THE PERFORMANCE OF HIGH RISE BUILDING IN GHANA PERSPECTIVE OF THE OCCUPANTS

by

Asiedu Rita Ama (BSc. Building Technology)

(PG. 4096610)

A Thesis submitted to the Institute Of Distance Learning, Kwame Nkrumah University of Science and Technology in partial fulfillment of the requirements for the degree of

COMMONWEALTH EXECUTIVE MASTERS OF BUSINESS ADMINISTRATION

SEPTEMBER 2012

DECLARATION

I hereby declare that this submission is my own work towards the Executive Masters of Business Administration and that, to the best to my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

RITA AMA ASIEDU

PG 40966610 …………… ………………….

Student Name & ID Signature Date

Certified by:

DR EMMANUEL ADINYIRA ………………….. ………………………..

Supervisor Name Signature Date

Certified by:

Prof. I. K. Dontwi …………………….. ………………………

Dean, IDL Signature Date

ABSTRACT

According to the International Building Code and the Building Construction and Safety Code, high-rise buildings are buildings of 75 feet or greater in height measured from the lowest level of fire department vehicle access to the floor of the highest occupiable story. In Ghana, high-rise buildings increase in number every year and the most common high rise buildings are the commercial ones, but recently investors have turned part of their attention to residential high rise buildings which is also on the increase and for that matter the focus of this study. The aim of this paper is to evaluate the impact of high rise living upon residents' satisfaction. The study specifically attempts to determine the important benefits of living in high rise buildings, to determine the critical challenges faced by residents of high rise buildings, to determine the level of satisfaction of occupants of high rise buildings and to make recommendations to improve on present and future high building schemes. In achieving the objectives of this paper, the survey design was chosen. The target population involved all occupants of residential high rise building with a convenient sample of 65 respondents selected randomly to participate. The structured questionnaire was used to collect views from respondents and the Statistical Package for the Social Sciences was used to analyse the data. The study found that despite the challenges occupants faced with high living, occupants were generally satisfied and also enjoyed the benefits of privacy and luxury living. The study however, ended with some recommendations such as providing inlet breeching water machines to pump water to the upper floors and to also serve as underground water backup system, efficient standby plant, public education and many others.

DEDICATION

To my lovely girls Michelle and Kaila, without whose caring supports it would not have been possible. To my family thank you for believing in me.

ACKNOWLEDGEMENTS

I thank God first and foremost for granting me life and everything else needed to start and complete this work. I want to thank my husband Mr. Joseph Osei Bonsu and my parents Mr. and Mrs. Asiedu for their love and contributions which have brought me this far. Special thanks go to JN for being a great father to me. My gratitude goes to all the occupants who participated in this work.

Special thanks also go to the following people:

- Dr. Emmanuel Adinyira, my supervisor, for the high energy he brought into the work especially in times of frustration.
- My good friend Samifred Quartey who brought fun into the climbing of this mountain and eased the usual stress associated with work.
- To Henry Datsomor and SM Quartey for their great friendship, love and support.
- Dr. Ernest Asiedu, Elijah Tukwariba, Ajara Hillia, Charlotte Klu, Karen Koranteng, Michelle Osei Bonsu, Kaila Osei Bonsu, Fred Mc Davies and many more who are not mentioned here, have been instrumental in my spiritual and physical growth and i am very grateful.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

1. NFPA - National Fire Protection Association
2. SFPE – Fire Protection Engineering
3. IBC – International Building Code
4. BCSC – Building Construction Safety Code
5. TGB – There Glazed Buildings
6. GNAT –Ghana National Association of Teachers
7. NFAC – National Fire Alarm Code

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

According to experts, as cities gear up to cope with the increasing population, tall buildings may well become the new normal not by choice but by default (India Times, 2011). Till some years ago there were hardly any residential buildings taller than 5 or 10 floors. According to Architect Hafeer there are now projects with 50 to 70 storeys. (India Times 2011).

Cities after cities have seen the launch of high rise residential projects in the past years. Many have more than 30 floors with some going up to 100 floors. Today high rise buildings denote power, prestige, wealth and success. The arrival of new construction technologies combined with a growing urban population have encouraged many cities to engage in high density site planning by building high rise apartment buildings (Smith et al, 2009).

A casual drive through downtown Accra these days shows many luxury high rise apartments sprouting up. These apartments can cost an average of US $ 100,000 for one or two bedrooms up to US $ 500,000 for 3 to 4 bedrooms or penthouse suites. Most of these apartments are sold even before they reach completion. High density living has become more prominent in Ghana in the last 10 years in particular the growth of high rise apartments. In Ghana high rise living has been traditionally associated with public living but more recently has become a new residential option allied to affluence. (Ghanabiz media, 2012).

High rise living emanated from the need to house the growing number of people living in the cities. It was also seen as a solution to housing the impoverished and arresting the spread of slum conditions. The dictates of limited land space growing population and the need for improved housing conditions have launched cities to experience and celebrate vertical development (Yuen et al, 2006).

High rise building today is being celebrated amongst government, developers, planners, as well as occupants. High rise is fast becoming a priority area in international research agenda. The quest is for liveable and sustainable high rise development (Yuen et al; 2006). Many cities around the world are embracing high rise urban agenda under current narrative of sustainable development.

1.2 PROBLEM STATEMENT

A significant amount of academic work has focused the construction of high rise buildings. Researchers have concentrated on the advanced countries with very little work done in Africa. There has been much documentation on the engineering and technological aspects of tall buildings, relatively little has been written about the social and liveability of high rise. This work explores to understand the residents appreciation and concerns of high rise living with the aim to uncover some of the challenges / problems residents of high rise are faced within Ghana.

1.3 RESEARCH OBJECTIVES

The study generally aims at evaluating the impact of high rise living upon residents' satisfaction. It specifically attempts to:

1. To determine the important benefits of living in high rise buildings
2. To determine the critical challenges faced by residents of high rise buildings
3. To determine the level of satisfaction of occupants of high rise buildings
4. To make recommendations to improve on present and future high building schemes.

1.4 RESEARCH QUESTIONS

The study aims to look at the increasingly important question of liveability of high rise living by discussing the occupants' appreciation and concerns of high risk. The study seeks to answer the following questions:

1. What are the important benefits of living in high rise buildings?
2. What are the occupants' levels of satisfaction living in high rise building?
3. What are the challenges faced by residents in high rise building?
4. What are the recommendations to improve living in high rise buildings?

1.5 SIGNIFICANCE OF THE STUDY

One importance of the study lies in the fact that it will reveal the nature of high rise buildings in Ghana. This will help policy makers rectify some lapses in people's perceptions so that appropriate measures can be put in place to deconstruct and reconstruct the ideologies people hold so far as high rise buildings are concerned. More so, the study will help the government and other relevant bodies to realize the importance of living in such buildings. Recommendations from this study are to help builders of high rise buildings to know the main concerns of occupants so that they can factor in occupants' needs in order to meet the desired requirements.

1.6 THE SCOPE OF THE STUDY

Researching into high rise buildings has become very necessary as it characterises development. The study concentrated on the high rise buildings in the Accra Metropolis.

1.7 LIMITATIONS TO THE STUDY

Very little information had been documented on high rise building in Ghana. As a result the researcher relied heavily on foreign literature. However, the researcher overcame this problem by making good use of the available information from contractors of such building in Ghana.

1.8 STRUCTURE OF THE STUDY

The research work is structured into five chapters as follows:

Chapter one – The present chapter introduces a review of the context of the study or the background of the study, statement of the problem, the research objectives, research questions, significance of the study, scope and organization of the study.

Chapter two - Focuses on a review of relevant prior literature in the field of high rise buildings.

Chapter three – Describes the research design, the population and sample of the study as well as the data collection techniques.

Chapter four – In this chapter the data collected was analysed and discussed.

Chapter five – This chapter was discussed under three headings, namely: summary of findings, conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter looks at related studies that have been undertaken in high rise buildings. It discusses the global situation, the case of Ghana, functional requirements, energy use, thermal comfort, indoor air quality, noise and vibration and many related discussions.

2.2 DEFINITION OF HIGH RISE BUILDING

A high-rise building is a structure whose architectural height is between 35 and 100 meters. (Business Journal, 2000). A structure is automatically listed as a high-rise when it has a minimum of 12 floors, whether or not the height is known. If it has fewer than 40 floors and the height is unknown, it is also classified automatically as a high-rise (Business journal 2000)

The National Fire Protection Association defines "high-rise building" as a building greater than 75 feet (25 m) in height where the building height is measured from the lowest level of fire department vehicle access to the floor of the highest occupiable story. It requires appropriate exits, alarms, emergency lighting, communication systems, and sprinkler systems are critical for residents' safety. When designing and maintaining exits, it is essential to ensure that routes leading to the exits, as well as the areas beyond the exits, are accessible and free from materials or items that would impede individuals from easily and effectively evacuating.

2.3 HIGH RISE RESIDENTIAL BUILDINGS

High Rise buildings throughout the world are becoming popular day by day. With the advent of modern day construction technology and computers, the basic aim has been to construct safer buildings keeping in view the overall economics of the project. Earlier the functional use of the tall buildings was limited to commercial office buildings. But nowadays, other uses such as, residential, mixed use and hotel tower developments are rapidly developing. The buildings completed in 2011 have effected significant change in the world's tallest 100 buildings with 17 new buildings added to the list. Perhaps most significantly, for the first time in history, the number of office buildings in the tallest 100 has diminished to 50% mark, as mixed-use buildings continue to increase, jumping from 23 to 31. As recently as the year 2000, 85% of the world's tallest were office buildings, meaning that a 35% change has occurred in over a decade to residential buildings (Hollister & Wood, 2012).

There has been a regular and significant change in the approach to the design of structures. The most radical change being the conceptual design. This stage of design is quite difficult since it involves various complex factors which are not explicitly defined. At conceptual stage of design process, there is usually very little time to consider all feasible alternatives before decisions have to be made and resources committed (Rafiq et al., 2003). Although, an ideal design is not always achieved using the conceptual design methodology, but it gives an idea to the structural designer to make sensible decisions. The decisions taken at the conceptual stage of design have a long term influence on the performance and economics of the entire high rise building project.

2.4 UNIQUE FEATURES OF HIGH RISE BUILDINGS

In urban areas where real estate is at a premium, apartment communities are building up — not out — in high-rise buildings. Usually located in downtown areas close to the hustle and bustle of metropolitan life, high-rise apartment communities offer residents many conveniences (www.movingtoday.com,/unique attributes of high rise living

The following features are some of the most unique attributes of high-rise apartment living that you're bound to encounter if you rent in one of these urban communities.

2.4.1 CONVENIENT CITY LOCATION

Perhaps the most appealing and unique attribute of high-rise living is location. High-rise apartments are typically located in very desirable metropolitan areas, close to work places, art and culture, entertainment, and shopping. Living near a city's hotspots is appealing to active apartment dwellers, and the possibility of either walking or taking public transportation is a bonus, as well. In many cities, urban high-rise apartment dwellers do not need cars and can therefore do away with this major expense and hassle.

2.4.2 ON-SITE RETAIL STORES

One of the many unique attributes of urban high-rise apartments is the presence of retail shops on the bottom level of the building. These retailers often include businesses like a grocery store, coffee shop, dry cleaner, or salon - all very useful places for residents to have convenient access to.

2.4.3 FITNESS CENTRES

While apartment gyms are becoming standard amenities in many apartment communities, they are also a common feature of high-rise apartment living. A typical high-rise apartment building gym is large enough to feature free weights, nautilus machines, and cardio equipment.

2.4.4 PRE-INSTALLED TELECOM SERVICES

Another of the unique attributes of high-rise living is the prevalence of pre-installed hook-ups. (www.movingtoday.com,/unique attributes of high rise living)

In an effort to offer convenience to tenants, high-rise buildings often are pre-wired for easy set-up of technology like surround-sound television and wireless Internet. All you have to do is move in and plug in your devices, and your phone, Internet, and cable all work together seamlessly. Be aware that the cost of this convenience may be bundled into the price of rent so you won't pay additional, separate utility bills for these services.

2.4.5 WIDE VARIETY OF UNITS

Another common feature of high-rise apartment living is a wide variety of rental unit types. A typical high-rise building will offer several floor plans, starting with smaller units like one bedroom or studio apartments and expanding to include spacious luxury units like a penthouse suite or loft space - unique spaces that you wouldn't find in a mid-rise or lo-rise building. Some high-rises may even offer furnished apartments. For apartment searchers, the number of floor plan options is a bonus because a wider variety of units may be available at any given time.

2.4.6 HEIGHT BEYOND AVAILABLE RESOURCES OF FIRE DEPARTMENT LADDERS

Typical fire department aerial ladders have the capability to have an effective reach (recognizing a setback distance from a building). Some building sites provide multiple levels of street access to a building. Therefore, many codes have defined “high-rise” buildings as those having an occupied floor level a defined height above the lowest level of fire department vehicle access. Buildings beyond the reach of exterior fire department ladders, then, must have additional protection features because exterior rescue and firefighting capabilities will be limited or unavailable for portions of the building above that height.

Furthermore, the lack of ability to use an exterior access requires fire fighters to access the upper floors of the building by interior means, frequently involving the use of stairways and sometimes using elevators if deemed appropriate under the circumstances. This interior access results in additional physical demands upon the fire fighters and extended time to reach the fire floor (SFPE, 2012).

2.4.7 EXTENDED EVACUATION TIME

The time necessary for full building evacuation increases with building height. In the case of very tall buildings, full building evacuation via stairways might be impractical. A “defend-in-place” strategy has been employed in many building designs by (1) designing compartments allowing people to remain in place, *e.g.*, residential units; (2) temporarily evacuating people to areas of refuge on a floor; or, (3) moving people to dedicated refuge floors elsewhere in the building. Recently, times for full building evacuation have been reduced by employing elevators specifically designed to supplement the egress system of a building.

Buildings employing assembly occupancies with large occupant loads on the upper floors of a tall building require special consideration.

2.4.8 PRONOUNCED STACK EFFECT

Stack effect is a natural physical phenomenon which occurs in high rise buildings which experience a pressure difference throughout their height as a result of temperature differentials between outside air temperature and inside building temperatures. (SFPE 2012). The effect is pronounced in tall buildings because of their greater height. Stack effect causes air to move vertically, either upward or downward in a building. It can cause smoke from a fire to spread in the building if it is not controlled. As a result, tall buildings include features such as automatic sprinkler protection to limit the size of fires and the resulting quantity and energy of smoke which can spread throughout the building, and smoke control means such as openable panels and mechanical systems to either vent, exhaust or limit the spread of smoke throughout the building.

2.4.9 WATER SUPPLY LIMITATIONS

The water supply needs in tall buildings can be beyond water supply capability of public mains and fire department pumpers. Public water supplies have pressures which will require supplemental pumps in the building to boost the pressure to a usable level on the upper floors of a building. The building's fire department connection allows the fire department to supply water to the sprinkler and standpipe systems in the event the building's water supply is out of service or inadequate. Above the height achievable by the local fire authority pumps, buildings must have the capability to supply its water independent of the fire department appliances. Therefore, multiple levels of pumps and water storage tanks are provided. Also, because of this potential loss of an external water supply, additional protection features may be considered necessary for such buildings.

2.4.10 GREATER CHALLENGES OF MIXED OCCUPANCIES

Many tall buildings contain mixed occupancies, involving various combinations of occupancies such as retail, residential, automobile parking, business, public assembly (*e.g.*, restaurant), transportation facilities, health care, educational, correctional and storage. The fire protection challenges presented by mixed occupancies – such as means of egress and the integration of protection systems – are even greater when they are housed in tall buildings.

2.4.11 ICONIC NATURE

Although a building need not be tall to be iconic, tall buildings generally are considered iconic because they are generally unusual in height, design or other feature. They are recognizable as unique.

2.5 OVERVIEW OF THE GLOBAL SITUATION

The International Building Code (IBC, 2000) and the Building Construction and Safety Code, NFPA 5000TM-2002, define high-rise buildings as buildings 75 feet or greater in height measured from the lowest level of fire department vehicle access to the floor of the highest occupiable story (NWCN, 2004). The overall building cost and the architecture of a High Rise Building depends predominantly on its structural system. Therefore the design concepts for High Rise buildings are entirely different for a low-rise building. The High Rise buildings are dynamically sensitive to lateral loads and hence the structural systems of such buildings are designed to resist the lateral loads, especially wind loads.

High Rise building is conceived globally as a vertical cantilever, fixed in ground. The structure is required to carry vertical gravity loads, lateral wind and earthquake loads. To counteract these loads the building should have adequate shear and bending resistance along with its vertical load carrying capacity.

All High Rise buildings are considered as composite structures. This is because, steel systems offer speed in construction and less self-weight whereas reinforced concrete systems offer resistance to fire and offer more damping and mass, which in a way is advantageous in combating motion perception by the occupants.

2.6 POST WORLD TRADE CENTRE ATTACK HIGH RISE FEATURES IN INTERNATIONAL PROJECTS

Perhaps the most significant lesson learned from the World Trade Center attack for high rise designers is that the threat from fire may not be the most critical threat to the building and that a broad range of emergency scenarios must be considered. Most of the high rise construction that has occurred since the World Trade Center attack has been outside of North America. None the less, many of the lessons learned from the World Trade Center attack have been quickly incorporated into the high rise design practice. This has occurred in four key areas:

2.6.1 STRUCTURAL HARDENING

Some buildings are currently being designed with hardened cores that contain emergency system risers and stairways. Structural fire resistance is being evaluated in these buildings to evaluate their ability to withstand full burnout.

2.6.2 ROBUST AND REDUNDANT LIFE SAFETY SYSTEMS

Current high rise design typically incorporates more robust and redundant life safety systems including redundant system risers for power, alarm and fire suppression systems. All of the features are intended to allow the building to function and to maintain a high level of life safety even in the event of partial system failure.

2.6.3 EGRESS

The World Trade Center attack has made clear the need for some incidents to facilitate full building evacuation of high rise buildings. In current international high rise design, this may include the use of an increased number of exit stairways, the use of safe areas or refuge floors within the building and the use of elevators to facilitate emergency evacuation of building occupants.

2.6.4 FIRE FIGHTER ACCESS

Some codes require a dedicated elevator for fire fighters, accessed through a vestibule. Other codes that require all elevators to have fire fighter emergency controls also require all elevators to be accessed from a vestibule.

2.7 THE CASE OF GHANA

In Ghana, very few have been documented on high rise buildings. Even this, most was done on commercial high rise buildings. Therefore, the case of Ghana is limited to a study done by Simons et al., (2012) under thermal perception, building control systems, energy implications, and energy flow consistencies.

2.7.1 THERMAL PERCEPTION

The Premier Towers, Heritage Tower and GNAT heights will hereafter be referred to as the 'three glazed buildings' (TGB). General perception of indoor environment was recorded as agreeable by over 95% of the respondents (mean temperature recorded was 27°C with relative humidity value of 68%). In the Cedi House, all of the respondents found the thermal environment to be good (mean temperature recorded was 25°C with relative humidity value of 60%).

Air-conditioning in the TGB was found to be adequate by over 90% of the occupants while in the Cedi House only a little over 60% found theirs adequate. This may be due to the higher smaller multi-occupancy offices in the TGB than in the Cedi House where multi-occupancy offices are larger and with larger numbers (over 30) of people. The performance of the air-conditioners at smaller office spaces correlates with a similar study in office buildings by (Koranteng, 2010).

2.7.2 BUILDING CONTROL SYSTEMS

Fewer than 40% of respondents in the three glazed buildings could open their windows if required while a little above 85% of respondents in the Cedi could operate their windows. This is due to the provision of operable windows in the Cedi House. In the case of the TGB, windows, even if operable, were usually internal windows except in the case of the GNAT Heights, which had external operable windows, were 100% of the time rarely opened. Despite the above results, in both the TGB and the Cedi House, windows (where present) were most of the time not opened due to the use of air-conditioning systems. The ability to operate windows and shades is known to have positive effects on building occupants (Rijal, 2008).

2.7.3 ENERGY IMPLICATIONS

In the three glazed buildings, only 11.5% of occupants thought they could influence building energy consumption in the way they operated building systems. The remaining percentage either did not know if they did or did not think they could. In the Cedi House, only 25% thought they could influence building energy consumption while the remaining either did not know if they did or did not think they could. Generally, knowledge of the influence on building energy consumption was poor and as such, there must be some form of education.

Furthermore, 100% of occupants in both categories of buildings did not ventilate their offices in the morning before using air-conditioners. Occupants in the Cedi House usually set the thermostats to18-23°C. In the TGB a little over 95% of the occupants set their thermostats to between 18 and 26 ^{o}C. These set points show the effect of user behaviour on the energy consumption of buildings. The low set points may be due to the effect of heat absorption by the excessive glazing in the case of the TGB and the infiltration and exfiltration of air through the building envelope in the case of the Cedi House (main façade oriented towards the west). The work of Mahdavi (2007) confirms the above results with regards to the behaviour of occupants.

In the TGB, 84.6% of the occupants did not switch off their air-conditioners during absence from their offices while all (100%) of occupants of the Cedi House did not do so at all. This behaviour will significantly influence the high energy consumption in these buildings. In addition to this, less than 40% of respondents in both building categories thought about energy conservation when operating building systems.

There was a higher preference for air-conditioned office environments than there was for naturally ventilated office environments. In the TGB, over 80% of the respondents preferred to work in an air-conditioned office environment. In the Cedi House, 63% of the respondents preferred to work in an air-conditioned office environment. It is not surprising that windows remain closed 100% of the time in the Cedi House, although proper shaded windows had been provided. Studies by Koranteng (2010) in low-rise office buildings had similar results on preference of building occupants. There seems to be a correlation in the results irrespective of whether a building is low or high-rise.

2.7.4 ENERGY FLOW CONSISTENCIES

Power outages as pointed out by over 50% of respondents in the TGB occurred always in their offices. In the Cedi House, only 25% said it occurred always. Despite the varied answers, these results show that blackouts do occur and this could affect general productivity and comfort. This result further goes to show that Ghana's energy supply is constantly fluctuating and dwindling and hence the outages. Over 70% of the occupants in both building categories said the blackouts lasted from 5 to 60 minutes. This is quite alarming, especially for high-rise office buildings without operable windows. It is therefore not surprising that over 38% of the respondents in the TGB felt between warm and hot during power outages due to either the lack of operable windows to help ventilate and/or the culture of clothing (high clo-value) in these buildings. In the Cedi House however, only 12.5% of the occupants felt hot during outages. This lower figure in the Cedi House may be due to the provision of well shaded operable windows that help to ventilate in the case of blackouts.

2.8 HIGH-RISE BUILDING REQUIREMENTS

Tall buildings require different systems than "standard" buildings. This is true for fire alarm systems as well as electrical systems. So what defines a "tall" building? The International Building Code (IBC, 2000) and the Building Construction and Safety Code, NFPA 5000TM-2002, define high-rise buildings as buildings 75 feet or greater in height measured from the lowest level of fire department vehicle access to the floor of the highest occupiable story. Once a building meets a code definition for a high-rise building, the fire alarm requirements ratchet up a few notches. The National Fire Alarm Code, NFPA 72-2002, defines a high-rise fire alarm system as an emergency voice/alarm communications system. Such a system provides dedicated manual and automatic facilities for the origination, control and transmission of information and instructions pertaining to a fire alarm emergency to the occupants of the building, including fire department personnel.

Emergency voice/alarm communications systems most often provide notification for partial evacuation or relocation of the occupants of a high-rise building. They also provide automatic or manual voice capability to permit voice instructions to the building occupants, either selectively or throughout the building. Most electrical contractors have already found out the hard way that emergency voice/alarm communications systems offer more complications than typical low-rise fire alarm systems. Reasons include:

- Other systems and devices must interface with the fire alarm system: stairwell pressurization; HVAC damper control; smoke control; door control; and security systems.
- Risers for the notification appliance circuits must survive during a fire.
- The sequence of occupant notification must meet the requirements of both local and state codes.
- The system must assure intelligibility of the voice messages.
- The system must incorporate firefighter telephones, fire department radio repeater systems and/or bi-directional amplifiers.

All these requirements add to the normal installation issues encountered in any high rise installation. Contractors with high-rise building systems installation experience know that the fire alarm system must be planned, installed and programmed well in advance of the scheduled building opening date. This procedure allows for a complete pre-acceptance test and re-programming, if necessary, of the emergency voice/alarm communications system before calling for the fire department acceptance test. Any contractor, prior to bidding such an installation, must ensure that the estimator and bidder for the fire alarm system equipment understand the requirements for the system operation and the programming of the system to ensure that operational sequence.

If the contractor does not plan the wiring of each system interface properly, no amount of programming will rectify that mistake. The design and installation of survivable fire alarm systems must ensure that attack by fire within an evacuation signaling zone (generally a floor) will not impair control and operation of the notification appliances outside the evacuation signaling zone. This means that a fire on one floor will not cause a fuse to blow or short out circuits that affect the operation of the speakers and strobes on any other floor, even when the risers for those circuits pass through the fire floor.

2.9 ENERGY USE

Apartment buildings are the most representative residential type in city areas in Korea and 25 to 30 story high rise apartment buildings are not unusual any more. Since the late 1990s, high-end high-rise mixed-use residential apartments have been developed in full scale. Now over 30 story buildings are common and super high-rise buildings with more than 50 stories are being developed in some areas. In this study, high-rise buildings are conceptualized as the buildings with over 30 stories reflecting such development characteristics.

It is trend that apartment buildings in Korea are being built as a complex with business or commercial facilities as some mixed-use apartment buildings. To avoid monotonous development, various kinds of shapes are being planned and such planning is encouraged by the government (apartment house design guideline- Official Announcement of the Ministry of Land, Transport and Maritime Affairs, September 8, 2009). Thanks to these efforts tower type shape buildings are built in addition to the conventional plate type buildings.

Accordingly, the development characteristics of high-rise apartment buildings can be classified as mixed-use and general apartments from the functional aspect and tower type and plate type from the floor plan configuration aspect. Studies regarding the energy consumption in the high-rise apartment buildings are mostly biased to total amount of energy consumed, Energy savings of window systems and building envelope system or the measurement of facility efficiency. In particular, from the perspective of energy consumption characteristics, Cho (2009) pointed that tower type buildings or high-rise mixed-use residential buildings with high proportion of curtain wall application over-consumed energy comparing to general multi-family apartment units. However, in this study the investigation index was the energy consumption by household. As the space per household in the mixed-use residential buildings is much larger than that in the general apartment housing units, the result of that study had limitation to explain the energy consumption status. On the other hand, in the study analyzing the consumption per actual area not household (Kang, 2008) there was no significant difference in the consumption of electricity and City Gas (LNG) between mixed-use residential buildings and general apartment buildings.

Additionally, Choi et al, (2007) reported that actually there was no significant difference in energy consumption between the general apartment model and high-rise mixed-use residential building model when energy consumption in the same cubic meter in each model type was investigated. However it is also pointed that cooling and heating energy cost in the high-rise mixed-use residential building is high and according to some newspaper article, the electricity bill of the households in the high-rise mixed-use apartment building was 10 times higher and consumes 4 to 5 times more energy than the general households (Kukinews, 2008).

Additionally there are other issues such as too much sunlight in summer and consequential overload because of curtain wall structure, the problems in ventilation and the use of common electricity because of high speed elevator and ventilation facilities (Cho, 2009). It shows that the energy consumption status in the super high-rise apartment buildings cannot be fully understood with the simple approach of the analysis of energy consumption unit as a ratio of energy consumption per area. Accordingly, to identify the actual energy consumption characteristics, the perception of the residents on the indoor environments and the type of their use of energy should be identified together.

2.10 THERMAL COMFORT

Thermal comfort in high-rise residential buildings is a design issue, where the focus should be to mitigate solar heat gains, particularly on upper floors and solar-facing facades that are not shaded by adjacent structures. ASHRAE 55 (1995) and

ISO 7730 (1994) provide design criteria for thermal comfort conditions in air-conditioned buildings. Derived from laboratory studies they specify combinations of personal (clothing, activity) and environmental factors (air temperature, RH, air movement, etc) acceptable to at least 80% of a building's occupants.

However, the heat balance model underlying the standards does not account for the complex ways that individuals interact with their environment, modify their behaviour, or adapt their expectations to match the prevailing conditions. Residents have greater control of the indoor environment, and behavioural adjustments provide an opportunity to maintain thermal comfort. As reported by Brager and de Dear (2000) people in naturally ventilated buildings seem to demonstrate a preference for a wider range of thermal conditions, perhaps due to their ability to exert control over the environment, by opening windows, operating fans and adjusting clothing, or because of changed expectations. They also tend to prefer conditions that more closely reflect outdoor conditions. For example, Feriadi *et al* (2003) show that for residents in naturally ventilated housing in Singapore non-physiological factors and adaptive actions contribute in a positive way to a higher level of thermal comfort acceptability. The study also revealed occupant's tendency to modify the hot and humid living environment by creating a higher air movement (using fans, opening windows). In residential buildings people adapt to (or tolerate) the thermal conditions that they can afford.

2.11 INDOOR AIR QUALITY

Acceptable IAQ is defined as air toward which the substantial majority of occupants express no dissatisfaction with respect to odour and sensory irritation and in which there are not likely to be contaminants at concentrations that are known to pose a health risk. The sources of air pollution are either mainly from outdoors (including neighbouring premises), or mainly from indoors. Proximity to outdoor ‘point’ sources such as industrial or commercial buildings, or ‘line’ sources such as vehicular traffic on adjacent roads, need to be assessed for potential impact. The indoor sources are both the building materials (over which designers have some control) and furnishings (mostly controlled by occupants), or from the activities of occupants (cooking, smoking, incense burning, etc).

Given the dearth of reliable information on the health effects resulting from exposure to low levels and mixtures of contaminants the pragmatic solution is to define limits of exposure (dose = level x time) that are not likely to be harmful. Owing to the uncertainties authorities use safety factors for daily and annual exposure to air pollutants, and set limits for short term (15-min) exposure. For most carcinogenic substances (e.g. formaldehyde, radon) threshold levels may not be specified, so the lowest levels considered practicable are used.

Ambient air quality standards in Hong Kong, as elsewhere, target only a few pollutants known to affect the general population, including susceptible persons (HKAQO, Table I). Under its IAQ management programme the HKSAR Government has established provided guidelines for IAQ in Public Transport Interchanges and enclosed car parks, with criteria for public transport facilities due for publication. The major initiative however is the IAQ Certification Scheme for air-conditioned buildings which provides health related criteria for eight pollutants, carbon dioxide (CO), and 3 thermal comfort parameters (IAQ, Table 2.1).

INDOOR AND OUTDOOR AIR QUALITY STANDARDS

Table 2.1: Indoor and outdoor air quality standards

Parameter	IAQ Certification Scheme	Excellent	Good	Hong Kong Ambient Air Quality Objectives				
	Unit	8-hour average		1-hour	8-hour	24-hour	3-month	1-year
Room temp.	°C	20<25.5	<25.5					
Relative humidity	%	40-70	<70					
Air movement	ms^{-1}	<0.2	<0.3					
Carbon dioxide (CO_2)	ppmv	<800	1000					
Carbon monoxide (CO)	μgm^{-3} ppmv	<2000 <1.7	<10000 <8.7	30000	10000			
Respirable Suspended Particulate (PM_{10})	μgm^{-3}	<20	<180			180		55
Nitrogen dioxide (NO_2)	μgm^{-3} ppmv	<40 <21	<150 <80	300		150		80
Ozone (O_3)	μgm^{-3} ppmv	<50 <25	<120 <61	240				
Formaldehyde (HCHO)	μgm^{-3} ppmv	<30 <24	<100 <81					
Total Volatile Organic Compounds (TVOC)	μgm^{-3} ppmv	<200 <87	<600 <261					
Radon (Rn)	Bqm^{-3}	<150	<200					
Airborne bacteria	$cfum^{-3}$	<500	<1000					
Lead	μgm^{-3}						1.5	

2.12 NOISE AND VIBRATION

Whilst it may not be a significant health issue noise, and to a lesser extent vibration, can certainly detract from the quality living. Noise from outside sources is a design issue, as is noise and vibration from building services equipment. The Hong Kong Planning and Standards Guidelines provide criteria for maximum permissible noise levels at the external façade of residential buildings for various outside noise sources (e.g. 70 dB(A) L10 (1 hour) for road traffic noise). The

Guidelines also indicate the likely noise attenuation by the building envelop for each type of noise, with well-gasketted double glazed windows achieving up to 15 dB(A) for road traffic noise. However, the existence of gaps such as in window units reduces their effectiveness. This suggests that further effort can be made if sleep is not to be disturbed.

Equally relevant is the noise transmission between apartments on the same floor, and between floors. The latter has not received much attention by designers. There are well established design criteria for airborne noise attenuation through party walls, and for impact noise through floors. Given that the use of floor coverings such as carpets are not generally preferred by homeowners designing floors/ceilings to reduce impact noise is an important quality feature for which some homeowners may pay a premium. Noise and from vibration building services plant is also a design issue, but one that should be satisfactorily addressed by acoustic enclosures and vibration dampers. In the event that vibration is perceived to be a problem ISO 2631 (1997) provides criteria whereby the impact on people can be assessed.

2.13 HAZARD, RISK AND DECISION ANALYSIS IN VERY TALL BUILDING DESIGN

Although fire hazards in very tall buildings are essentially the same as in low-rise buildings of similar uses (*e.g.*, business, residential, mixed-use), the consequences of a fire have a potential to be more severe given the large numbers of occupants, the inherent limitations in egress and access, and the physical aspects of the structure which can affect the hazard (*e.g.*, stack effect). This is not a new concept: it is why many existing regulations for tall (high-rise) buildings include more provisions for fire and life safety than those for low-rise buildings of a similar use. While such a defense-in-depth approach has resulted in a predominately good fire record for tall buildings, there are sufficient examples of what can go wrong (*e.g.*, see the History) to highlight the benefits of applying appropriate levels of hazard, risk and decision analysis to the design of very tall buildings in order to try and achieve a high degree of fire safety performance while meeting other project objectives.

There is a wide variety of hazard, risk and decision analysis tools and techniques that can be applied to very tall buildings, starting at the feasibility or conceptual planning phase, at various stages of design and construction, and throughout the life of the building. The basic risk assessment process is outlined below. The aim of this part is to identify aspects of very tall buildings which may warrant application of hazard, risk or decision analysis at various stages of design, construction and operation.

2.13.1 FIRE

During the design of very tall buildings, there may be cases where hazards are introduced or somehow enhanced. For example, with a focus on sustainability, there may be additional hazards of concern associated with new materials that may be introduced to address energy performance or other objectives, include façade material, new thermal insulating materials, fuel cells, photovoltaics, and other such materials. Fires in Busan South Korea (Busan High-Rise Fire Sends

Urgent Warning, 2010) (October 2010 - See figure 2.1) and Shanghai, PRC (Kurtenbach, 2010) (see figure 2.2) associated with combustible façade material installed, or being installed, for energy efficiency upgrades point to one concern. As noted in the Korean media (Busan High-Rise Fire Sends Urgent Warning, 2010) regarding the Busan fire, "it took just 20 minutes for the blaze that started at a trash collection site on the fourth floor to travel up to the 38th floor. The building's concrete body was covered with aluminum panels for aesthetic effect, filled with glass fiber for insulation and coated with flammable paint causing the flames to spread upward quickly" (Kurtenbach, 2010).

Likewise, as reported in the media following the Shanghai fire, (Kurtenbach, 2010) to meet energy efficiency targets by adding insulation to the outside of existing buildings - the project the welders were working on when the fire broke out. Although the insulation meant for such work is supposed to be treated with fire retardant, it is nonetheless flammable. Many are now questioning if the energy savings are worth the risk."

While new materials for energy efficiency are not unique to tall buildings, it is likely that energy efficiency will be a significant objective for very tall buildings, and fire hazard assessment should be extended to include these new materials and the expected in-use application.

Figure 2.1: Fire in Busan   Figure 2.2 Fire in Shanghai

(Source: BBC News, World Asia, 2010

2.13.2 TECHNOLOGICAL EVENTS

System failures occur every day. Air-conditioning systems malfunction. Power might be lost for a few minutes to a room or floor of a building. A lift is out of service. In most cases the interruptions are brief and result in little, if any, detrimental outcomes. However, in a vertical city that is a very tall building, interruptions to critical systems can have significant impacts on the building and its occupants. Loss of a lift servicing the 100th-140th floor of a building is more than a minor inconvenience, especially if the lift is intended to serve as part of the egress plan as an occupant self-evacuation lift. Likewise, loss of fire suppression water at the 100 floor is more severe than a similar loss at the 1st floor, which can be more readily reached by responding fire brigade personnel and equipment. Extended power outages can have major implications. Gas explosions can result in fire and partial or total building collapse.

2.13.3 EXTREME NATURAL EVENTS

Extreme natural hazard events, such as earthquakes, tsunami, drought and high wind events, pose an additional challenge. In these situations, one needs to consider both the primary event (natural hazard) and the secondary event (fire), given the potential for any damage resulting from the primary event. This is particularly important for assessing fire and life safety systems availability and efficacy following the natural hazard event.

For many of these assessments, the FPE will likely work closely with structural engineers or others focused on the natural hazards evaluation. However, in addition to a focus on structural performance, it is critical to include the nonstructural systems performance, including power, lighting, piping, HVAC, communication, nonstructural compartment integrity internally (passive protection, including walls, ceilings, dampers, doors, etc) and at the exterior boundaries (façade, window or door openings, etc). The aim is to estimate the functionality or damage states of the building and systems – post initial event – for assessing post-event fire performance.

For example, fire protection systems can suffer significant damage in seismic events. Reports published following the Northridge and Kobe earthquakes provide some examples (Sekizawa et al., 2003). While not all details are yet available regarding the impact of the March 11, 2011 tsunami in Japan (see figures 2.3 and 2.4), the fire and explosions at the Fukushima nuclear power plant, Cosmo oil refinery, and industrial areas of Sendai illustrate the potential for post-earthquake and tsunami fire and explosion. An additional challenge in such events is that the initiating event (earthquake, tsunami) can take out critical infrastructure needed to support firefighting operations, including water supply and roadways (for access) (SFPE-TGFS-TB, 2012).

Figure 2.3: & Figure 2.4: Fire after Tsunami
(Source: herald sun news, 2011)

Different types of challenge are associated with potential climate change. These include rising sea level (flooding), drought (increased risk of wild land fires, decreased water available for suppression), and increased severity of hurricanes/cyclones (increased wind speeds). As with the above, the focus for the fire protection engineer is post-event fire protection performance of the building. In the case of flooding, issues include location of critical equipment and ability of emergency responders to reach the building. The water resource issues with drought may lead to a need to have 100% on-site capacity of expected firefighting water for the target duration. High winds could result in damage to the building envelop, resulting in loss of compartmentation.

2.13.4 TERRORISM

The World Trade Center attack is a clear indication that very tall buildings may be considered targets for acts of terrorism. As with natural hazard events, a key consideration is operation of the fire and life safety systems following the initiating event. With respect to acts of terrorism, initiating events could include impact, explosion, arson, or chemical, biological or radiological (CBR) release. While assessment of these hazards may not be within the FPE's scope, concerns may include the state of the fire protection systems post event (*e.g.*, the World Trade Center bombing in 1993 took out fire alarm, emergency lighting, communications, and many other systems; the 2001 World Trade Center attack resulted in loss of passive and active fire protection systems, egress systems, and access for emergency responders), as well as consideration for system operation for multiple hazards (*e.g.*, CBR management and smoke management) (SFPE-TGFS-TB, 2012).

2.13.5 COLLAPSE

The collapse of a building could be considered the "worst case" for everyone involved in its planning and realization. The financial consequences for its owner and the exposure risk for the people inside the building and in its vicinity is when it collapses are devastating. The possible causes are often complex and difficult to ascertain retrospectively, but risk potential can be identified and corresponding precautions taken.

The following risks are a potential source of errors during the planning and construction phases:

- Flawed analysis of the subsoil
- Flawed structural analyses
- Lack of coordination between the parties involved in the planning and
- Realization (changes which are not taken into account, etc.)
- Defective work (stripping times, wrong quality of materials, etc.)
- Incorrect use of the building during the construction phase (e.g. concentrated
- storage of materials on floors not structurally dimensioned for this purpose)

During the occupancy phase, a building may collapse for the following reasons:

- Structural changes which have not been taken into account in the structural analysis of the building (e.g. by adding floors or removing supporting structures)
- Poor maintenance
- Evacuation of the people in the building depends very strongly on the manner in which it collapses. No precautions can be taken against a sudden failure of the supporting structure. Cracks in the tension zone of the concrete or plastic deformation of the steel structure could be detected if the building is properly serviced. It would then have to be closed due to the risk of collapsing.

2.13.6 WASTE DISPOSAL

In the days when waste was collected without preliminary sorting on site, waste chutes were frequently installed in residential and administrative buildings, as well as in high rise buildings with up to 20 floors. Such waste chutes are not advisable in taller buildings – due to the associated greater height of fall – for paper or plastic bags tear open as they fall and considerable noise is generated by the waste as it falls and collides with the walls and bottom of the chute. The fire hazard is also enormous. Standard practice today is to collect the waste separately on each floor: paper, recyclable secondary materials, compostable organic waste and residual household waste which is collected in large containers and then transferred via the goods elevator (or service elevator) to a central collecting point (in the basement) alongside the delivery area or to the underground parking deck. The waste is compressed to a fraction of its original volume in special containers at the central collecting point. Mobile waste collecting bins are ready and waiting in the goods elevators in the World Trade Center in New York, for instance. In addition, there are five filling hoppers which can comminute all manner of objects, including desks (MRC, 2000).

2.14 DRAWBACKS OF HIGH-RISE APARTMENTS

Whilst the long list of convenient urban apartment features may make high-rise living sound ideal, there are a few drawbacks. Privacy, for instance, is sometimes an issue in high-rise apartment living. Because so many residents are living in such close quarters, it’s not uncommon to hear nearby noise on occasion. Add in the regular city noise coming from traffic and the street below, and high-rise living is most certainly bound to be a bit less peaceful than life out in the ‘burbs.

Another notable drawback of high-rise apartment living is often the price point. Because of the many conveniences a high-rise apartment building offers residents, the price tag is often on the higher side. With luxury services like fitness centres and pre-wired cable hook-ups bundled into the price of monthly rent, high-rise rents can sometimes cause sticker shock.

For many renters, however, the extra luxuries and conveniences of high-rise living more than justify the price. You may find that, despite drawbacks, high-rise apartment living is one type of that suits you perfectly.

2.15 OVERCOMING SOME CHALLENGES

There are several challenges with high rise living that might make you think twice before renting one. Some of these challenges can be solved with creativity if you don't have other options. However, other problems present with this type of apartment living will always be there, making it hard to enjoy your apartment.

2.15.1 WATER SUPPLY

Availability of the municipal water supply will dictate overall on-site storage needs. Some very tall buildings are planned for what will eventually become a city. However, there may be no public utility infrastructure in place. Very tall buildings cannot wait for a water supply of adequate duration to arrive with the rest of the city and therefore appropriate on-site storage needs to be considered.

Primary water supplies may need to consider sprinkler in addition to standpipe demands. In most buildings, the water supply system is generally designed for the larger of either the sprinkler or the standpipe demand. This is predicated on the understanding that the fire department will respond in emergency situations and are able to supplement the water supply for the two systems. However, because fire department apparatus will generally not be capable of reaching the top, fire protection systems in very tall buildings need to be designed to be essentially self-sufficient.

In a very tall building, the designer should consider providing a system capable of meeting the combined demands of sprinklers and standpipes. Discussions with the responding fire departments will provide better understandings of their anticipated tactics for deploying hose streams, which will help the designer to identify necessary flow rates and pressures needed. This will drive the determination of the standpipe system demands.

Reliability of the water supply will also be a key consideration for very tall buildings. Since the fire suppression and standpipe systems will depend upon pumps for moving water up to the top of the building, back-up pumps, gravity based storage supplies, or both may be considered in order to enhance the reliability of the water supply system.

2.15.2 DETECTION AND ALARM

Fire detection and alarm systems are intended to provide notification of fire events within the buildings in which the systems are installed. They provide early warning notification to building occupants and notification of fire events for both on- and off-site emergency response personnel. They also provide control of fire safety functions for fans and dampers to reduce smoke spread, recall and shutdown elevators and control fire doors.

Fire detection is provided through initiating devices such as heat detectors, smoke detectors, flame detectors and other fire-related detection devices. Fire alarm systems also monitor extinguishing systems such as automatic sprinklers, gaseous agents and other extinguishing agents. Recognition of a fire event can also be provided by building occupants via manual fire alarm stations. All of these input devices provide an indication that a fire event may be present within a facility. These input functions also serve to initiate specific output functions.

Output functions include occupant notification, emergency response notification, fire safety functions and annunciation of input device type and location. Occupant notification can occur throughout the building or within selected zones as required for building evacuation concepts. Emergency response notification can be transmitted directly to the Fire Department, but typically occurs through a third party or by onsite personnel responsible for monitoring the fire detection and alarm system.

Fire/smoke damper and fire door closure is often used to compartmentalize buildings areas to limit the spread of smoke and fire. Fire safety functions also include elevator recall for fire safety service use and building occupant safety, along with shutdown in the event of a hoist way or machine room fire.

2.15.3 SMOKE CONTROL

Smoke control is incorporated in the overall fire strategy in many different building types, independent of size. However, the matter of smoke spread and smoke control is a little more complicated in tall buildings. Their inherent geometry, occupant distribution, the physics of smoke flow and the characteristic design features such as extensive networks of shafts, complex ventilation systems and spatial interconnections makes for a structure potentially more vulnerable to smoke spread and its negative consequences (Klote, 2008).

According to Klote & Milke (2002) careful consideration should be given to the desired performance goals for the structure. Once the goals are developed and criteria are set, an appropriate smoke control strategy can be implemented. A number of different smoke control strategies are possible incorporating one or more of a variety of design features. Features that might achieve the goals vary from the simple, passive reliance on smoke barrier walls and floors to utilization of air handling systems that develop pressure differentials to restrict smoke spread from a fire zone. A sprinkler system can similarly be thought as an effective smoke control feature because it restricts fire development, limiting smoke production and reducing buoyancy. Even sprinkler controlled fires can continue producing smoke, albeit at a reduced rate, until final extinguishment is accomplished by the fire brigade or fire department. Without any floor by floor smoke barriers, smoke from sprinkler controlled fires can spread to adjacent floors. Such smoke could also damage property in other areas of a building. Although a tall building equipped with a sprinkler system might meet the local life safety code requirements for minimizing smoke spread, the owner's performance goals may require a higher level of performance.

The smoke control strategy for a given building will therefore be determined based on the performance goals established among the stakeholders. Occupant life safety, as the most common goal will influence the design. Consequently, the type of egress plan – phased, staged defend in place etc; will influence the smoke control design. Additional performance goals may also need to be considered, including fire fighter safety and the aforementioned property protection (Milke & Klote, 2008). These goals need to be reviewed and established before developing the smoke control strategy. The design solution needs to address the nature of the building, its relevant occupant characteristics, the stakeholders' performance objectives and, lastly reliability.

2.15.4 ELECTRICAL

Electrical systems for very tall buildings are crucial for normal operation and life safety. Some places will have normal power available at all times, except for unique circumstances, whereas other places may have power only certain times of the day or for only days at a time. As part of the design of the electrical systems, the reliability of utility power should be investigated.

The reliability of utility power can be evaluated through historical data available from the power company. When this data is not available, it is more difficult to estimate, and allowances should be taken into account. Furthermore, evaluating the reliability of the utility power needs to consider both total power outages and the quality of power being delivered, as this may impact the equipment as well. In areas where utility power is considered unreliable, enhancements to on-site electrical supply systems should be considered.

Using the same equipment for both the augmentation of normal power and emergency power needs to be considered. It may be practical to increase the level of power generation to take into account the dual use of such equipment. For example, if on-site generators are used to provide normal power and emergency power, these systems may need to be enhanced to increase their reliability during emergency conditions.

The quality of on-site generated power affects the reliability of the power. Often, power coming from generators is sufficient to run critical systems for limited periods of time, but these generators may not be designed to run equipment continuously. If on-site power generation is required on a continuous basis, the system needs to be designed as a primary power system rather than standby. One of the things to consider about on-site generated power is the impact that quality of power will have on equipment that is used during both normal and emergency situations (SFPE, 2012).

2.15.4.1 EMERGENCY AND STANDBY POWER

Many life safety systems require power to operate. The integrity of the power supply needs to be evaluated for very tall buildings. Many building and electrical codes govern which systems require secondary power and what type of power they need. Loads are subdivided, so that those most directly impact preservation of life and safety are given the highest priority. Typically these include:

- Emergency power
- Standby power

- Optional standby power

The time required to initiate emergency power after loss of loss normal power affects the performance of the life safety systems and therefore needs to be determined. During loss of normal power, batteries can be used on some equipment to maintain operation during switchover. Other systems will have a temporary loss of power until emergency or standby power can be provided.

Some systems will tolerate a very short switchover to emergency power, while other systems can have a longer duration of power loss. Generally, emergency power is provided within 10 to 15 seconds, whereas standby power is provided within 60 seconds, based on many of the standards and codes used around the world. Emergency systems for high-rise and very tall buildings include the following:

- Exit signs and means of egress illumination
- Elevator car lighting
- Fire detection and alarm systems
- Emergency voice alarm and communication systems
- Electrical fire pumps

Standby power is typically required to be available after power is provided to emergency equipment. For very tall buildings, the items that might need standby power include:

- Elevators
- Smoke control systems
- Power and lighting for Fire Command Rooms

Optional standby power systems can also be connected to on-site emergency generators. It might be prudent to separate optional equipment from code required standby systems. When designing systems for very tall buildings, emergency and standby power is necessary for the continued operation of essential life safety systems. The integrity of the emergency and standby power systems will need to be evaluated as part of the overall building fire strategy.

Maintaining power to critical equipment is essential to the preservation of life during emergency events and building evacuation. Consideration should be given to the level of protection provided for emergency and standby power circuits and equipment. If a defense in place strategy is implemented, protection of rooms containing emergency and standby power switchgear and transformers may need to be considered. Providing fire-resistance for these rooms consistent with the rating of floor assemblies may be appropriate because this will provide a level of protection consistent for the overall compartment. Fire resistance of vertical risers consistent with this level of protection may also be desirable to protect feeders and circuits supplying systems outside the fire area. On-site electrical generators are normally used to provide emergency and standby power.

Survivability of systems is a fundamental principle for the design. Separation of the generation system and engines from the normal/utility power service to the building should be considered to avoid common mode failure of sources. The reliability and integrity of the generator system should be evaluated as part of the design process. For very tall buildings, it may be appropriate to provide multiple parallel backup generators so that power is available should one generator be down or taken off line (SFPE, 2012).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter considers the methodology of the research and describes the selection of sample and design of the survey instrument used to collect the data from the occupants of high rise buildings in Accra Metropolis. The main objective of this chapter is to present the instruments used in the study and the statistical analysis undertaken in an effort to provide answers to the research questions and the general objectives of the research.

3.2 RESEARCH DESIGN

The study adopts the survey research design. According to Sproul (1988) research design can be used to categorise into experimental design and non experimental design. The survey design has been used by many researchers as it has been proven to be a useful tool for investigating trends and specific situations in many scientific disciplines. The study is carried out by gathering data from primary sources in order to achieve the research objectives.

3.3 POPULATION AND SAMPLE SIZE

The study population covers all residents in high rise buildings in the Accra Metropolis. In all 65 respondents were selected for the study and this was based on the availability and willingness to participate. The sample size was selected because the researcher was not interested in large numbers but to understand how occupants perceive living in high rise buildings.

3.4 SAMPLING TECHNIQUES

The sampling method employed in the study was the randomized sampling technique where each person had the chance of being selected to participate in the study. Any potential participant from the randomly selected houses / apartment the researcher chanced on was given the questionnaire to answer after the aim of the study has been explained. The researcher by using this method was able to capture varied views on the issues under investigation from various individuals.

3.5 RESEARCH INSTRUMENTS

The data collection instrument used was the questionnaire and informal interview. The questionnaire was made up of both opened-ended and closed ended questions. The questions were based on the research objectives. The questionnaire had an introductory note assuring respondents of confidentiality and anonymity. Questionnaires were subject to thorough testing and review before administering to respondents. All mechanical deficiencies were rectified. Questionnaires were randomly administered to 65 respondents. According to Ahorney (2004) unpublished 0.003 percent of a large population can be used to represent the views of the population

3.6 PROCEDURE FOR DATA COLLECTION

The procedure for interviewing the required number of people for the study is explained in this section. Verbal consent was obtained from the authorities of the various high rise buildings. The participants were voluntarily invited to participate in the study. The language used for the discussions was only English. This was to facilitate communication between the researcher and the participants. The questionnaire was partly researcher-administered while others were given to respondents who could not participate at that moment to respond to it later. The questionnaires were later taken to be included in the already administered ones.

3.7 DATA ANALYSIS

The statistical programme used for analysing the data collected was the Statistical Package for the Social Sciences (SPSS) software (version 18). Statistical analyses on the data were made using descriptive statistics which involved tables showing frequencies and the corresponding percentages. Graphs were also used to provide pictorial information where appropriate.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF RESULTS

4.1 INTRODUCTION

This chapter presents the analysis of the results of the field work and discussions of the findings of the study. It examines the performance of high rise building in Ghana. It seeks to determine the satisfaction level and challenges with high rise living.

4.2 SOCIO-DEMOGRAPHIC DATA

A total of 70 questionnaires were administered to residents of some high rise buildings in the Accra Metropolis. Out of this 65 questionnaires were completed and returned. Over 70 percent of the respondents were males indicating more males occupying high rise building than females in Ghana.

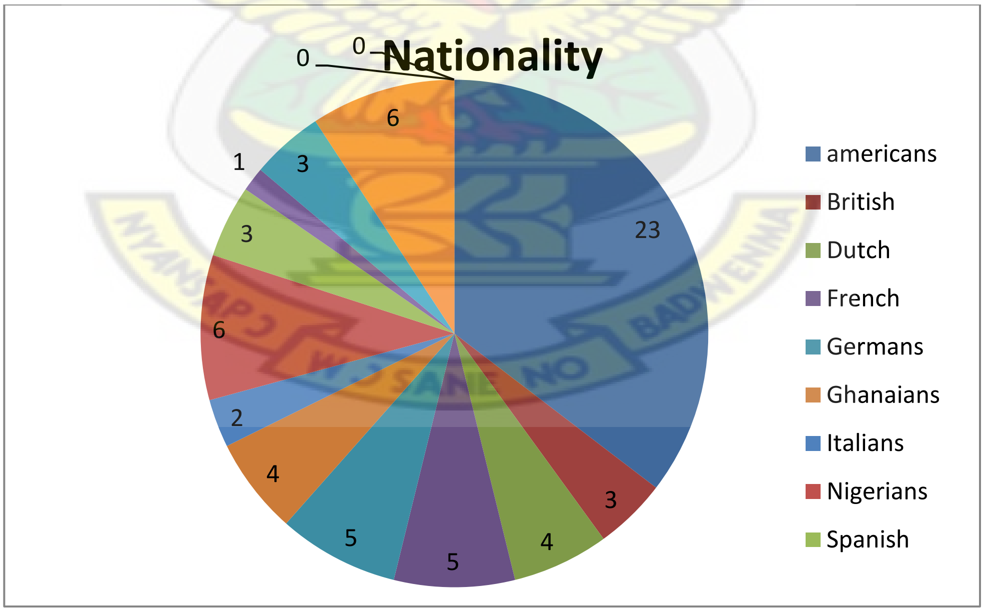

Figure 4.1: Nationality
Source: Field Survey, 2012

In the case of respondents nationality, 35.4 percent were Americans, 4.6 percent were British, 6.2 percent were Dutch, 7.7 percent were French, 7.7 percent were Germans, 6.2 percent were Ghanaians, 3.1 percent were Italians, 9.2 percent were Nigerians, 4.6 percent were Spanish, 1.5 percent were Togolese, 4.6 percent were Chinese while 9.2 percent did not identify their nationality, indicating majority of occupants being foreigners.

4.3 AGE

With respect to the respondents age, 1.5 percent was between 21-30 years, 14 (21.5 percent were between 31-40 years, 36.9 percent were between 41-50 years while the majority 40 percent were between 51-60 years. This shows that most of the occupants are adult with probably good financial standing.

4.4 FAMILY SIZE AND FLOORS OCCUPIED

The study revealed that 70.8 percent o the occupants lived with their families, 29.2 percent did not have their families living with them. Those living away from their families were mostly expatriates who are on contract in Ghana for not more than 5 years. Regarding the size of the family, 71.1 percent had family size between 1- 2, 23.9 percent had family size of 3-5 and 4.3 percent had over five persons in the family. This shows that majority of occupants had small family size

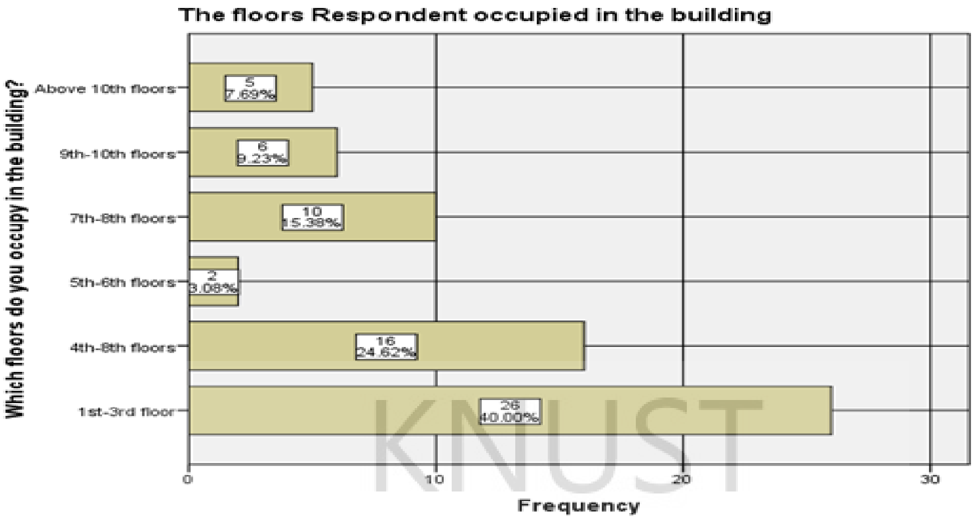

Figure 4.2: Floors respondents occupied in the building Source: Field Survey, 2012

In terms of the floors respondents occupies, 40 percent occupied the 1st to 3rd floors, 24.6 percent occupied 4th to 5th floors, 3.1 percent occupied the 5th to 6th floors, 15.4 percent occupied 7th to 8th floors, 9.2 percent occupied the 9th-10th floors and 7.7 percent occupied the apartments above the 10th floors. This means majority of the occupants were living on the down floor even though they might prefer to go higher because the top floors are more expensive compared to the down floors.

4.5 PERIOD LIVED IN THE APARTMENT

When the respondents were asked of how long they have lived in the building, 35.4% percent had lived in the apartment for less than a year, 46.2 percent had lived in it for 1-2 years and 18.5 percent had lived in the apartment for 3-5 years. The reason why majority of the respondents had lived in the building for less than 2 years is the fact that high rise buildings are now emerging in the country and as a result most respondents did not get access to it earlier than now.

4.6 HOME OWNER

With respect to tenancy, more than 50 percent of the respondents were home owners representing and the rest of the occupants were renting by themselves or their employers.

4.7 THE LEVEL OF SATISFACTION WITH LIVING IN HIGH RISE BUILDING

4.7.1 First experience with high rise living

Majority of the respondent representing 67.7 percent had experienced high rise living whilst 32.3 percent were experiencing for the first time. This high rise building is gradually becoming attractive in Ghana. People with no experience are trying it for the first time.

Table 4.1 Height Occupants are willing to go

	Frequency	Percent
1-3rd floors	9	13.8
4th -8th floors	19	29.2
9th -15th floors	17	26.2
Above 20 floors	20	30.8
Total	65	100.0

Source: Field Survey, 2012

Indeed more than 50 percent of respondents are willing to go high above 15th floor even beyond 20 floors.

Table 4.2 Level of Satisfaction towards Living in this Apartment

	Frequency	Percent
Very satisfied	34	52.3
Unsatisfied	2	3.1
Satisfied	29	44.6
Total	65	100.0

Source: Field Survey, 2012

From the table, 52.3 percent of the respondents said they were very satisfied with the level of satisfaction towards living in high rise buildings, 3.1 percent were unsatisfied, while 44.6 percent were satisfied with high rise buildings. This means that most occupants are high satisfied living in high rise buildings.

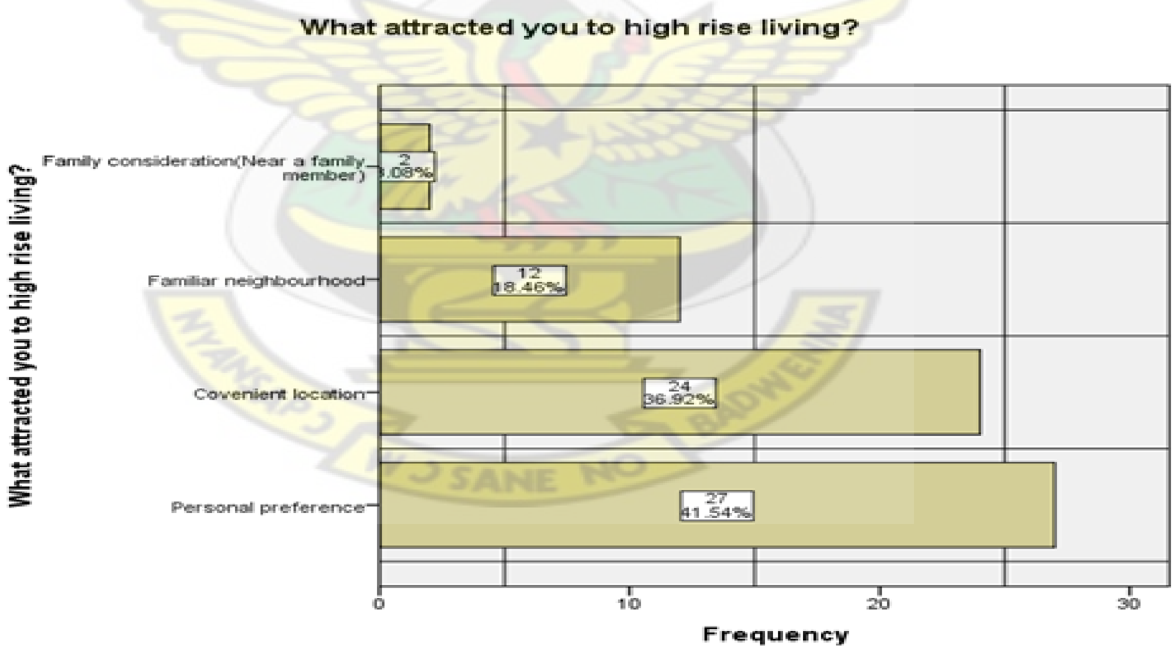

Figure 4.3: What attracted respondents to high rise building
Source: Field Survey, 2012

With what attracted the respondents to high rise buildings, 41.5 percent said personal preference, 36.9 said convenient locations, 18.5 said familiar neighbourhood while 3.1 percent said family consideration that is near a family member.

Table 4.3 Occupants satisfaction level with floors

	Frequency	Percent
Because i have to climb to the highest floor when the lift break down	2	3.1
I do not experience noise from the lower floors	9	13.8
I easily come down stairs when i want to	1	1.5
I feel safe	1	1.5
I have access to every facility that comes with the apartment	4	6.2
It does not have any problem in terms of water flow	3	4.6
It is not high enough to pose any problems	5	7.7
It's closer to the ground	1	1.5
It's convenient with no special problems	5	7.7
Its high and distant from many people making living comfortable	12	18.5
My children don't have to climb the stairs or join the lift to come to the room	9	13.8
No response	4	6.2
Sometimes it's difficult getting water	2	3.1
The floor is very nice and luxurious	5	7.7
This is because when the location is flooded, i am not affected	2	3.1
Total	65	100.0

Source: Field Survey, 2012

With respect to the reasons why they were happy or not, 3.1 percent said because they have to climb to the highest floor when the lift break down, 13.8 percent said they did not experience noise from the lower floors, 1.5 percent said they easily came down stairs when they wanted to, 1.5 percent said they felt safe, 6.2 percent said they had access to every facility that came with the apartment, 4.6 percent said they did not have any problem in terms of water flow, 7.7 percent said it was not high enough to pose any problem, 1.5 percent said it was closer to the ground, 7.7 percent said it was convenient with no special problem, 18.5 percent said it was high and distant from many people making living comfortable, 13.8 percent said their children didn't have to climb the stairs or join the lift to come to the room, 4 6.8 percent did not respond to the questions, 3.1 percent said sometimes it was difficult getting water, 7.7 percent said the floor they occupied was very nice and luxurious while 3.1 percent said they were not affected when the location flooded. This suggests that occupants of high rise buildings derive some benefits in living in such buildings. For example, the benefit of less noise and convenience even though there are some challenges.

Table 4.4 Choice and Satisfaction Level of Floor

	Yes (Persons / %)	No (persons / %)
Happy with current floors	61 93.8	4 6.2
Own choice	40 61.5%	25 38.5%

Source: Field Survey, 2012

Whether the respondents were happy with the floors they were occupying, 93.8 percent agreed in affirmative while 6.2 percent were not happy with the floors they occupied.

With regards to the choice of floors 61.5percent chose the floor whilst 38.5percent did not. Reason was they had no option but to choose those floors because that was the only floor available at that time.

Table 4.5 Reasons for satisfaction levels Recorded

	Frequency	Percent

Climbing up and down the stairs serves as a source of exercise	5	7.7
Convenience	10	15.4
I considered the flow of water and easy getting down	3	4.6
I didn't want to go to the top floors	4	6.2
I do not experience noise from the lower floors	8	12.3
I moved there just at the time a former tenant was moving out	2	3.1
I want to stay close to the ground floor so that in case of fire outbreak or emergency i can escape	1	1.5
It was a rented gift	1	1.5
It was allocated to me by my organization	7	10.8
My parents are old and using the top floors will give them problems therefore i prefer the down floor	2	3.1
No response	8	12.3
That was the available floor	9	13.8
The top floors are very expensive	5	7.7
Total	65	100.0

Source: Field Survey, 2012

From the above table , when respondents were asked to give reasons for their answer, 7.7 percent said climbing of the stairs serves as a form of exercise for them, 15.4 percent said it was convenient, 4.6 percent said they considered the flow of water and easy access getting down, 6.2 percent said they didn't want to go to the top floors, 12.3 percent said they did not experience noise from the lower floors, 3.1percent said they moved there just at the time other tenants were moving out, 1.5 percent said they wanted to stay close to the ground floor so that in case of fire outbreak or emergency they could escape, 1.5 percent said it was a rented gift, 10.8 percent said it was a rented gift, 3.1 percent said their parents were old and using the top floors will give them problems therefore preferred the down floor, 13.8 percent said that was the available floor, 7.7 percent said the top floors were very expensive and 12.3 percent did not respond.

Table 4.6 Benefits from High Rise Living

	Frequency	Percent
Clear air	14	21.5
On top of the world feeling	27	41.5
Breeze	20	30.8
Others	4	6.2
Total	65	100.0

Source: Field Survey, 2012

About 21.5 percent of the respondents were satisfied with the clear air , 41.5 percent felt satisfied with the 'top of the world feeling' 30.8 percent feel satisfied with the breeze the enjoy and 6.2 percent had reasons like quiet environment away from noise and many people). With regards to benefits respondents point out that, the benefits are with the feeling of living in a prestigious environment, on top of the world feeling and the breeze they enjoy makes them very satisfied.

Table 4.7: Importance attached to luxury, feeling of isolation, lack of privacy, and scared of lift breakdown in considering high rise living

	Least	Less	Moderately	Very	Most

	Important persons / %)	Important persons / %	Important. Persons / %)	Important persons / %	Important (persons / %)
Luxury	6 (9.2%)	2 (3.1%)	17(26.2%)	5 (7.7%)	35(53.8%
Feeling of isolation and loneliness	19(29.2%)	14(21.5%)	28(43.1%)	-	4 (6.2%)
Lack of privacy	11 (16.9%)	11(16.9%)	7(10.8%)	5(7.7%)	31(47.7%)
Scared of lift breakdown	11 (16.9%)	3(4.6%)	16(24.6%)	21(32.3%	14(21.5%)

Source: Field Survey, 2012

When the occupants were asked to indicate the level of importance they attached to the luxury in their decision to or not to live in tall buildings, 9.2 percent marked least important, 3.1 percent marked less important, 26.2 percent marked moderately important, 7.7 percent luxury was very important to them while (53.8 percent said luxury was most important.

When the occupants were asked to indicate the level of importance they attached to the feeling of isolation and loneliness in their decision to or not to live in tall buildings, 29.2 percent said least important, 21.5 percent said less important, 43.1 percent said moderately important while 6.2 percent said feeling of isolation and loneliness was most important.

The importance occupants attached to the lack of privacy in their decision to or not to live in tall buildings, 16.9 percent said least important, 11.9 percent said less important, 10.8 percent said moderately important, 7.7 percent said very important while 47.7 percent said lack of privacy was most important.

In the case of the importance they attached to the being scared of lift breakdown in their decision to or not to live in tall buildings, 16.9 percent said least important, 4.6 percent said less important, 24.6 percent said moderately important, 32.3 percent said very important while 21.5 percent said scared of lift breakdown was most important.

Table 4.8: Current perception of living in tall buildings

	Yes (persons / percentage)	No (persons / percentage)
Reliable lifts	51 (78.5%)	14 (21.5%)
Best housing for growing Ghanaian population	54 (83.1%)	11 (16.9%)
Structural quality	51 (78.5%)	14 (21.5%)
Solution of lack of shelter	49 (75.4%)	16 (24.6%)

Source: Field Survey, 2012

In the case of what represented respondents' perception of living in tall buildings, with reliable lifts 78.5 percent said 'yes' while 21.5 percent said 'no'. Majority of respondents representing 83.1 percent agreed in affirmative that they see high rise living as the best housing for growing Ghanaian population. With respect to structural quality 78.5 percent marked yes to represent their perception while 21.5 percent said it did not. About 75.4 percent of the respondents from the study also believed that high rise living is a solution to lack of shelter being experienced in Ghana while 24.6 percent said it did not represent their perception of high rise living being a solution to the lack of shelter problem in Ghana.

Table 4.9 Satisfaction level with High Rise Living

	Unsatisfied (persons / percentage)	V. Satisfied (persons / percentage)	Satisfied (persons / percentage)
Garbage disposal	3 (4.6%)	12 (18.5%)	50 (76.9%)
Smoke detectors	13 (20%)	12 (18.5%)	40 (61.5%)
Phone services	-	44 (67.75)	21 (32.3%)
Maintenance	5 (7.7%)	39 (60%)	21 (32.3%)
Management of facility	5 (7.7%)	37 (56.9%)	23 (35.4%)
Safety	5 (7.7%)	35 (53.8%)	25 (38.5%)
Clearing of ground floor garbage collection point	3 (4.6%)	33 (50.8%)	29 (44.6%)
Security	11 (16.9%)	31 (47.7%)	23 (35.4%)
Noise level	19 (29.2%)	28 (43.1%)	18 (27.7%)
Conducive environment	6 (9.2%)	33 (50.8%)	23 (35.4%)
Location	16 (24.6%)	26 (40%)	23 (35.4%)
Emergencies	9 (13.8%)	16 (24.6%)	40 (61.5%)

Source: Field Survey, 2012

When respondents were asked to indicate their level of satisfaction with the garbage disposal provision in their apartments, 4.6 percent said they were unsatisfied, 18.5 percent said they were very satisfied while 76.9 percent said they were satisfied. This indicates that there are proper / adequate provisions in terms of garbage disposal in high rise buildings in Ghana. In the case of smoke detectors, 20 percent said they were unsatisfied, 18.5 percent said they were very satisfied while 61.5 percent , indicating that smoke detectors installed this the apartments are adequate. With respect to phone services, respondents were positive with their responses. Phone services provided were adequate and reliable. With maintenance, majority of respondents were satisfied with maintenance routine carried out in their apartments. Regarding facility management 7.7 percent were unsatisfied, 56.9 percent were very satisfied while 35.4 percent were satisfied. From the study respondents feel much safe living in their apartments and not alarmed their safety. Clearing of ground floor garbage collection point is also another area respondents are satisfied within their various apartments. With security, 16.9 percent were unsatisfied, 47.7 percent said very satisfied while 35.4 percent said satisfied. With noise making, 29.2 percent were unsatisfied, 43.1 percent were very satisfied while 27.7 percent were satisfied. With conducive location, 9.2 percent were unsatisfied, 50.8 percent were very satisfied while 40 percent were satisfied. With location, 24.6 percent were unsatisfied, 40 percent were very satisfied while 35.4 percent were satisfied. With emergencies, 13.8 percent were unsatisfied, 24.6 percent were very satisfied while 61.5 percent were satisfied.

Table 4.10 Efficiency of lifts during rush hour

	Very efficient	Efficient Percent	Not efficient
Waiting time	16 24.6%	37 56.9%	12 18.5%
Travelling time	22 33.8%	31 41.7%	12 18.5%

Source: Field Survey, 2012

With how efficient the waiting time was during rush hour for the lift, 24.6 percent said it was very efficient, 56.9 percent said it was efficient while 12 (18.5%) said it was not efficient. In the case of how efficient the travel time for the lift during rush hour, 33.8 percent said it was very efficient, 47.7 said efficient while 18.5 percent said it was not efficient.

4.8 CHALLENGES FACED BY RESIDENTS

Table 4.11: Occupants Concerns

	Yes	No
Structural reliability	47 (72.3%)	18 (27.7%)
Insecurity	38 (58.5%)	27 (41.5%)
Falling off	28 (43.1%)	37 (56.9%)
Cleaning your apartment	19 (29.2%)	46 (70.2%)

Source: Field Survey, 2012

When respondents were asked whether they were concerned with structural reliability, 72.3 percent were concerned about structural reliability while 27.7 percent were not concerned about that. This means respondents saw structural reliability as a serious concern managers of high rise buildings need to deal with when constructing them. With insecurity, 58.5 percent were concerned about it while 41.5 percent were not concerned about in security. This means occupants saw insecurity as a challenge. With falling off, 43.2 percent were concerned while 56.9 percent were not concerned. There is only a marginal difference between those who talked of falling off and not falling off. This means administrators of high rise buildings are to deepen public trust in living in such buildings. In the case of cleaning their apartment, 29.2 percent were concerned while 70.8 percent were not concerned.

Table 4.12 Occupants rating of challenges in high rise buildings

	Least important	Less Important	Moderately Imp	Very Important	Most Important
Lift problems	17 (26.2%)	28 (43.1%)	17 (26.2%)	3 (4.6%)	-
Problem with waste disposal	13 (20%)	31 (47.7%)	5 (7.7%)	13 (20%)	3 (4.6%)
Lack of security	19 (29.2%)	28 (43.1%)	5 (7.7%)	5 (7.7%)	18 (12.3%)
Problem of maintenance	13 (20%)	21 (32.3%)	10 (15.4%)	14 (21.5%)	7 (10.8%)
Problem with smoke detectors	6 (9.2%)	19 (29.2%)	27 (41.5%)	6 (9.2%)	7 (10.8%)
Problem with location	19 (29.2%)	2 (3.1%)	24 (36.9%)	7 (10.8%)	13 (20.8%)

Source: Field Survey, 2012

When respondents were asked to rate the factors which were challenges/concerns they faced with their apartment, 26.2 percent said lift problems were least important, 43.1percent said it was less important, 26.2 percent said moderately important while 4.6 percent said it was very important. With problems related to waste disposal, 30 percent of the respondents rated it as least important, 47.7 percent said it was less important, 7.7 percent said it was moderately important, 20 percent said it was very important while 4.6 percent said it was most important. In the case of lack of security, 29.2 percent said it was least important, 43.1 percent said it was less important, 7.7 percent said moderately important, 7.7 percent said it was very important while 12.3 percent said it was most important. With problems of maintenance, 20 percent said it was least important, 32.3 percent said it was less important, 15.4 percent said it was moderately important, 21.5 percent said it was very important while 10.8 percent said it was most important. With the problems related to smoke detectors, 9.2 percent rated it as least important, 29.2 percent said it was less important, 41.5 percent said it was moderately important, 9.2 percent said it was very important while 10.8 percent said it was most important. With problems related to location, 29.2 percent said it was least important, 3.1 percent said it was less important, 36.9 percent said it was moderately important, 10.8 percent said it was very important while 20 percent said it was most important.

Table 4.13 Safeness during fire outbreak

	Frequency	Percent
Yes	39	60.0
No	26	40.0
Total	65	100.0

Source: Field Survey, 2012

From the table, about 60 percent of the respondent said they felt safe in the case of a fire outbreak and 40 percent had fears about their safety during fire outbreak,

Table 4.14 Reasons why people would not want to live in tall buildings

	Least Important	Less important	Moderately Important	Very Important	Most Important
Fear of height	9 (13.8%)	14 (21.5%)	16 (24.6%)	15 (23.1%)	11 (16.9%)
Absence of experience	31 (47.7%)	10 (15.4%)	13 (20%)	11 (16.9%)	-
Never visited such high place before	4 (6.2%)	38 (58.6%)	10 (15.4%)	6 (9.2%)	7 (10.8%)
Imaginary perception	15 (23.1%)	21 (32.3%)	10 (15.4%)	7 (10.8%)	12 (18.5%)
Safety concerns	3 (4.6%)	4 (6.2%)	19 (29.2%)	24 (26.9%)	15 (23.1%)
Travelling time in lift	12 (18.5%)	20 (30.8%)	14 (21.5%)	12 (18.5%)	7 (10.8%)
Problem with location	13 (20%)	1 (1.5%)	16 (24.6%)	18 (27.7%)	17 (26.2%)
Lift breakdown	7 (10.8%)	2 (3.1%)	22 (33.8%)	20 (30.8%)	14 (21.5%)
Fire rush	-	2 (3.1%)	28 (43.1%)	20 (30.8%)	15 (23.1%)
Collapse of building	-	6 (9.2%)	13 (20%)	31 (47.7%)	15 (23.1%)

Source: Field Survey, 2012

The study revealed that about 40 percent marked occupants of high rise buildings fear of height as an important factor why people would not want to live in tall buildings, 11. With respect to how occupants perceived the absence of experience as a reason why people would not want to live in tall buildings, 47.7 percent said that is least important, 15.4 percent said less important, 20 percent said it was moderately important while 16.9 said it was very important, indicating that people are not attracted to high rise living because they lack the experience in one. The study also revealed that people consider an experience or a visit to a high rise less important in deciding whether to live in a tall building on not.

With how occupants perceived imaginary perception as a reason why people would not want to live in tall buildings, 23.1 percent said least important, 32.3

percent said less important, 15.4 percent said it was moderately important, 10.8 said very important while 18.5 percent said imaginary perception was most important. In the case of how occupants perceived safety concerns as a reason why people would not want to live in tall buildings, 4.6 percent said least important, 6.2 percent said less important, 29.2 percent said it was moderately important, 36.9 percent said very important while 23.1 percent said safety concerns was most important. With how occupants perceived travelling time in lift as a reason why people would not want to live in tall buildings, 18.5 percent said least important, 30.8 percent said less important, 21.5 percent said it was moderately important, 18.5 percent said very important while 10.8 percent said travelling time in lift was most important. In the case of how occupants perceived problem of location as a reason why people would not want to live in tall buildings, 20 percent said least important, 1.5 percent said less important, 24.6 percent said it was moderately important, 27.7 percent said very important while 26.2 percent said imaginary perception was most important. In the case of how occupants perceived lift breakdown as a reason why people would not want to live in tall buildings, 10.8 percent said least important, 3.1 percent said less important, 33.8 percent said it was moderately important, 30.8 percent said very important while 21.5 percent said lift breakdown was most important. As to how occupants perceived fire rush as a reason why people would not want to live in tall buildings, 3.1 percent said least important, 43.1 percent said less important, 30.8 percent said it was moderately important, 23.1 percent said very important while 23.1 percent said fire rush was most important. With how occupants perceived collapse of building as a reason why people would not want to live in tall buildings, 9.2 percent said least important, 20 percent said less important, 47.7 percent said it was moderately important, 23.1 percent said very important while 23.1 percent said collapse of building was most important. Therefore, every occupant will prefer to look at how fit a building is. In this regard, high rise building must be built with quality materials to prevent fall as it is seen as a challenge.

Table 4.15 Making living in tall buildings attractive and satisfactory

	Frequency	Percent
Easy access to water and a small shop in the building so that we don't have to drive to buy certain things	4	6.2
Facilities like swimming pool should be provided to occupants	2	3.1
Improve upon services provided such as maintenance and cleaning services	2	3.1
It should be built with very high quality materials to withstand pressures from climate	3	4.6
No response	4	6.2
Reliable lifts should be provided With good fire detectors	8	12.3
Tall buildings should be located a little away from the capital city to avoid noise pollution	1	1.5
The corridors should be made more spacious	2	3.1
The culture of maintenance should be practiced so that facilities will be at its maximum safety	9	13.8
The floors should only be limited to only three	3	4.6
The sewage system and the entire building must be checked and maintained regularly	3	4.6
There should be more public education and encouragement to erase the false perception people have about high rise buildings	24	36.9
Total	65	100.0

Source: Field Survey, 2012

When respondents were asked of what they thought could be done to make living in high rise buildings attractive and satisfactory, 6.2 percent said easy access to water and a small shop in the building so that they don't have to drive to buy certain things, (3.1 percent said facilities like swimming pool should be provided to occupants, 3.1 percent said they should improve upon services provided such as maintenance and cleaning services, 4.6 percent said the building should be built with very high quality materials to withstand pressures from climate, 6.2 percent did not respond, 12.3 percent said reliable lift with good fire detectors should be provided, 1.5 percent said tall buildings should be located a little away from the capital city to avoid noise pollution, 3.1 percent said the corridors should be made more spacious, 13.8 percent said the culture of maintenance should be practiced so that facilities will be at its maximum safety, 4.6 percent said the floors should be limited to only three,4.6 perfect said the sewage system and the entire building must be checked and maintained regularly while majority of occupants 36.9 percent said there should be more public education and encouragement to erase the false perception people held about high rise buildings. Respondents upon given this recommendation suggest that there is more to be done to make high rise buildings attractive.

Table 4.16 Reasons why occupants do not enjoy high rise living

	Frequency	percent
Frequent light out and irregular flow of water	1	1.5
Frequent power outages making lift usage impossible	4	6.2
No response	4	6.2
Noise from other neighbours	8	12.3
Sometimes the elevator delays and noise from the surroundings is quiet embarrassing	3	4.6
Sometimes the place becomes so lonely that it scares me	3	4.6
The fear of insecurity and the level of noise in the city	1	1.5
The flow of water up to the top floors is very difficult	3	4.6
The location of the building is too close to the roadside and the noise from moving vehicles makes stay boring	25	38.5
There is nothing	13	20.0
Total	65	100.0

Source: Field Survey, 2012

When respondents were asked if there was something that prevented them from enjoying their stay, 1.5 percent said frequent light out and irregular flow of water, 6.2 percent said frequent power outages making lift usage impossible, 6.2 percent did not respond, 12.3 percent said noise from neighbours, 4.6 percent said sometimes the elevator delayed and noise from the surrounding was embarrassing, 4.6 percent said sometimes the place became so lonely and scared them, 1.5 percent said talked about the fear of insecurity and the level of noise in the city, 4.6 percent said the flow of water to the top floors was difficult, 38.5 percent said the location of the building was closed to the roadside and the noise from moving vehicles made their stay boring while 20 percent said there was nothing that made them not to enjoy their stay.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter presents the summary of findings, conclusions and recommendations that emerged from the study. It summarises the performance of high rise building in Ghana looking at the challenges people living in high rise buildings encounter, how satisfied occupants are and how high rise building can be attractive to the Ghanaian population. It presents the final conclusions of the study and goes on to suggest practical recommendations aimed at improving the performance of high rise building in Ghana and to also creating awareness of the benefits of high rise living to the Ghanaian economy.

5.2 SUMMARY OF FINDINGS

Nowadays High Rise buildings are built to maximize the land use and investment return. High Rise buildings have become part of the Ghanaian modern housing system. People have become aware of the facilities provided for occupants' safety.

In Ghana there is very little documentation on high rise building and this has been limited to commercial buildings. High rise building is widely acceptable means of maximising land to accommodate the growing population in Ghana.

This study sought to discover the impact of high rise building upon residents' satisfaction. The objectives of the study were to determine the benefits residents of high rise buildings enjoy, the challenges residents are faced

The case study approached was adopted in the study which involved residents of high rise building in Accra Metropolis. Using random procedure and the structured questionnaire as the main sampling and data tools respectively responses were obtained from 65 residents for the analysis.

The data obtained were analysed quantitatively using the SPSS and the Microsoft Excel programmes, the results were presented through frequency distribution, pie chart, tables and graphs.

The research identified some challenges with high rise living which included the lack of privacy, availability of water to higher floors, reliable utility power supply to all floors, lift breakdown, and structural quality.

The study discovered that over 90 percent of the occupants of high rise buildings are satisfied with the various high rise buildings they occupy.

The study also confirmed that a high rise building is the best housing for the growing Ghanaian population and solution to the lack of shelter for the Ghanaian population.

Finally, most occupants believed providing reliable lift, maintaining facilities and public education were the most important things that could be done to make living in high rise buildings attractive.

5.3 CONCLUSION

The study has assessed the impact of high rise building upon resident's satisfaction in Ghana. The results from the study confirmed that residents of high rise buildings are satisfied with the various apartments they occupy since high rise living in Ghana is seen as affluence and luxury living.

The results of the study also confirmed that high rise living is not attractive to majority of the Ghanaian population because people have this perception about high rise buildings which include collapse of the building, lift breakdown, fear of height, fear of the use of lifts and the absence of experience.

From the conclusion and summary of findings, it is clear and convincing to say the study had achieved it aims as it was to look at the benefits of living in high rise buildings, challenges, level of satisfaction and to make recommendations.

5.4 RECOMMENDATIONS

In view of the findings and conclusion of the study, the following recommendations are made for consideration for developers/ investors, the government and other relevant bodies to realize the importance of living in such buildings to the occupants and consider what occupants of high rise buildings prefer in order to meet the desired requirements.

The study also identified reasons why people do not wish to live in high rise buildings which include failure of lifts; frequent power outage, lift breakdown, fear of height and the absence of experience.

Further studies can be undertaken to identify performance and state of fire safety facilities in high rise buildings as some respondents were not sure of their safety in terms of fire outbreak. On this note, fire hose cabinets should always be at their maximum safety with both in and out emergency exits. The study further recommends the followings:

- Inlet breeching water machines should be provided to pump water to the upper floors and to also serve as underground water backup system.
- The Location of high rise buildings should be considered as most occupants complained of noise of moving vehicles which they didn't like.
- In addition, management should make sure that they have effective and efficient stand by plant to power the lift system and other facilities immediately power goes off.
- It is also recommended that there should be more public education and awareness of the advantages of high rise living in Ghana so more people can understand and appreciate what high living is about so that the negative perceptions people have can be changed.. This is because from the study most people feared the building will collapse. Therefore, if they are educated about the structural quality and the materials used to build people will feel safe and find high living attractive in order to consider vertical construction as a solution to house the growing Ghanaian population and the creation of slums especially in the cities.
- Finally, it is recommended that builders or investors in high rise buildings should give preference to what the occupants prefer and the satisfaction of the occupants and not what they (investors) like.

A further study into the post occupancy of high rise buildings is extremely important and recommended.

REFERENCES

1. ANSI/ASHRAE 55-1995. Thermal Environmental Conditions for Human Occupancy.

2. ANSI/ASHRAE 55-1995. Thermal Comfort: Compliance with ASHRAE 55-1992, LEAD Credit 7.1

3. Brager G. S. & de Dear R. (2000) A Standard for Natural Ventilation. ASHRAE Journal, pp 21-28.

4. Belinda Y., Lanny K. K. (2005) High Rise living in Singapore Public Housing.

5. Belinda Y., Lanny K.K. (2006) Urban Studies Vol. 43No.3 page 583-600

6. Cho, S.C. (2009) A Study on the Integrated Envelope System of Super High-rise mixed-use Apartment for Energy Efficiency Design, Master Thesis, Suwon University.

7. Chosunilbo, (2010). "Busan High-Rise Fire Sends Urgent Warning,"

8. Davey, Ed, (2009) Tower Bocks Potential Disaster, BBC News retrieved 25/11/2012.

9. Feriadi H, Wong N. H, Chandra S and Cheong K. W. (2003). Adaptive Behaviour and thermal comfort in Singapore's naturally ventilated Housing. Building Research & Information, Vol. 31(1), pp 13–23.

10. Hollister N and Wood A (2012), Skyscraper completion reaches new high for the fifth year running. The Indian Concrete Journal, 86(3), 39-42.

11. International Organization for Standardization. ISO 7730-1994. Moderate Thermal Environments – Determination of the PMV and PPD Indices and Specifications of the Conditions for Thermal Comfort.

12. ISO 2631-1: 1997. Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration. Part 1 General requirements.

13. Jianlei N.(2003) Some significant environmental issues in high rise residential buildings designs in urban areas, department of building services Hong Kong Polytechnic University, Hong Kong , china, Received 31 March 2003;accepted 26 July 2003

14. Kang D.H, and Kang J. (2008) A Study on the Characteristic of Energy Consumption in the Super High-rise Mixed-use Housing, Journal of the Urban Design Institute of Korea, 529-535.

15. Klote, J. (2008), "Smoke Control," *SFPE Handbook of Fire Protection Engineering*, National Fire Protection Association. Quincy, MA.

16. Klote, J., Milke, J., (2002), *Principles of Smoke Management*, American Society of Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA.

17. Koranteng C., (2010) An Evaluation of the Thermal Performance of Office Buildings in Ghana, Institute of Building Physics and Human Ecology, Technology University of Vienna.

18. Kumar S. K., (2011), How to Engineer Tall Buildings to Resist Wind, Civil Engineering and Construction Review, 24(12), 98-101.

19. Kurtenbach, E. (2010), "Shanghai Fire Toll at 58; Beijing Reviews Projects," Associated Press.

20. Kukinews, Super High-rise Mixed-use Residential Buildings ignoring Energy Efficiency, (2008. 10. 05).

21. LUND, B. (1996) Housing Problems and Housing Policy, New York, Longman, p.127.

22. Managing High Rise Residential Building in Malaysia, available from www.inspen.gov.my/inspen.com

23. Rafiq M.Y., Mathews J.D. and Bullock G.N., (2003), Conceptual Building Design-Evolutionary Approach, Journal of Computing in Civil Engineering, 17(3), 150-158.

24. Rijal H.B., Tuohy P., Humphreys M.A., Nicol J.F., Samuel A., Raja, I.A. and Clarke, J., ASHRAE Transactions, 2008, Atlanta, USA.

25. Robin G. (2007) Consequences of Living in High Rise Buildings invited paper accepted 28/01/07

26. Society of Fire Protection Engineers (SFPE) (2012): Guidelines for Designing Fire Safety in Very Tall Buildings: Public Review Draft p. 6-11

27. Sarantakos, S. (1997) Social research. (2nd Ed). London, Great Britain: Macmillan Press Ltd.

28. Sarah Williams Goldhagen (2012), Living High retrieved 28 June 2012.

29. Shipman, J.G.T. (1984) The hadhramaut Asian Affairs 15(2) 154-62

30. Xue M., Zhao Y., (2011) The Conceptual Design of High-rise Structures, Journal of Applied Mechanics and Materials, 99100, 46-50.

APPENDIX

Asiedu Ama Rita
KNUST Research Student
Institute of Distance Learning
Tel: 0244 652543 **Date: 24 July 2012.**

Sir/ Madam,

Research Questionnaire Survey
Please be informed that I am a research student from Institute of distance learning Kwame Nkrumah University of Science and Technology. Currently, I am pursuing Common Wealth Executive Masters of Business Administration and undertaking my Final Year Research Project.

I would appreciate your assistance with this research project on the performance of high rise buildings in Ghana, the perspective of the occupant.-case study of some high rise buildings in the Accra metropolis. This research will help me understand the benefits of high living and also determine the critical challenges residents of high rise building faces.

Kindly fill in this short questionnaire, which should take approximately 20 minutes of your valuable time. Respondents will be completely anonymous; your name and your apartment name will not appear anywhere on any publication.

The rating systems for this questionnaire survey as follows: **Likert Scale/ Rating Score**	**Level of Importance**
1	Least Important
2	Less Important
3	Moderately Important
4	Very Important
5	Most Important

QUESTIONNAIRE

PERFORMANCE OF HIGH RISE BUILDING IN GHANA

- THE PERSPECTIVE OF OCCUPANTS.

This questionnaire is set up to determine the current satisfaction level of residents of high rise buildings, critical challenges faced by residents of high rise buildings and the benefits of living in high rise buildings.

.

Your participation in the survey is voluntary and your answer will be kept strictly confidential.

There are **four parts** of the questionnaire:

Part I: Particulars of Respondent

Part II: General Information

Part III: Level of satisfaction in living in high rise buildings

Part IV: Challenges faced by residents of high rise buildings

Dr. Emmanuel Adinyira
(Research Supervisor, Department of Building Technology, KNUST)
Email: eadinyira.feds@knust.edu.gh

Rita Ama Asiedu
(Research Student)
Common Wealth Executive MBA.
IDL -KNUST

If you have any questions, please contact me at
Tel: 0244 652543
Email: ritasiedu@yahoo.co.uk

PART 1: PARTICULARS OF RESPONDENT (OPTIONAL)

Name of person completing the questionnaire……………………………………

Apartment name ………………………………………………………………

Sex: Male [ ] Female [ ]

Nationality--

Marital status:

[ ] Married
[ ] Single
[ ] Divorced
[ ] Widowed

Age

[ ] 25-30

[ ] 31-40

[ ] 41-50

[ ] 51-60

[ ] Above 60 years

PART II: GENERAL INFORMATION (PLEASE TICK)

Q1. Do you have your family living with you?

[ ] No

[ ] Yes, If yes Please state your family size

[ ] 1-2

[ ] 3-5

[ ] over 5

Q2 Which floors do you occupy in the building?

[ ] 1st – 3 rd floors
[ ] 4th – 8th floors
[ ] Above 12th floors

Q3. How long have you been living in this apartment?

[ ] Less than a year
[ ] 1-2 years
[ ] 3-5 years

Q5. Are you a home owner?

[ ] Yes

[ ] No,

PART III LEVEL OF SATISFACTION WITH LIVING IN HIGH RISE BUILDING

Q1. Is this your first experience in a tall building?

[ ] Yes

[ ] No

Q2. How high are you willing to go?

[ ] 1-3 floors
[ ] 4-8 floors
[ ] 9-15 floors
[ ] 20 and beyond

Q3. What is your level of satisfaction towards living at this apartment?

[ ] Very satisfied
[ ] Unsatisfied
[ ] Satisfied

Q4. What attracted you to high rise living?

[ ] Personal preference
[ ] Convenient location
[ ] Familiar neighbourhood
[ ] Family consideration (near a family member)

Q5. Are you happy with the floor you now occupy?

[ ] Yes

[ ] No

Please give reasons for your answer

Q6. Did you choose the floor you occupy?

[ ] Yes,
[ ] No,

Please give reasons---

Q7. Which of the following makes you satisfied?

[ ] Clear air
[ ] On top of the world feeling
[ ] Breeze

Other please specify--

Q8. Indicate the level of importance you will attach to the following in your decision to or not to live in tall buildings?

Least important → most important

	1	2	3	4	5
Luxury					
Feeling of isolation and loneliness					
Lack of privacy					
Scared of lift breakdown					

Q9. Which of the following represent your current perception of living in tall buildings?

	Yes	No
Reliable lifts		
Best housing for growing Ghanaian population		
Structural quality		
Solution of lack of shelter		

10. Indicate your level of satisfaction for each of the following

I. Unsatisfied - 1
II. Very satisfied - 2
III. Satisfied -3

	1	2	3
Garbage disposal			
Smoke detectors			
Phone services			
Maintenance			
Management of facility			
Safety			
Clearing of ground floor garbage collection point			
Security			
Noise level			
Conducive environment			
Location			
Emergencies			

Q11. How efficient is the travel time for the lift during rush hour
[ ] Very efficient
[ ] Efficient
[ ] Not efficient

Q12. How efficient is the waiting time for the lift during rush hour
[ ] Very efficient
[ ] Efficient
[ ] Not efficient

PART IV CHALLENGES FACED BY RESIDENTS (PLEASE TICK).

Q1. Are you concern about; (Yes / No) Please thick (/)

	Yes	No
Structural reliability		
Insecurity		
Falling off		
Cleaning your apartment		

Q2. How do you rate the following factors as some of the challenges/concerns you are faced with in your apartment?

Least important → most important

	1	2	3	4	5
Lift problems					
Problem with waste disposal					
Lack of security					
Problem of maintenance					
Problem with smoke detectors					
Problem with location					

Q3. Do you feel safe in case of fire outbreak?

Yes [ ]

No [ ]

Q4. How do you perceive the following factors as reasons why people would not want to live in tall buildings?

Least important → most important

Fear of height	1	2	3	4	5
Absence of experience					
Never visited such high place before					
Imaginary perception					
Safety concerns					
Travelling time in lift					
Problem with location					
Lift breakdown					
Fire rush					
Collapse of building					

Q5. Is there anything that you think can be done to make living in tall buildings attractive and satisfactory?

Q6. Is there anything that prevents you from enjoying your stay?

Thank you for your co-operation in completing this questionnaire. Am confident that the information you provided will greatly assist me in my research.

Once again thanks you for your support.