampling was used to ensure that all the residents and the contractors who have access and knowledge in the use of glass in building material were included in the study. This is because they are most likely to provide information relating to the use and security implication of glass in building. The study drew one hundred and twenty four (124) residents and ten (10) contractors involved in the execution of glass building in the Wa Municipality. Purposive sampling allowed the researcher to use cases that have the required information with respect to the objectives of the study (Mugenda & Mugenda, 2003).

The study obtained its sample size by assigning quotations to the Communities selected, Dobile, Kambale, Kabanye and Kpaguri. Each Community was assigned with quotation of twenty five per cent (25%) on each of their residents inclusive of contractors. Table 3.1 shows the distribution of the sample size.

Table 3. 1: Sample Size Determination and Distribution

Selected communities	Population	Quotation determination	Sample Size
Dobile	200	[25/100] x 200	50
Kpaguri	100	[25/100] x100	25
Kambale	70	[25/100] x 70	17
Kabanye	130	[25/100] x130	32
Total	**500**		**124**

Source: Survey, 2018

3.5 Data Collection Instrument

Data collection instrument involved questionnaire, interviews and observation

3.5.1 Questionnaires

The questionnaire were designed and developed for the residents in Dobile, Kpaguri Kambale, and Kabanye in the Wa Municipality. The questionnaire sought data on the use of glass in building construction in the Wa Municipality, the effectiveness of glass in building construction, and the security implications of using glass in building in the Wa Municipality. The reasons for the choice of this instrument are because it aided the researcher to easily approach the respondents and it is less expensive and produced speedy results.

3.4.2 Interview

The researcher interviewed ten (10) contractors in Dobile, Kpaguri Kambale, and Kabanye in the Wa Municipality. The interview schedules consisted of open-ended based on the objectives of the study. The interview schedule addressed details on the respondents' views and opinion on the uses of glass in building construction in

the Wa Municipality, the effectiveness of glass in building construction, and the security implications of using glass in building in the Wa Municipality. The interview enabled the researcher to obtain clear and in-depth information. There was the opportunity to ask leading questions whenever the need arose. The researcher in this instance gained rapport which enabled her to obtain information relevant to the dissertation and was permitted to visit interviewees anytime the need arose.

3.4.3 Observation

The researcher took field trip to Dobile, Kpaguri, Kambale, and Kabanye in the Wa Municipality to help in undertaking on-the-spot observation of glass as cladding material in building.

At Dobile; the researcher observed how the major uses of glass in building, the type of glass used and the safeness of glass in building.

At Kpaguri; the researcher observed the uses of glass, the condition of the glass fixed.

At Kambale: the researcher observed the uses and the type of glass being used in the area.

At Kabanye: the researcher observe how the glass is being insolate, the type of glass used and the safeness of glass in building in the area.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter primarily focuses on field data analysis and the discussion of the findings. The chapter specifically concentrates on the demographic characteristics of respondents, use of glass in building construction, the effectiveness of glass in building construction, and the security implications of using glass in building in the Wa Municipality. Out of the One hundred and twenty four (124) questionnaires distributed to the respondents, 112 of them were completed and received for analysis. The remaining 12 could not be completed due to the absence of the respondents as the study progressed.

4.2 Results and Discussion of Questionnaire from Residents

Background Information of Respondents

The demographic characteristics of respondents comprise the age, gender, highest educational level and marital status of the respondents. The demographic characteristics of respondents are essential to analyzing the effectiveness of glass buildings and the underlying security implication of both users and non-users in the Wa municipality.

Table 4. 1: Age of Respondents

Age	Frequency (N)	Percentage (%)
18-24 years	3	2.7
25-34 years	20	17.9
35-44 years	43	38.4
Above 44 years	46	41.1
Total	**112**	**100.0**

Source: Field Survey, 2018

Table 4.1 shows the age group of the respondents. Statistically, 3 respondents representing 2.7% were within the ages of 18-24 years, 20 respondents representing 17.9% were also between the ages of 25-34 years, 43 respondents representing 38.4% were between the ages of 35-44 years. Majority (N=46) of the respondents representing 41.1% were above 44 years. Age category of the respondents was captured in the study to help the researcher assess all the users and non-users of glass in building by the different age category. The results also suggests that majority of the respondents were mature and therefore could be captured in an academic study such as this.

Table 4. 2: Sex of Respondents

Sex	Frequency (N)	Percentage (%)
Male	84	75.0
Female	28	25.0
Total	**112**	**100.0**

Source: Field Survey, 2018

The result on the gender from the respondents indicated that, both males and females were captured in the study. This is because the views of both genders were needed to make fair conclusions on the effectiveness of glass buildings and the underlying security implication of both users and non-users in the Wa municipality. From the statistics, it could be seen that, 84 respondents representing 75.0% were male, while 28 respondents representing 25.0% were female (Table 4.2). This indicates that there were more male respondents than female respondents captured in the study.

Table 4. 3: Highest Educational level

Highest education	Frequency (N)	Percentage (%)
SHS	25	22.3
Diploma/Highest National Diploma	24	21.4
First degree	42	37.5
Master's Degree	21	18.8
Total	112	100.0

Source: Field Survey, 2018

Table 4.3 recorded the educational level of respondents. As depicted in the Table, 25 of them representing 22.3% were Senior High School graduates, 24 respondents constituting 21.4% were Diploma/HND graduates, and 42 respondents representing 37.5% were first degree holders. On the other hand, 21 respondents constituting 18.8% were Master's Degree holders. On the other hand, 8.4% of the total respondents responded to basic education. Educational qualification of the respondents was needed to determine whether educational qualification have an effect on the use of glass as building material.

Table 4. 4: Marital Status of Respondents

Marital Status	Frequency (N)	Percentage (%)
Married	79	70.5
Single	22	19.6
Divorce	11	9.8
Total	112	100.0

Source: Field Survey, 2018

On the question that sought the views the marital status of the respondents, it could be seen that majority (N=79) of the respondents representing 70.5% were married, while 22 respondents constituting 19.6% were singles, and the remaining 11

respondents constituting 9.8% were divorced. This indicates that majority of the respondents studied were married.

Use of glass in building construction in the Wa Municipality

Glass is a magical material which has so many different uses, that it has presented Architects with many new possibilities and designs. Glass is most typically used as transparent glazing material in construction and also used in architectural features. The respondents were asked to indicate glass in building construction in Wa Municipality. Table 4.5 presents the uses of glass material in building in the Wa Municipality.

Table 4. 5: Responses on the use of glass in building construction

Uses of glass in Wa Municipality	N	Responses					Mean	Rank
		SD	D	U	A	SA		
Glass is used for glazing windows	**112**	9 (8.0)	12 (10.7)	2 (1.8)	54 (48.2)	35 (31.3)	3.84	**1**
Glass is used in architectural features like doors	**112**	8 (7.1)	12 (10.7)	4 (3.6)	57 (50.9)	31 (27.7)	3.81	**2**
Glass is used as reinforcement structures	**112**	14 (12.5)	20 (17.9)	3 (2.7)	56 (50.0)	19 (17.0)	3.41	**3**
Glass is used for internal partitions	**112**	18 (16.1)	21 (18.8)	7 (6.3)	49 (43.8)	17 (16.2)	3.23	**4**
Glass is used in the form of block walls	**112**	31 (27.7)	14 (12.5)	5 (4.5)	45 (40.2)	17 (16.2)	3.11	**5**
Glasses are used as a protective system	**112**	37 (33.0)	28 (25.0)	5 (4.5)	29 (25.9)	13 (11.6)	2.58	**6**
Glass is used as roof-lights in the building	**112**	34 (30.4)	42 (37.5)	6 (5.4)	19 (17.0)	11 (9.8)	2.38	**7**
Glass are being used as conservatories and orangeries	**112**	39 (34.8)	35 (31.3)	6 (5.4)	27 (24.1)	5 (4.5)	2.32	**8**

Key: *SD=Strongly agree, D=Disagree, U=Uncertain, A=Agree, SA=Strongly agree*
Source: Field Survey, 2018

Table 4.5 shows varying views of the respondents on the use of glass in building construction in Wa Municipality. From Table 4.5, 54 respondents constituting 48.2% and 35 of them representing 31.3% agreed and strongly agreed respectively to the statement that glass is used for glazing windows. Conversely, 9 respondents constituting 8.0% and 12 respondents constituting 10.7% strongly disagreed and disagreed respectively to the statement. Meanwhile the remaining 2 of them forming 1.8% remained uncertain on the statement. Moreover, on the issue that glass is used in architectural features like doors, 57 respondents representing 50.9% agreed and 31 respondents constituting 27.7% strongly agreed to the statement. On the other hand, 8 respondents representing 7.1% strongly disagreed and 12 respondents constituting 10.7% disagreed to the statement that glass is used in architectural features like doors in Wa Municipality. However, 4 respondents representing 3.6 remained uncertain to the statement. As per Halliday (2008), glass can be used in a variety of commercial and residential applications, including doors, and windows. According to Stagno (2001), glass is most typically used as transparent glazing material in construction and also used in architectural features like doors, and windows. Taylor (2000) on the other hand indicated that glass is the most common material used in windows and doors.

On whether glass is used as reinforcement structures, 56 respondents representing 50.0% and 19 of them representing 17.0% agreed and strongly agreed respectively to the statement. On the contrary, 14 respondent representing 12.5% and 20 respondents representing 17.9% strongly disagreed and disagreed respectively to the statement. Again, 3 respondents representing 2.7% were uncertain as to whether glass is used as reinforcement. According to the report by Chikaher and Hirst (2007) who found that glass has a wide range of applications in building structures as

reinforcement. Creative architects are building structures ranging from arching canopies and rising facades to delicate cubes and footbridges entirely of glass**.** Architects can make use of the strength of modern glass for structural purposes and can use it in creative way.

Furthermore, in answering the questions of whether glass is used for internal partition, 49 respondents constituting 43.8% and 17 respondents representing 16.2% agreed and strongly agreed respectively to the statement. On the contrary, 18 of them representing 16.1% and 21 respondents constituting 18.8% strongly disagreed and disagreed respectively to the statement that glass is use for internal partitions. The remaining 7 respondent constituting 6.3% were uncertain about the statement. The finding concurs with the study by Calgarian (2007) who emphasized that glass is used for internal partitions and as an architectural feature. As per Ballast (2007), interior designers make use of the glass in partitions, walls and counter tops.

On whether glass is used in the form of block walls, 45 respondents representing 40.2% agreed and 17 of them constituting 16.2% strongly agreed to the statement. Conversely, 31 respondents representing 27.7% and 14 respondents constituting 12.5% strongly disagreed and disagreed respectively to the statement that glass is used in the form of block walls. The remaining 5 respondents constituting 4.5% remained uncertain to the statement. The finding agrees with the study by Ballast (2007) that interior designers make use of the glass in block walls.

Moreover, in answering the question of whether glasses are used as protective system, 29 respondents representing 25.9% and 13 of them constituting 11.6% agreed and strongly agreed respectively to the statement. However, 37 respondents representing 33.0% and 28 respondents constituting 25.0% strongly disagreed and disagreed respectively to the statement, while 5 respondents constituting 4.5% were

uncertain to the statement that glasses are used as protective. In addition, on whether glass is used as roof-lights in the building, 19 respondents constituting 17.0% and 11 respondents representing 9.8% agreed and strongly agreed respectively to the statement. However, 34 respondents constituting 30.4% and 42 respondents representing 37.5% strongly disagreed and disagreed respectively to the statement, whilst 6 respondents representing 5.4% remained uncertain to the statement. As to whether glasses are being used as conservatories and orangeries, 27 respondents constituting 24.1%, and 5 respondents representing 4.5% agreed and strongly agreed respectively to the statement. Interestingly, 39 respondents constituting 34.8% and 35 respondents representing 31.3% strongly disagreed and disagreed respectively to the statement that glasses are being used as conservatories and orangeries. Meanwhile, 6 respondents representing 5.4% remained uncertain on the statement as to whether glasses are being used as conservatories and orangeries.

The study reveals that in Wa Municipality, glasses in building are mostly used for, architectural features like doors, windows, and partitions. Furthermore, it appeared that glasses are used for reinforcement structures, and in the form of block walls. As per Halliday (2008), glass can be used in a variety of commercial and residential applications, including doors, windows, roof-lights, glass facades, conservatories and orangeries. Pilkington (2008) on the other hand viewed that there has been this revolution of the use of glazing (aluminium doors and windows, curtain walling), as against the use of traditional doors and window (louvers and timber doors) and sandcrete block walls.

Table 4. 6: Factors accounting for the use of glass

Factors	Frequency (N)	Percentage (%)
Durability	37	33.0
Aesthetics	30	26.8
Transparency	27	24.1
Security	3	2.7
Sustainability	9	8.0
Cost	6	5.4
Total	**112**	**100.0**

Source: Field Survey, 2018

On the factors accounting for the use glass in building construction, 37 respondents constituting 33.0% indicated glass is highly durable, while 30 respondents forming 26.8% affirmed that glass is used in building construction because of its aesthetics. Moreover, 27 respondents representing 24.1 % affirmed that the transparency of glass accounts for the use of glass in building construction. Moreover, 3 respondents representing 2.7% indicated that the security of glass accounts for its usage, 9 respondents representing 8.0% mentioned that sustainability accounts for the use of glass in building construction. On the other hand, 6 respondents representing 5.4% indicated that the cost of glass accounts for their usage in building construction (Table 4.6). This implies that durability, aesthetics, and transparency of glass accounts for its usage in building construction. According to Amoa-Abban (2017), glass is extremely durable and has excellent resistance to salt water, strong acids, organic acids, ultraviolet radiation and aerated water and has poor resistance to strong alkali. The beauty of the façade alone is enough for designers to use glass as cladding material (Amoa-Abbah, 2017).

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Effectiveness of glass in building construction in the Wa Municipality

Glass is one of the most sophisticated and versatile materials used in the construction industry. Extensive use of glass helps in creating a very hi-tech and modern look in buildings.

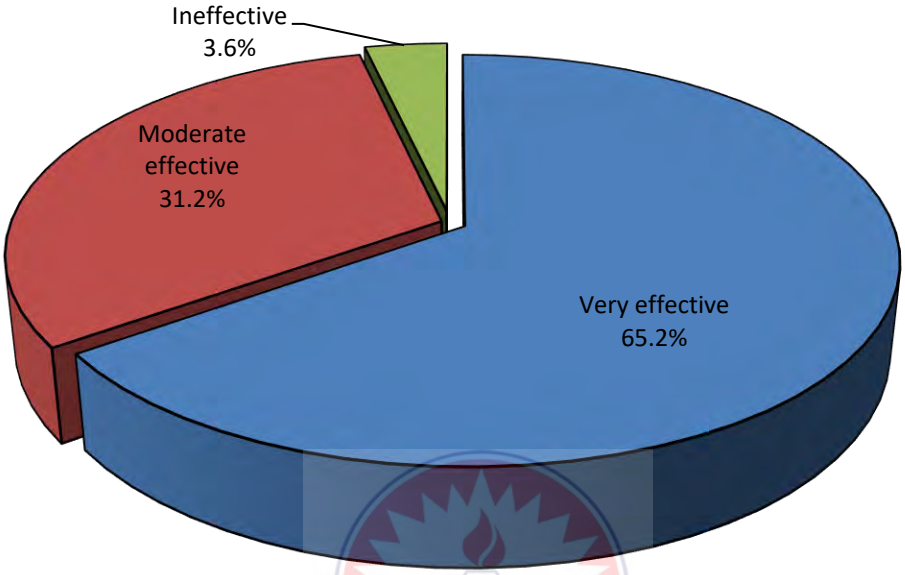

Figure 4. 1: Effectiveness of Glass in building
Source: Field Work, 2018

Respondents were asked to indicate whether glass in building construction is effective. Statistically, results (Figure 4.1) have shown that 73 respondents representing 65.2% indicated that glass in building construction is very effective. In addition, 35 respondents constituting 31.2% indicated that glass in building construction is moderately effective. However, 4 respondents constituting 3.6% asserted that glass in building is ineffective. Haldimann et al. (2008) emphasized that glass is effective in architecture work. According to Haldimann et al. the recent developments of high-tech glass products expands the range of applications of glass beyond the merely decorative, to functional and structural roles. Light, comfort, well-being, style, safety, security, and sustainability are among the benefits that can be achieved from the appropriate use of modern glass products in buildings.

Table 4. 7: Responses on the effective use of glass in building

Effectiveness	N	Responses					Mean	Rank
		1	2	3	4	5		
Resistance to corrosion	**112**	14 (12.5)	11 (9.8)	3 (2.7)	52 (46.4)	32 (28.6)	3.69	**1**
Glass has the ability to make the structure look more stunning, sophisticated and adds beauty to the building	**112**	27 (24.1)	30 (26.8)	7 (6.3)	35 (31.3)	13 (11.6)	3.59	**2**
Glass has a smooth, glossy surface so it is dust proof and can be easily cleaned	**112**	24 (21.4)	14 (12.5)	9 (8.0)	50 (44.6)	15 (13.4)	3.16	**3**
Glass absorb, refracts or transmits light	**112**	27 (24.1)	13 (11.6)	8 (7.1)	46 (41.1)	18 (16.1)	3.13	**4**
Glass saves space when used in the interiors	**112**	14 (12.5)	16 (14.3)	--	54 (48.2)	28 (25.0)	3.09	**5**
Reduction of energy consumption	**112**	27 (24.1)	30 (26.8)	7 (6.8)	35 (31.3)	13 (11.6)	2.79	**6**
Glass is resistant to weather and hold up to the effects of the wind, rain, or the sun.	**112**	33 (29.5)	35 (31.3)	4 (3.6)	25 (22.3)	15 (13.4)	2.59	**7**
Glass is unaffected by noise, air, water.	**112**	35 (31.3)	34 (30.4)	7 (6.3)	26 (23.2)	10 (8.9)	2.48	**8**

Key: *1=Very ineffective, 2=somewhat ineffective, 3=Neither effective nor ineffective, 4=somewhat effective, 5=very effective*

Source: Field Survey, 2018

Table 4.7, shows the varying opinions of respondents on the effective use of glass in building construction. On the issue that glass in building is effective in resistance to corrosion, 52 respondents constituting 46.4% and 32 of them representing 28.6% indicated that it is somewhat effective and very effective respectively to the statement. On the other hand, 14 respondents forming 12.5% and 11 respondents constituting 9.8% affirmed that glass is very ineffective and somewhat ineffective respectively to that effect, whilst 3 respondents representing 2.7% remained uncertain. Bilgen (1994) emphasized that glass can resist corrosion. It does

not rust so it does not degrade gradually by chemical and surrounding environment effects.

On the question of whether glass is effective to make the structure look more stunning, sophisticated and adds beauty to the building, 35 respondents representing 31.3% and 13 respondents representing 11.6% affirmed that glass is somewhat effective and very effective respectively to the statement. On the other hand, 27 respondent representing 24.1%, and 30 respondents constituting 26.8% indicated that it is very ineffective and somewhat ineffective respectively to the statement, whereas 7 of them representing 6.3% were remained uncertain to the statement. As per Billow (2012), glass has the ability to make the structure look more stunning, sophisticated and adds beauty to the building. It is used to achieve the architectural view for external decoration and when used in the interiors, glass saves space.

In answering the question on whether glass is effective in terms of its smoothness, glossiness so it is dust proof and can be easily cleaned, 50 respondents representing 44.6% and 15 of them constituting 13.4% affirmed that glass is somewhat effective and very effective respectively to the statement. However, 24 respondents representing 21.4% and 14 respondents constituting 12.5% indicated that glass is very ineffective and somewhat ineffective respectively to the statement, while 9 respondents constituting 8.0% remained uncertain to that effect. Burch and Tread (1978) glass has a smooth glossy surface so it is dust proof and can be easily cleaned.

Concerning the issue that glass absorbs, refracts or transmits light, 46 respondents representing 41.1% and 18 respondents constituting 16.1% revealed that glass is somewhat effective and very effective respectively to the statement. On the other hand, 27 respondents constituting 24.1% and 13 of them representing 11.6% responded that glass is very ineffective and somewhat ineffective respectively to the

statement, whiles 8 respondents representing 7.1% remained uncertain on statement. The most striking property of soda-lime glass is its transparency to visible light. Glass has a refractive index of 1.5, and the reflection of visual light is about 4% per surface; hence, the transmissivity of one glass sheet (ie, two surfaces) is more than 90% (Haldimann et al., 2008). The view of the respondents concurs with the study by Brookes and Grech (1996) who emphasized that glass absorbs, refracts or transmits light. It can be made transparent or translucent so it adds extraordinary beauty to the building. Glass transmits up to 80% of available natural day light in both directions without any yellowing, clouding or weathering . Glass allows natural light to enter the house even if doors/windows are closed so thus it saves energy and also lowers the electricity bills, brightens up the room and brings out the beauty of the home, and most importantly it boosts the mood of occupant. Day lighting is essential for the function of the buildings, and it also helps to improve the health and productivity and to regulate the biological clock of the occupants (Aboulnaga, 2006).

The views of respondents were sought on whether glass save space when used in the interiors, 54 respondents representing 48.2%, and 25 respondents constituting 25.0% responded to somewhat effective and very effective respectively to the statement. However, 14 respondents constituting 12.5%, and 16 respondents representing 14.3% gave a response to very ineffective and somewhat ineffective respectively to the statement. In the study by Wurms (2007), the glass is used as curtain walling in the façade the interiors are flooded with natural light throughout the day thus increasing the working efficiency of its occupants. Glass is a very Light weight building material hence helps in reducing the dead load of the Building. It offers unobstructed views thus making the interiors look big. When used in the

exteriors it helps in bringing the outdoors into the indoors (Laar & Grimme, 2002; Lloyd, 1998).

In responding to whether glass reduces energy consumption, 35 respondents representing 31.3% and 13 respondents constituting 11.6% responded to somewhat effective to the statement. However, 27 respondents constituting 24.1% and 30 respondents representing 26.8% responded to very ineffective and somewhat ineffective respectively to the statement, whilst 7 respondents representing 6.8% remained uncertain that glass reduces energy consumption. Again, on the issue that glass is resistant to weather and hold up to the effects of the wind, rain, or the sun, 25 respondents constituting 22.3% and 15 respondents representing 13.4% asserted that glass is somewhat effective and very effective respectively to the statement. On the other hand, 33 respondents representing 29.5% and 35 respondents representing 31.3% responded to very ineffective and somewhat ineffective respectively to the statement, whiles 4 respondents constituting 3.6% remained uncertain to the statement. Yeang (1996) indicated that glass is fully weather resistance so it can withstand the effects of the wind, rain, or the sun and can retain its appearance and integrity. Glass provides an ideal way to showcase a product (Yeang, 1996).

On whether glass is unaffected by noise, air and water, 26 respondents constituting 23.2% and 10 respondents constituting 8.9% asserted that glass is somewhat effective and very effective respectively to the statement. Interestingly, 35 respondents representing 31.3% and 34 respondents constituting 30.4% gave a response to very ineffective and somewhat ineffective respectively to the statement that glass is unaffected by noise, air, and water. On the other hand, 7 respondents constituting 6.3% remained uncertain to the statement According to Kadir (2005), glass is unaffected by noise, air, water and most of the acids hence discoloration,

alteration in the degree of shine, softening, swelling, the detachment of coatings and blistering will not occur. According to Zhu et al. (2004), propagation of sound may be retarded by either reflecting the noise back towards the source, or by absorbing the energy within the glass. Resin-based interlayers, those bonded between the glass sheets of laminated glass, are used to reduce the propagation of sound through glass windows.

The result indicates that glass in building construction is effective as it resists corrosion, makes structure look more stunning, sophisticated and adds beauty to the building, it is dust proof and can be easily cleaned, absorb, refracts or transmits, and saves space when used in the interiors.

Security implications of using glass in building in the Wa Municipality

Table 4.8, shows the varying views of the users and non-users on the security implication of using glass in building.

Table 4. 8: Responses on the security implication of using glass in building

Question	Response	Frequency (N)	Percentage (%)
Are there any security implication of using glass in building	Yes	89	79.5
	No	18	16.1
	I don't know	5	4.5
Total		**112**	**100.0**

In determining the security implication of using glass in building, 89 respondents representing 79.5% said "Yes"; thus, there are security implication of using glass in building. They opined that glass allow people to see through which has serious implication on the property in the building and can easily be broken. Moreover, 18 respondents representing 16.1% said "No", and the remaining 5

respondents representing 4.5% answered to "I don't know" option. The percentages above shows that glass in building construction have serious implication on the live and property in the building. The result agrees with the study by study by Bos (2009) reported that glass in building have serious implication. According to the study majority of the respondents (97%) indicated that glass allow people to see through the building which has serious implication on the lives and property in that building. Also, 89% of them indicated that glass buildings can easily be broken by thieves whereas 73% are of the view that strong winds can break the building giving way to criminal operations. According to the study by Starossek and Haberland (2012) glass can be broken easily and it causes danger to human life and severe economic consequences. This development validates the literature by Calgarian (2007) which revealed that glass in building construction can breaks easily. Calgarian mentioned that this can be prevented, or at least minimized, by using glazing or opening protection systems that have been designed to resist wind and windborne debris forces specified in the building code this in the long run makes glass buildings safer for habitation. Impact-resistant such as debris-resistant systems provides protection through the use of laminated glass or polycarbonate glazing systems which also make them conducive for use. However it appeared that glass buildings are not safer as compared to other buildings (Calgarian (2007)

4.3 Results of Interview

Results of Interview from Building Contractors

The researcher interviewed ten (10) contractors in Dobile, Kpaguri Kambale, and Kabanye in the Wa Municipality. For the purpose of anonymity, the interviewees were given pseudonyms; CONS 1 – CONS 10. The interviewed conducted were on

the following sub headings; uses of glass in building construction, effectiveness of glass in building construction, and the security implications of using glass in building.

Uses of glass in building construction in Wa Municipality

The findings revealed that glass is used as a building material, including windows in the external walls. Glass is also used for internal partitions and as an architectural feature. The respondents further mentioned that in the Wa Municipality, glasses are most typically used in architectural features like doors, windows, and partition for most building including banks, supermarkets, boutiques, schools and stores.

CONS 1 indicated that:

> Glass is the dominating material in modern day architectures in Wa Municipality. Glass is no longer just a filler element, but is rather nowadays also used for supporting or enveloping purposes. A closer examination of this multifunctional building material requires a look at its historical background and also at the fast developments of modern times.

According to CONS 2:

> Glass is an unlimited and innovative material that has plenty of applications. Glass is used to transform a building into a thing of natural and elegant beauty

CONS 5 revealed that

> Glass is most typically used as transparent glazing material in the building envelope, including windows in the external walls. Glass is also used for internal partitions and as an architectural feature.

Most respondents affirmed that glass is a magical material which has so many different properties and uses, that it has presented Architects with many new possibilities and designs. Glass is most typically used as transparent glazing material

in construction and also used in architectural features like doors, and windows of many buildings in Wa Municipality. The finding aligns with the study by Bay and Ong (2006) who mentioned that interior designers make use of the glass in doors, partitions, walls and counter tops. A more creative designer also creates transparent staircases, translucent floors, designer ceilings and colorful bookshelves. Creative architects are building structures ranging from arching canopies and rising facades to delicate cubes and footbridges entirely of glass

Effectiveness of glass in building construction

When the contractors were asked about the effectiveness of glass they all seemed to agree that glass is effective in building. They affirmed that glass is fully weather resistance so it can withstand the effects of the wind, rain, or the sun and can retain its appearance and integrity. They indicated that glass does not rust so it does not degrade gradually by chemical and surrounding environment effects.

CONS "1" for instance had this to say:

> Glass is effective as it can resist the effects of the rain, or the sun and can retain its appearance and integrity…..Glass has a smooth glossy surface so it is dust proof and can be easily cleaned

CONS "2" also stated that:

> Glass is effective as it does not rust. It also has the ability to make the structure look more stunning, sophisticated and adds beauty to the building. It is used to achieve the architectural view for external decoration…….When used in the interiors, glass is effective in saving space.

CONS “6” commented that:

> Using glass in building construction is effective. The glass in building absorbs, refracts or transmits light. It can be made

transparent or translucent so it adds extraordinary beauty to the building. The Glass transmits up to 80% of available natural day light in both directions without any yellowing, clouding or weathering.

"…..The use of glass in building is very effective. In the use of glass it allows natural light to enter the house even if doors/windows are closed so thus it saves energy and also lowers the electricity bills, brightens up the room and brings out the beauty of the home, and most importantly it boosts the mood of occupant…" [CONS 7, 2018].

"…glass architecture admits the light of the moon, and of the stars into the rooms, not only through a few windows, but through as many walls as feasible, these to consist entirely of glass…" (CONS 9, 2018].

More than any other building material, the use of glass in buildings is associated with modernity, both because it was not until close to the mid-20th century that developments in technology allowed the manufacture of large panels of glass that were structurally sound, but also because glass, in many ways, is associated with the modern ethos in architecture of lightness, airiness, transparency and variability…." [CONS 10, 2018].

The view of the participants indicates that glass is effective in building construction. These supports the study by Chabasa (2008) who asserted that glass in building construction can withstand the effects of the sun and can retain its appearance and integrity. It is an excellent insulator against electricity. It is impossible to conduct an electric current under the influence of an electric field. As per Hong (2009), glass can be blown, drawn and pressed to any shape and hence it is used for general glazing purposes in building, shop fronts, building doors and

windows and workshops. It is also used for furniture after being laminated with plywood or metal sheet.

Security implications of using glass in building

When the opinions of contractors were solicited on the security implication of using glass in building, almost all the respondents signifies that glasses in buildings are the weakest element of a house with regard to prevention of burglaries. The respondents affirmed that glasses in building have the tendency to break when expanded with a force that overcomes the internal stress of the material.

CONS "2" signified that:

> Glass in building construction is unsafe; an experienced burglar can break into glass sliding doors as compared to traditional solid hinged doors.

As per CONS 3:

> If a human intruder wanted to enter into a property, he or she will look for any weak spot to exploit. Depending on where the glass is located, it could represent a convenient spot to reach into the house as breaking glass window is easier.

CONS 4 clarify that:

> Glasses in buildings construction break easily. They are the weakest element of a house with regard to prevention of burglaries.

CONS 6 on the same issue said:

> Intruders like sliding glass doors and windows as they create easy entry points to gain access to property, but there are measures that can be taken to make things harder for any possible intruders.

The respondents further mentioned that glass panels on buildings can easily explode and fall on pedestrians, when the buildings are at residential and congested

areas. As per Sørensen (2010), sometimes glass breaks in a building without any obvious cause. When this occurs, it could be due to glass edge damage or surface damage from handling and glazing that then weakens the glass during high winds, building or framing system movement, vandalism or a specific type of inclusion inside the glass.

4.4 Results and Discussion of Observation

Observation at Dobile

At Dobile it was observed that glass is mostly used for sliding glass doors and windows. It was also observed that most commercial buildings glasses are used as cladding material, fulfils a variety of functions from aesthetic point of view, the glass provides transparency and natural light. As depicted in Figure 4.2 and Figure 4.3.

Figure 4. 2: Glass used in building
Source: Field Work, 2018

Figure 4. 3: Glass sliding doors for building
Source: Field Work, 2018

It was observed that glasses in building are mostly used for sliding doors and windows at Dobile. The type of sliding doors in architecture and construction observed, is a large glass window opening in a structure that provide door access from a room to the outdoors, fresh air, and copious natural light. It was viewed that the sliding glass door is a single unit consisting of two panel sections, one being fixed and one a being mobile to slide open. Another design observed was that a wall sized glass

pocket door has one or more panels movable and sliding into wall pockets, completely disappearing for a 'wide open' indoor-outdoor room experience.

Observation at Kpaguri

At Kpaguri, it was observed that glass material is used in architectural features like doors and windows. It was seen that glass window and balcony glass breaks spontaneously and fall which pose danger to residents. Figure 4.4 and Figure 4.5 shows breakages of glass windows.

Figure 4. 4: Glass window hit with stone
Source: Field Work, 2018

Figure 4. 5: Glass window breakages
Source: Field Work, 2018

There are many potential causes for breakage of tempered glass. While such damage may not be readily apparent, stress concentrations around these imperfections can occur as the glass expands and contracts in response to in-service temperature changes, wind load, and other environmental factors.

Observation at Kambale

At Kambale, the researcher observed that there are different types of glass in building construction. Glass is a unique combination of fascinating physical, optical, chemical, and thermal properties makes glass the most preferred construction material in modern buildings. The appropriate use of glass windows, doors, staircases, and

partitions of commercial buildings like banks, stores etc in Wa Municipality makes the buildings look nice and bright and it also enhances comfort of the occupants as can be viewed in Figure 4.6 and Figure 4.7.

Figure 4. 6: GN Bank glaze with glass doors
Source: Field Work, 2018

Figure 4. 7:NHIS office with glass windows
Source: Field Work, 2018

It was observed that the nice buildings in Kambale are decorated with glass windows and doors. Glass in buildings like banks, supermarkets, and boutiques make it nice, transparent and have smooth surfaces.

Observation at Kabanye

The researcher observed at the various houses in Kabanye that glass material can be used for indoor and outdoor designs. Glasses are used for glass panels, floors, staircases and partitions. Figure 4.8 and Figure 4.9 shows the indoor and outdoor designs of buildings in Kabanye.

Figure 4. 8: Glass used for partition
Source: Field Work, 2018

Figure 4. 9: Glass used for staircase
Source: Field Work, 2018

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of findings, draws conclusion arising from the study and makes recommendations based on the findings.

5.2 Summary of Findings

The following are the summary of findings:

- The study shown that, in Wa Municipality, glasses in building are mostly used for architectural features like doors, windows, and partitions. Furthermore, it appeared that glasses are used for reinforcement structures, and in the form of block walls
- The study found that durability, aesthetics, and transparency accounts for glass usage in building construction in the Wa Municipality.
- The result indicated that glass in building construction is effective as it resists corrosion, makes structure look more stunning, sophisticated and adds beauty to the building. The study further revealed that glass has a smooth, glossy surface so it is dust proof and can be easily cleaned, and also absorb, refracts or transmits light.
- The study indicated that glass in building construction have serious implication on the live and property in the building. It was observed that glass allow people to see through the building, it can easily be broken by thieves, strong winds can break the building giving way to criminal operations.

5.3 Conclusion

Glass is one of the very used and favored building materials with multiple applications, such as a building construction material. Glass as used in construction is a compound of elements of silica, lime, soda, magnesia and aluminium. No other building system combines as significant an impact to both a building's performance and aesthetics. In the Wa Municipality, glass in buildings construction now sprung across the length and breadth of every facet particularly in residential areas. For most buildings in the Wa Municipality, the glasses are most typically used in architectural features like doors, windows, and partition. The owners of these building enjoy utilizing glass in building designs for a variety of reasons. It was found that durability, aesthetics, and transparency are the main primary reasons of choosing glass in building construction in the Wa Municipality.

Glass is one of the most sophisticated and versatile materials used in the construction industry. Glass in building construction is effective as it resists corrosion, makes structure look more stunning, sophisticated and adds beauty to the building. The study further revealed that glass has a smooth, glossy surface so it is dust proof and can be easily cleaned, and also absorb, refracts or transmits light. The study indicated that glass in building construction have serious implication on the live and property in the building. It was observed that glass allow people to see through the building, it can easily be broken by thieves, strong winds can break the building giving way to criminal operations

5.4 Recommendations

Based on the findings of the study, the researcher recommends that:

- Professional bodies should educate contractors on the best type of glass to include in buildings in or to improve indoor quality, energy conservations and ensuring of interior and exterior views and the factors influencing glass use.
- The government through its agencies should develop by-laws to control the type of glass building materials to be used to avoid any serious implication on the live and property in the building.
- All stakeholders should work together and ensure that the security implication associated with glass in building construction are prevented or at least minimized.

5.5 Suggestion for Further Research

A further research could be conducted to the sustainability of glass in building construction in Ghana. Moreover, a similar study can also be conducted either in a different district in the Upper West or an entirely different region since the current research was carried out in the Wa Municipality. Finally, it is suggested that a further research be conducted to include the professional bodies in Ghana to ascertain the use and effectiveness of glass in building construction.

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APPENDIX A

UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

QUESTIONNAIRE FOR RESIDENTS IN WA MUNICIPALITY

TOPIC

ASSESSING THE EFFECTIVENESS OF GLASS IN BUILDING AND ITS SECURITY IMPLICATIONS: CASE STUDY OF BUILDING IN WA MUNICIPALITY

PREAMBLE: The researcher, a student of the University of Education, Winneba - Kumasi Campus is seeking information relating to the above topic. The information that you provide is purely for an academic exercise and would be treated with necessary confidentiality. Please offer answers to all the questions in all frankness as much as possible and to the best of your knowledge. You may tick (√) where applicable or give a brief explanation where necessary.

Section A: Demographic Characteristics of Respondents

1. Age (years)?
   18-24] 25-35 [ ] 35-44 [ ] More than 44 [ ]

2. Highest Educational Level:
   SHS [ ] Diploma/Certificate [ ] Degree/Masters' [ ]
   Others [Specify]……

3. Sex? Male/M [ ] Female/F [ ]

4. Marital Status Married [ ] Single [ ] Divorce [ ]
5. Job Title……..

Section B: Uses of glass in building construction

1. Are you aware of the use of glass as building material?

   Yes [ ] No [ ]

2. If yes to question 1, who are the mostly the owners of these buildings

   (a) Private (b) Government (c) Commercials (d) Don't know

   .....

   .....

   .....

3. How will you agree to and/or not uses of glass material in Building in Wa Municipality. Please rate using a scale of 1 to 5 where 1=strongly disagree, 2=disagree, 3=Neutral, 4=agree and 5=strongly agree. *Please tick* [√] *the appropriate box below*.

S/N	Statement	1	2	3	4	5
1.	Glass is used as roof-lights in the building					
2.	Glass is used for internal partitions					
3.	Glass is used in architectural features like doors					
4.	Glass is often of a safety type, which include reinforced, toughened and laminated glasses					
5.	Glass is used for glazing windows					
6.	Glass is used in the form of block walls					
7.	Glass are being used as conservatories and orangeries					
8.	Glass is used as reinforcement structures					
9.	Glasses are used as a protective system					

4. What are the factors that accounts for the increasing use of glass in building in Wa Municipality

   Durability [ ] Aesthetics [ ] Sustainability [ ] Security [ ]

   Transparency [ ] Cost [ ]

Section B: Effectiveness of glass in building construction

5. How do you found the effective of glass as a building material in Wa Municipality?

   Very effective [ ] Moderate effective [ ] ineffective [ ]

6. How effective is glass building in Wa Municipality. Please rate using a scale of 1 to 5 where 1=Very ineffective, 2=somewhat ineffective, 3=Neither effective nor ineffective, 4=somewhat effective, 5=very effective

S/N	Statement	1	2	3	4	5
1	Glass absorb, refracts or transmits light					
2	Very high compressive strength					
3	Resistance to corrosion					
4	Reduction of energy consumption					
5	Glass is resistant to weather and hold up to the effects of the wind, rain, or the sun.					
6	Glass has a smooth, glossy surface so it is dust proof and can be easily cleaned					
7	Glass is unaffected by noise, air, water. Sealed glass panes transmit very little sound, and hence can be a good sound insulator					
8	Sufficient indoor ventilation (e.g. clean air flowing through the building/office)					
9	Glass has the ability to make the structure look more stunning, sophisticated and adds beauty to the building					
10	Glass saves space when used in the interiors					

Section D: Security Implication of Glass Building

7. Are there any security implications of glass building in Wa Municipality?

   Yes [ ] No [ ] I don't know [ ]

8. If "Yes" what are the implication of glass building in Wa Municipality?

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APPENDIX B

UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

INTERVIEW GUIDE FOR THE CONTRACTORS

TOPIC: ASSESSING THE EFFECTIVENESS OF GLASS IN BUILDING AND ITS SECURITY IMPLICATIONS: CASE STUDY OF BUILDING IN WA MUNICIPALITY

This interview collects data on the effectiveness of glass in building and its security implications: Case Study of building in Wa Municipality. Your response is assured of utmost confidentiality since the result will be used only for academic purposes.

1. Name of interviewee: ……
2. Position of the interviewee: ……..…….
3. Place of interview: ……..……..……
4. Date of interview: ……..…….…….
5. Time of interview: ……..…….……

Section A: Personal Details of Respondent

Name:……..

Location:……..

Age; …….

Occupation; ……..

Educational Level; ……

SECTION B

1. Are there any glass building in Wa Municipality?

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2. What are the major uses of glass in building in the Wa Municipality?

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3. How effective is glass in building?

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4. What are the security implications of using glass in building?

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……
……

5. Do you have any risk assessment strategy when building? Yes [ ] No [ ]
If your answer is yes, state the strategy (ies).

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6. Does the risk assessment clearly identify key vulnerable assets and sensitive processes requiring protection? Yes [ ] No [ ]

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7. Are the threat levels clearly understood and how?

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8. Does the risk assessment identify the likelihood and severity of consequences with credible threat scenarios?

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9. Are any neighborhood operations, building tenants and location risk factors present that contribute to an increase in security threats?

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