AN INVESTIGATION OF THE SUSTAINABILITY OF STEEL CONSTRUCTION TECHNOLOGIES IN MOBILE TELECOMMUNICATION INDUSTRY IN KENYA

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An Investigation of the Sustainability of Steel Construction Technologies in Mobile Telecommunication Industry in Kenya

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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This thesis has been submitted for examination with our approval as University supervisors.

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DEDICATION

This thesis is dedicated to my family; Dear wife Judith Owira - Akech and our lovely daughters: Elvira, Natasha and Kimberly for their encouragement, support and inspiration throughout the preparation of the research thesis.

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ABBREVIATIONS AND ACRONYMS

SCMT	Sustainable Construction Materials and Technologies
GSM	Global System for Mobile communications
BTS	Base Transceiver Station
SSCT	Sustainable Steel Construction Technologies
WCED	World Council on Economic Development
CCK	Communication Commission of Kenya
MRM	Mabati Rolling Mills
CIB	Innovation in Building and Construction
ICR	International Council for Research
UNEP	United Nation Environmental Programme
BRE	Building Research Establishment
DETRE	Department of the Environment, Transport and the Regions (UK)
EMS	Environment management systems

DEFINITIONS OF OPERATIONAL TERMS

Aerial Antenna: A device from which radio waves are transmitted and received. There are different designs in operation.

Cabin: A container which protects transmitters and receivers from harmful weather and provide controlled climate.

Cell: A geographic area of coverage that a Radio Base Stations covers.

Cold rolling is the passing a metal through a pair of rolls whose temperatures are below its re-crystallization**.**

Hot rolling is the passing a metal through a pair of rolls whose temperatures is above its re-crystallization**.**

Demountability is the ability to dismantle and re-erect quickly.

Pre-fabricate is to assemble components of a structure in a factory or other manufacturing site, and transport complete assemblies or sub-assemblies to the construction site where the structure is to be located.

Slimdek is an engineered floor solution developed to offer a cost-effective, service integrated, minimal depth floor for use in multi-storey steel framed buildings.

Mast is a ground-based or roof top structure that supports antennas at a height where they can satisfactorily send and receive radio waves.

ABSTRACT

The growth in Mobile Telecommunication sector has been rapid to the extent that by the end of 2011, there were 6 billion mobile subscriptions worldwide. This is an equivalent of 87% of the world's population. The rapid growth in the sector has caused mobile telecommunication service providers to constantly roll out mobile base stations in order to meet their capacity and coverage demands. Steel is the most commonly used material in the construction of the antenna support structures. The study evaluated the degree of sustainability of steel construction technologies in base stations. Sustainability is about reducing negative environmental impacts, enhancing social aspects and improving economic efficiency throughout a project's life cycle. This thesis focused on all aspects of sustainability of steel construction technologies in the sector in Kenya with specific focus on Safaricom Ltd. Questionnaires were administered to 67 subjects who are contracted or directly employed by Safaricom such as Project Managers, Engineers, Environmental Experts, Suppliers, Civil work contractors, Site Supervisors and Acquisition Experts. Results of the study revealed very high level of sustainability awareness but with low level of understanding of the concept of sustainability. Findings indicate that sustainable steel construction technologies in Kenya are cost effective, has low recyclability index and average sustainability knowledge. There is need for specialized training on sustainability knowledge to promote its applications in the industry.

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

1.1.1 Overview

Report by Philips Business Information (1993) indicates that Global System for Mobile (GSM) story begun in Europe in early 1980's, and initially stood for 'Groupe Spéciale Mobile', named after the study group that created it. The acronym was later changed to refer to 'Global System for Mobile (GSM) communications'. Moreover, Finland and Germany were among the first European countries to launch GSM digital cellular network in early 1990's. Germany, specifically, was known as the main driver of European GSM cellular penetration (Phillips Business Information, 1993).

In the world today, majority of the largest mobile telecommunication service providers have tried to make steps towards addressing sustainability (Sonnenschein et al 2009). Essentially according to Sonnenschein et al (2009), most of these sustainability strategies are aimed at leveraging mobile technology to make progress on reducing its carbon emissions and through innovation develop services that enable more efficient and effective healthcare; access to basic financial services to mobile payment solutions, and machine-to-machine applications that can bring substantial carbon and energy cost savings during mobile site operations. However, none of these efforts have focused on the sustainability of steel construction technologies in current use in the construction of mobile communication sites (Sonnenschein et al, 2009).

1.1.2 Sustainable Construction

Sustainability is a systemic concept, relating to the continuity of economic, social, institutional and environmental aspects of human society (ISO/DIS, 2006). According to agenda 21 for sustainable construction in developing countries, sustainability is defined as; "condition or state which would allow the continued existence of homo-sapiens and provide a safe, healthy and productive life in harmony with nature and local cultural and spiritual values" (Du Plessis, 2002). Generally, sustainability focuses on reducing negative environmental impacts, enhancing social aspects and improving economic efficiency, which are the three common aspects in steel construction technologies applied in the mobile communications sector (Glavic & Lukman, 2007).

The essence of sustainability is captured in the definition of sustainable development from the Brundtland report of the World Council on Economic Development (WCED, 1987) as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This means that sustainable construction is a process which incorporates the basic themes of sustainable development (Parkins, 2000). Sustainable construction has as a result been defined as a holistic process aiming to restore and maintain harmony between the natural and built environments, and create settlements that affirm human dignity and encourage economic equity (Du Plessis, 2002). Such construction processes would thus bring environmental responsibility, social awareness, and economic profitability, objectives to the fore in the built environment and facilities for the wider community (Langston & Ding, 2001; Miyatake, 1996). Therefore, Sustainable Construction Materials and Technologies (SCMT) refers to construction processes, materials and tools that are renewable, energy efficient, cost-effective, safe, innovative, green/environmentally friendly, as well as acceptable to the climate, socio-economic conditions, and natural resources of an area throughout a project's life cycle (Du Plessis et al, 2002).

1.1.3 Sustainable Steel Construction Technologies in the GSM Industry

According to Randall et al (2012) steel has been playing an integral part in making construction more efficient for decades, thus steel construction has no equal in sustainability. The discovery of steel, which is the most predominant material in the manufacture of towers used in the mobile communications industry today was made possible in industrial quantities by the Bessemer process of 1856. Towers found in the GSM stations which are mobile communication sites are responsible for carrying communication gadgets used for transmitting and receiving cellular signals during mobile communication process (Du Plessis et al, 2002). (Appendix 3: GSM Station Architecture).

Subsequently, given that the towers are the chief consumer of steel; it is considered to be a sustainable material since it has always been manufactured off site using standardized components. As such, it delivers the benefits of modern methods of construction such as zero waste, high quality, repeatability, reduced cost and improved health and safety (Randall et al, 2012). The standardized steel components can be produced in repeatable modular units that can be very efficient for height flexibility (Ashby, 2009) in the construction of towers. Hence, according to Ashby (2009) through the use of steel in constructing towers, sustainability can be achieved from the key benefit of modular towers that can be dismantled easily and re-used elsewhere hence maintaining asset value after use.

Moreover, focusing on the process of setting up the GSM stations for mobile communications after obtaining the license, usually it involves site survey, site acquisition, system planning, and frequency planning (Du Plessis et al, 2002). These processes have to be completed before commencement of the actual construction and civil works. The construction/civil works phase is another time consuming phase and before it starts, the various levies and taxes to the different tiers of government and statutory bodies and rent to the local landowners must be paid (Du Plessis et al, 2002).

Notably, the construction process includes; civil works related elements such as foundations and the delivery to site and assembling of the steel towers, the shelters, the generating sets, the power elements, air-conditioning, the earthing processes, and the radio equipment up to integration and the final commissioning (Watuka & Aligula, 2002). The processes described above are mandatory for initial deployment of telecom services anywhere, but when the technology has attained some level of maturity in any market, it becomes a very ineffective approach for any new operator entering the market, both in terms of cost, security, logistics, and time to market (Watuka & Aligula, 2002).

In the case of buildings, the inability to adapt and upgrade buildings can compromise occupant comfort, energy efficiency and in commercial buildings reduce the productivity of workers. Therefore, according to Glavic and Lukman (2007) re-using and recycling construction materials such as steel have a significant contribution to make towards achieving sustainable development, as it reduces waste and saves primary resources. Again, in the case of steel construction technology, the designer can also maximize the potential for re-using steel structures by using bolted connections in preference to welded joints, using standard connection details, bolt size and spacing of holes, ensuring easy access to connections and using long span constructions to offer maximum possibility of re-use by cutting the beam to a new length (Ashby, 2007). According to Cagan and Vogel (2002) re-use sometimes demands that structures can be extended vertically to create more usable space and make them economically viable. This can be achieved by roof-top extensions and using lightweight steel to ensure that existing structure is not overloaded.

1.2 Statement of the problem

According to Phillips Business Information (1993), the successful development and deployment of mobile telecommunications over the past three decades is most significant in the advancement of the global telecommunication sector today. GSM networks had over 50 million subscriber base in Europe alone during the first seven years compared to fixed networks which took nearly 50 years to acquire the same number of subscribers worldwide (Bout et al, 2000). International Telecommunication Union (ITU) report (2012) shows that there were 6 billion mobile subscriptions worldwide at the end of 2011, which was equivalent to 87% of the world population.

Surprisingly, the African continent so far outpaces the rest of the world in average annual growth of mobile phone subscriptions. ITU report (2012) indicates that from 1999 through to 2004, Africans signed up for cell phones at a far greater rate than Asians and nearly three times as fast as Americans, with most of that growth being in the sub-Saharan region.

In Kenya, the liberalization of telecommunications industry in 1999 saw introduction of new players Safaricom Ltd and KenCell Communications Ltd, now Airtel to roll out and provide a service that has succeeded in reaching beyond their expectations. According to London-based Tele-Geography Research on launching its service in 1999, Safaricom expected to have 3 million subscribers by 2020 yet only in six years (by 2005), there were more than 4.6 million subscribers in Kenya, split between the two carriers.

Communications Commission of Kenya (CCK) 3rd quarterly sector statistics report (2012) indicates that by March 2012 the number of mobile subscribers in Kenya had grown to over 29 million.

In order to meet the ever growing demand of GSM, the mobile telecommunication companies are always rolling out base transceiver stations (BTS) so as to achieve their capacity and coverage objectives (Bout et al 2000). The construction industry therefore plays a key role in the attainment of these objectives and the most commonly used material in the construction of structures to support GSM antennas in BTS sites is steel (Justin & Cook, 2006). Due to rapid growth witnessed in the industry over the last three decades, there is need to evaluate the sustainability of steel construction technologies used in the construction of masts in BTS sites. This would benefit the mobile communications sector by establishing their level of sustainable construction which is a sub set of sustainable development.

Furthermore, research on sustainability of construction materials and technologies in mobile communications industry would also greatly benefit in future from being commissioned jointly by the relevant government regulatory bodies rather than on an individual basis. This is due to the fact that, construction is a major consumer of non-renewable resources and a massive producer of waste, and the operation of buildings is responsible for emissions of carbon dioxide (Gibberd, 2003). Thus, this industry faces the challenge of delivering economic structures that maintain or enhance quality of life, while at the same time reducing the impact of the social, economic and environmental burdens which it places on the society (Anderson et al, 2009).

Therefore, the search for sustainable steel construction technologies for the mobile sector is assumed to be one of the possible solutions to reducing impact on social, environmental and economic burdens. In this regard assessing the level of sustainability of steel construction technologies in the GSM sector is paramount to the sustainable development of mobile telecommunication sector.

1.3 Objectives

1.3.1 General Objective

To investigate the Sustainability of Steel Construction Technologies in Mobile Telecommunication Industry in Kenya.

1.3.2 Specific Objectives

1. To explore the extent of sustainability of steel construction technologies in the mobile telecommunication industry in Kenya.
2. To assess factors that influence the use of sustainable steel construction technologies in the mobile telecommunication industry in Kenya
3. To formulate evaluation criteria to measure sustainability of steel construction technologies in the mobile telecommunications Industry in Kenya.

1.4 Research Questions

1. What is the extent is of sustainability of steel construction technologies used in construction of Safaricom base stations sites?
2. What are the factors influencing the use of sustainable steel construction technologies in Safaricom base stations sites?
3. What are the criteria to be considered in the evaluation of sustainability of steel construction technologies in the mobile communications industry in Kenya?

1.5 Justification of the Study

Sustainability, as it relates to telecommunications industry, is important for meeting current and future consumer demand, regulatory requirements and reduced costs through enhanced operational efficiencies (WCED, 1987). Through primary legislation; the constitution of Kenya (2010) also makes the pursuit of sustainable development a new underpinning requirement. Article 42 of the constitution guarantees every person the right to clean environment whereas Article 69 envisages that the state shall ensure sustainable management and conservation of environment. Consequently, due to the rapid growth in the mobile communications sector, the constitutional requirement for sustainable development and clean environment, and the commonality of steel in the industry, there is a justification to find out the extent of sustainability of steel construction technologies used in the deployment of the mobile communication sites.

The aim of this research was to carry out a comprehensive study and analysis on the sustainability of steel construction technologies in use in the mobile communications industry in Kenya while focusing on Safaricom Ltd. The findings of this study were to create awareness within the mobile communications industry on the level of sustainability of steel construction technologies in use, and areas of improvement required to achieve sustainable construction. Through the findings, the industry is expected to have the capacity to develop strategic methods and solutions to improve sustainable construction. This would ensure the operators benefit from; long term economic returns, reduced construction costs, and improved quality of life to the construction workers, reduced effort, time and waste using sustainable steel construction technologies. Furthermore, the industry would benefit from sustainable land use, thereby achieving sustainable construction which is a subset of sustainable development. As a result, the society would also benefit through enhanced health and productivity, environmentally effective use of steel construction technologies and reduced environmental impact – cleaner environment.

1.6 Scope and Limitations of the study

1.6.1 Scope

The aim of the research was to carry out a comprehensive study and analysis, on the sustainability of steel construction technologies in use in the mobile communications industry in Kenya. At the time of the study, there were four mobile telecommunication service providers in Kenya namely; Safaricom Ltd, Airtel Networks Kenya Ltd, Telkom Kenya Ltd (Orange) and Essar Telecom Kenya Ltd. Apparently, according to CCK 3rd quarterly sector statistics report (2012) Safaricom Ltd was found to be the largest mobile telephone operator as it commanded 65% of the market share by percentage of mobile subscription. As a result, due to its dominance in the market, the study focused on Safaricom Ltd, with the outcome being generalized to the entire mobile industry in the country.

1.6.2 Limitations

During the study some setbacks which were beyond the control of the study were encountered. Time for data collection was limited hence not all the questionnaires were returned as some respondents had not filled in the required data. Some respondents had only specialized in one area of GSM, and hence not all questions were answered. There was also limited access to some respondents and information but there was persistent and close follow up in order to gather adequate information.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Sustainability has evolved as a mainstream research focus, with much attention being devoted to the sustainability agenda from researchers of various backgrounds. Different organizations of the international communities have devoted considerable efforts to ensure that every human activity fulfills the requirements of sustainable development (Angioletti et al, 1998). The essence of sustainability in a society is to bring about sustainable development, which is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). This is the reason as to why the world today, in any process undertaken is concerned in taking sustainable measures which is a commitment to the development and growth of sustainable communities for the sake of the future generation (Du Plessis, 2002).

Generally, sustainability focuses on reducing negative environmental impacts, while enhancing social aspects and improving economic efficiency, which are the three common pillars in steel construction technologies applied in the mobile communications sector (Glavic & Lukman, 2007). The mobile operators are known to seek the services of construction industry in their quest to roll out GSM base stations for telecommunication purposes. Apparently, construction processes are a major consumer of non-renewable resources and a massive producer of waste, and the operation of buildings is responsible for emissions of carbon dioxide (Gibberd, 2003). Thus, the industry faces the challenge of delivering economic structures that maintain or enhance quality of life, while at the same time reducing the impact of the social, economic and environmental burdens which it places on the society (Anderson et al, 2004).

Subsequently, the use of steel in sustainable construction supports the ideology of the World Council on Economic Development (WCED, 1987) on use of materials to bring about sustainable development. As such, according to Randall et al (2012), steel is one of those materials that have no equal in sustainability. This is because, the essence of environmental sustainability can be achieved by construction technologies which use eco-friendly materials and technologies, and steel has been regarded as sustainable since it is;

recyclable, energy efficient, cost effective, safe to use and environmental friendly (Du Plessis et al, 2002) making it ideal for construction of GSM stations in the mobile industry.

2.2 Theoretical Framework

2.2.1 Introduction

The theoretical framework provides a context for examining the research problem and makes generalizations about observations. It also consists of an interrelated, coherent set of ideas and models about sustainable development.

Sustainable development has been firmly introduced into the political arena of international thinking since the interdependency of economic growth and environmental sustainability was recognized (WCED, 1987). As a result, theories of sustainability attempt to prioritize and integrate social and economic responses to environmental problems. According to Harrington (2013) the evolution of the concept and its emergence as a global challenge has been largely shaped by three mega - conferences; The United Nations Conference on the Human Environment in Stockholm in 1972, The United Nations Conference on Environment and Development in Rio de Janeiro in 1992 and The World Summit on Sustainable Development in Johannesburg in 2002. Understandings of sustainable development have been altered over time, due to the evolution of environmental and development studies culminating in the widespread recognition of economic and social development which can be achieved in an environmentally - friendly manner (WCED, 2007).

Consequently, there has been extensive academic literature produced on the concept of sustainable development. This literature has emerged from various disciplines such as development studies, environmental studies, sociology and economics which adopt differing views of the emergence, practice and goals of sustainable development (Harrington, 2013). On the other hand, most if not all approaches to sustainable development have reached a consensus that it is mainly concerned with maintaining conditions for the future generations (WCED, 1987).

Most definitions acknowledge the three interdependent pillars on which sustainable development is based; the environmental, economic and social dimensions and they recognize that the ultimate goal is to simultaneously achieve maximum progress across all three areas (Castro, 2004; Elliott, 2008). The majority of approaches also accept the necessity of establishing a compromise between economic development and environmental sustainability so that economic growth can be pursued in an environmentally sustainable manner in both the developed and the developing world (Castro 2004; Elliott 2008).

2.2.2 The United Nations Approach

The most established mainstream perspective of sustainable development is provided by the approach of the United Nations (UN), which is widely recognized as the initiator of serious international discussion on sustainable development as a global challenge (Harrington, 2013). The UN views poverty and inequality as an underlying cause of environmental degradation. Therefore, it focuses on addressing the underlying causes of poverty and inequality in order to prevent further environmental degradation and ensure greater environmental sustainability in the future (WCED, 1987). The UN proposes that greater economic growth in developing countries through the creation of freer markets and by the transfer of knowledge, capital and technology from the developed world will reduce and eventually eradicate poverty and inequality.

On the other hand, the World Bank (WB) adopts a similar neoliberal approach to sustainable development and emphasizes the importance of the free market and market mechanisms in achieving environmentally sustainable practices (World Bank, 2005). The approach of the UN and the WB is based on mainstream environmental economics which argues that economic growth in the periphery is necessary to prevent further environmental degradation. Environmental economics highlight that the effects that environmental policies have on the economy need to be determined in order to design appropriate environmental policies which will ensure environmental sustainability without limiting economic growth (Castro, 2004).

2.2.3 The Human Rights Approach

Adebowale (2004) has articulated the case for adopting a human rights and environmental justice approach to sustainable development. She argues that existing legal research suggests that the application of human rights within an environmental context is justified on the grounds that a healthy environment is a fundamental prerequisite for upholding the human right to life. This is because, at the most basic level, a dignified life cannot be realized without access to clean water, air and land (Adebowale, 2004).

Within the discourse, human rights and the environment are essentially perceived in two ways, the first in terms of civil and political rights and the second in terms of economic, social and cultural rights (Adebowale, 2004). Civil and political rights provide for moral and political order, including the right to life, equality, political participation and association. They are couched most clearly in the Universal Declaration of Human Rights (1948) and the International Covenant on Civil and Political Rights (1966). Civil and political rights are crucial to guaranteeing good governance, essentially protecting public participation around environmental protection and achieving greater equity.

The second set of rights, economic, social and cultural, establish the right to a healthy environment and support the right of all peoples to manage their own natural resources. These rights can be sourced in a number of international human rights conventions, such as the International Covenant on Economic Social and Cultural Rights (1966) and Conventions on the Rights of a Child (1989).

The Constitution of Kenya (2010) also makes the pursuit of sustainable development a new underpinning requirement. Article 42 of the constitution guarantees every person the right to clean environment whereas Article 69 envisages that the state shall ensure sustainable management and conservation of environment.

2.2.4 The Capital Approach

Classical development theory is strongly focused on investment and capital as central determining factors for development. While traditionally restricted to understanding economic development through expansion of markets and increases in human-made capital, the theory is increasingly extended and broadened so that it addresses the broader question of how to secure sustainable development as well (United Nations et al., 2003). According to United Nations et al (2003) from a capital perspective, sustainable development can be defined as non-declining per capita wealth over time. In particular, it states directly the need to maintain wealth as the basis of sustainable development.

Moreover, it also recognizes that wealth per capita is what matters and not just the total wealth of a society. This reflects the fact that populations increase over time and that the rate of increase of wealth must be at least equal to population growth if sustainable development is to be achieved. All goods and services can be viewed as being produced through the use of capital, normally in conjunction with human labour. It should be noted that managing total national wealth in a manner that sustains it over time, measured per capita, only provides the potential for sustainable development.

This is because there is no guarantee that future generations will manage well the capital base they inherit. They may fail in utilizing it effectively to create their well-being and instead waste the resources on wars or on excessively high living without concern for the well-being of their descendants. Contrastingly, according to Hamilton and Ruta (2006) stable or growing total wealth per capita is no guarantee of sustainable development, yet the opposite is a guarantee of its impossibility. That is, in the face of declining per capita capital stocks, well-being will in the long run deteriorate and sustainable development will not be possible (Hamilton & Ruta, 2006). Hence, by taking the perspective of capital, the challenge of sustainable development is simplified into a question of whether a country's total capital base or total national wealth is managed in a way that secures its maintenance over time.

2.2.5 The European Perspective

In 2001, the European Council adopted the European Union (EU) Sustainable Development Strategy (European Commission, 2001) which provides a long-term vision that involves combining a dynamic economy with social cohesion and high environmental standards. It requires a new emphasis on policy coordination and integration. As part of the implementation of the strategy, the Commission introduced a system of extended impact assessment for all major policy proposals. This approach provides information on the tradeoffs between the economic, social and environmental dimensions of sustainable development to inform decisions. By allowing a full appraisal of the potential environmental costs and benefits of all major Commission proposals, as well as of the costs and benefits of specific environmental measures, it helps promote environmental integration.

The importance of integration of environmental programmes into other aspects of European policy was reaffirmed in the Sixth Environmental Action Programme (European Commission, 2002). The new programme identified four priority environmental areas to be tackled for urgent action and improvement, namely: climate change, nature and biodiversity, environment and health and quality of life, and natural resources and waste.

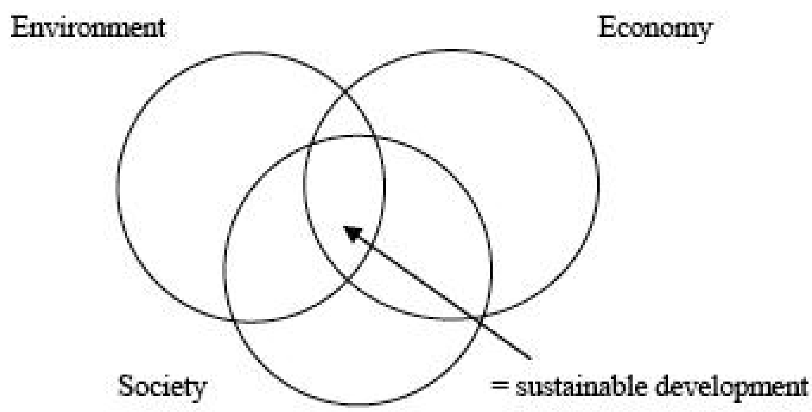
2.2.6 The Economic Approach

Many of the academics with an interest in sustainable development in the late eighties and early nineties approached the subject from an economics background (Dasgupta, 1993; Pearce, 1989) attempting to price the environment through a framework of fiscal controls and incentives (Dresner, 2002). This argues that the best way to protect the natural environment is to assign it an economic value based on people's willingness to pay. The aim is to internalize all the external costs to the economy in terms of pollution, resource depletion and human health.

There have been numerous criticisms of this approach, including how to price irreplaceable resources, how to ensure equitable or fair distribution, or both, within and between nations, and how to reflect the resource needs of future generations within the current market place. Indeed, Aubrey Meyer has gone as far as to describe the approach as the economics of genocide (quoted in Dresner, 2002). Nevertheless, economic tax reform has been taken up as the most likely way for the western world to control the environmental impact of our systems of production and consumption. And it has the added advantage of generating government income, which can be targeted at new technologies and other interventions to improve the environment.

2.2.7 Venn Diagram Explanation of Sustainable Development

According O'Riordan (1998) conceptually, there has been some movement towards greater understanding of sustainable development, as demonstrated by the simple Venn diagram, which explains that such development can be achieved through interactions of the economic, environmental and social aspects in a society, which are commonly referred to as the sustainability pillars. These are the pillars that most of the approaches towards understanding sustainability have been based on, and their needs to be interaction among them so as to bring about sustainable development in a society, as explained on the diagram below (O'Riordan, 1998; see Figure 2.1). Consequently, such integration also provides the avenue through which sustainable development can be measured (O'Riordan, 1998)



Source: O'Riordan 1998

Figure 2.1: Venn diagram explanation of sustainable development

2.3 Conceptual Framework

2.3.1 Introduction

Conceptual framework is used in research to outline possible courses of action or to present a preferred approach to an idea or thought. According to Rose (2008), conceptual framework is an intermediate theory that attempts to connect all the aspects of inquiry. Moreover, the framework is a structure of assumptions and principles that hold together the ideas comprising a broad concept (Armstrong, 2010). According to Guest and Conway (1998), conceptual framework therefore assists in synthesizing ideas for the purpose of organized thinking and provides direction in a study, by showing the relationship between the independent and dependent variables. Figure 2.2 below shows a diagrammatic illustration of conceptual framework.

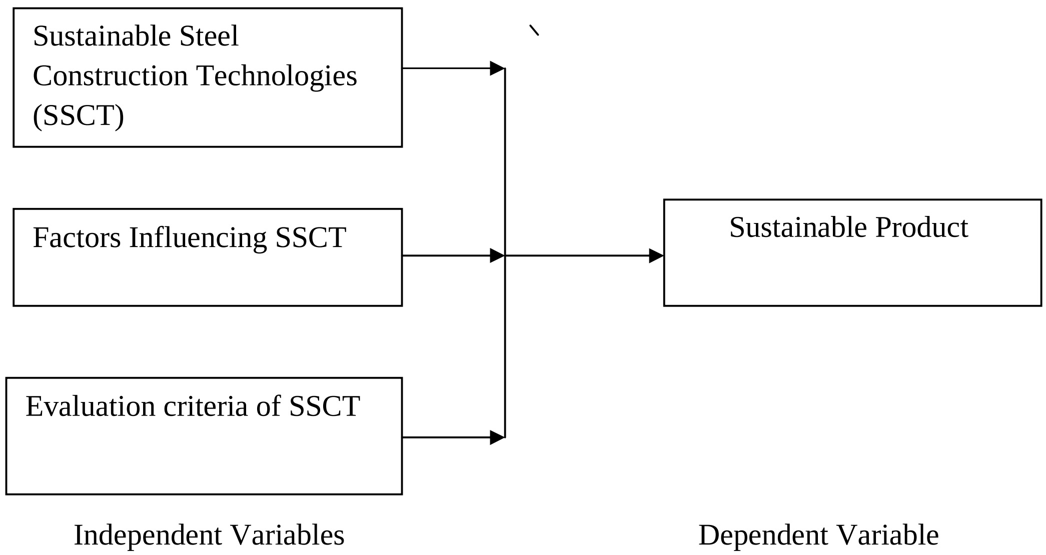


Figure 2.2: Conceptual framework

Based on figure 2.2, the study identified both the dependent and independent variables. Sustainable steel construction technologies (SSCT), factors influencing the SSCT and its evaluation criteria are the independent variables whereas all the testing will be done onto the dependent variable which is the sustainable product.

2.3.2 Sustainable Steel Construction Technologies

Du Plessis et al (2002) define construction as a broad process for the realization of human settlements and the creation of infrastructure that supports development. Hence, construction technologies are therefore defined by construction methods followed and materials used, whereby the methods are directly related to the availability of skills and workforce, while materials used are related to the resources available (Du Plessis et al, 2002). Commonly, the choice of technology largely determines the resources mix and techniques used in construction (Moavenzadeh, 1978). As one author states that, “at any stage, man’s development and his achievement in time has been marked by two factors; resources and technology” (Jain, 2007).

Steel has been playing an integral part in making construction generally more efficient for decades given its capacity of being a sustainable material (Randall et al, 2012). According to Steel Construction Sector Sustainability Committee (SCSSC) report (2002) in the United Kingdom (UK), the recycling and reuse rate for steel construction products was 94% and as high as 99% for structural steelwork. The SCSSC report (2002) established that steel accounts for very little of the 100 million tonnes of construction waste that goes to landfill sites each year in the UK due to its inherent value and long established recovery infrastructure. By contrast, concrete is estimated to contribute two-thirds by weight of all construction and demolition materials transported to landfill (Randall et al, 2012). Recent surveys show that an amount equivalent to some 40% of total world steel production is recovered and recycled annually, and this material can be recycled over and over again into new products with no reduction in its properties (Randall et al, 2012).

Consequently, the advancement of steel technology in sustainable construction has unfolded exciting architectural opportunities, such that the architects are able to expand their artistic expression and design spectacular structures (Ashby 2009). This is because Ashby (2009) classifies steel as a quasi-sustainable material whose structural framing, art and function can come together in limitless ways to offer new solutions and opportunities. According to Mora (2007) and Zhou (2009) sustainable construction requires good design which is made in the initial stage of the project development. Thus, Ljungberg (2007) asserts that these sustainable designs of structures can therefore be reached by specifying steel as well as the life-time of the structure, a scenario that would benefit the mobile industries which requires structures that are durable since they aim to stay longer in the market. In addition, post construction benefits of sustainable steel construction technologies include energy-efficient structure envelopes, flexibility in long-term use, non- polluting, non-combustibility, corrosion free, no shrinkage, ease of extension and adaptation, and ultimately, refurbishment, recycling and re-use (Cagan &Vogel, 2002).

2.3.3 Factors Influencing Sustainable Steel Construction Technologies

Sustainable structures are high quality, energy efficient, long life, and adaptable to future demands and assets to the economic and social life of the community and the built environment (Annie & Jaya, 2011). Therefore, some of the factors that would commonly influence the use of steel in construction to produce such structures includes; technological advancement used in production of steel for construction, cost of construction and material usage in construction (Well, 2005; Bout et al, 2000).

Technically, Schimid (2003) declares that all steel systems used in construction are highly produced as industrialized components by modern manufacturing processes in safe factory conditions. Wells (2005) asserts that, these systems are highly pre-fabricated, minimize on-site process and impact beneficially on sustainability of construction. Moreover, Schimid (2003) indicates that design by the Computer Aided Design increases efficiency, reduces waste and improves quality and accuracy in production of steel components to be used in construction. As a result material use is minimized by the high: strength ratio of steel components which makes it suitable for construction (Bout et al, 2000).

Nevertheless, construction cost relates to the use of materials, labor, specialist components, equipments and machinery, and it is also influenced by time related factors (Bout et al, 2000). Steel construction achieves high levels of productivity and therefore labor cost is reduced on the construction site in comparison to site based construction (Persson, 2002). This is because the speed of construction and safety is increased by the higher levels of pre-fabrication implicit in steel-intensive construction systems (Wells, 2005). The cost of the steel framework is typically only 12-15% of the as-built component of the building, thus it influences on the choice of structure on the other building components and speed of installation. Life cycle costing shows that the operational costs can be more than the construction cost over 50 year life. The operational benefits of steel are due to energy savings, low maintenance and flexibility (Wells 2005).

Furthermore, according to Hill and Bowen (1997) construction is one of the major users of materials and resources, hence it is important to minimize their use by maximizing their recyclability. In steel construction this is achieved effectively; typical lightweight steel framed house uses only 40-45 kg steel per m^3 (Wells, 2005). Lightweight steel construction reduces material use by up to 30% in brick clad houses which are equalized to 54% in the GSM industries in construction of mobile base stations (Hodges, 2010).

According to Hodges (2010) a light steel framework is protected by lightweight materials like plasterboard and mineral wool insulation, and as a result, the physical weight and use of materials is much less than in more traditional construction. The recyclability and demountabilty of steel contributes to sustainability in the construction industries (Singh, 2007).

2.3.4 Evaluation Criteria for Sustainability of Steel Construction Technologies in the Mobile Sector

It is important to evaluate the current steel construction technologies to ascertain its sustainability in the mobile communications industry (Irurah, 2001). According to Irurah (2001) this is for the better and healthier development of the current and future generations. Evaluation test shows that there are two extreme sides which are essential in the growth and economic development of various states (Miyatake, 1996). There are various indicators that can be used to measure sustainability in construction. Such indicators according to Miyatake (1996), CIB (1999) and DETR (2000) are meant to portray in general improved; profitability and competitiveness, client's and stakeholder satisfaction, best value and quality in creating the built environment or the products, maximization of resource reuse, use of renewable and recyclable resources, protection of the natural environment, and minimization of impact on energy consumption and natural resources, as a result of embarking on sustainable construction technologies (Miyatake, 1996; CIB, 1999 & DETR, 2000). According to Hill and Bowen (1997) they identified attributes that are commonly regarded as the pillars to a sustainable construction, they include; social, economic, and biophysical indicators.

The social pillar is based on the notion of equity and social justice, where sustainability in construction is expected to propagate social progress which recognizes the needs of everyone in the society (DETRE 2000). Hence, Hill and Bowen (1997) assert that sustainability in the social context should be a driver to; improving the quality of life through provision for social self determination and cultural diversity, protect and promote human health through a healthy and safe working environment. Secondly, the economic pillar in sustainable construction ensures; financial affordability, employment creation, enhanced competitiveness, client satisfaction and sustainable supply chain management

(Hill & Bowen, 1997). Finally, the biophysical pillar is focused on the quality of human life within carrying capacity of supporting ecosystems (Cole & Larsson, 1999). Cole and Lerson (1999) point out that the pillar ensures that sustainability puts in place; waste management, prudent use of the four generic construction resources namely; water, energy, material and land, while avoiding environmental pollution (Hill & Bowen, 1997).

2.3.5 Sustainable Products

Construction process truly has a significant effect on the quality of life. The process usually yields products that often alter the nature, function and appearance of the towns and countryside in which people live and work. Consequently, Products are normally expected to have specific perceived characteristics that contribute to their success or failure. Such product characteristics include; good value, quality, meet stakeholder's needs, unique features or solve problems other products do not, safe, efficient, durable and serviceable (Cagan & Vogel, 2002). These are some of the characteristics that are thought to provide value to the concerned product. Apparently, there are six components that contribute towards making a product to attain value; invoking appropriate emotion, displaying aesthetic attributes, acquiring product identity, safe to use, being technologically operational and having quality (Cagan & Vogel, 2002). Since, a sustainable product must give as much satisfaction as possible to the user to be successful in the market (Ljungberg, 2007) it should incorporate all these values in its production.

Given the above scenario on what is anticipated of a product, a sustainable product therefore can be defined as a product made using processes and systems that are non-polluting, that conserve energy and natural resources in economically viable, safe and healthy ways for consumers, and which are socially and creatively rewarding for all stakeholders for the short and long term future (Glavic & Lukman, 2007). This is because sustainability achieved in products is partly as a result of the choice of the materials and construction process selected (Annie & Jaya, 2011). Consequently, the majority of the sustainability benefits do arise from improvements in the built environment and performance of structures in service, including adaptability and end of life issues (Annie & Jaya, 2011).

2.4 Empirical Review

2.4.1 Application of Sustainable Steel Construction Technologies

Normally, construction processes include the extraction and beneficiation of raw materials, the manufacturing of construction materials and components, the construction project cycle from feasibility to deconstruction, and the management and operation of built environment (Du Plessis et al 2002). Irurah (2001) also provides interpretation of construction at four levels: as site activity, as the comprehensive project cycle, as everything related to the business of construction, and as the broader process of human settlement creation.

Consequently, the first definition of sustainable construction was proposed by Charles Kibert during the first international conference on sustainable construction in Tampa, 1994. It states that sustainable construction is the creation and responsible management of a healthy built environment based on resource efficient and ecological principles (Bourdeau, 1999). As such, Miyatake (1996) identified six main principles of sustainable construction which were presented by Charles Kibert as; minimization of resource consumption, maximization of resource re-use, use of renewable and recyclable resources, protection of natural environment, creating a healthy environment and pursuing quality in creating the built environment.

As a result, sustainable construction involves considering the entire life cycle of the building taking into account environmental quality, functional quality and future values (Kibert, 2008). In addition, it entails creating buildings that allow the user to continue enjoying standards of living experienced today, while at the same time ensuring that future generations will have access to goods and services needed for their survival (Luther, 2005). Luther (2005) further suggests that, sustainable construction promotes efficient use of resources in the design, construction and use of building by using recycled, reuse and ecology materials. The process thus focuses on minimizing waste production and energy consumption, preserving and enhancing biodiversity, conserving water resources and respecting people and the environment (DETRE, 2000).

Ideally, sustainable development therefore relies on long term planning, Schmid (2003) asserts that the future of sustainable construction has its roots in the past, present actions and the future depending on ethical awareness concerning the consequences of actions and deeds. Summarily, Van Bueren and Priemus (2002) thus present sustainable construction as the design, development, construction, and management of real estate such that the negative environmental effects of the construction, restructuring, and management of the built environment are reduced as far as possible.

In the world today, according to Sonnenschein et al (2009) majority of the largest mobile telecommunication service providers have tried to make steps towards addressing sustainability. However, none of these efforts have focused on the sustainability of steel construction technologies in current use in the construction of mobile communication sites (Sonnenschein et al, 2009)

2.4.2 Factors Influencing Use of Sustainable Steel Construction Technologies

The UK Government's strategy in its effort for pushing for more sustainable construction at the time (DETRE, 2000) suggested key factors that include; design for minimum waste, lean construction, minimization of energy use, reduced pollution, preservation and enhancement of biodiversity, conservation of water resources, respect for people and local environment, and setting targets, monitoring and reporting in order to benchmark performance (Miyatake, 1996; Ofori et al., 2000).

The contribution of steel to sustainable construction is infinite. Firstly, Schimid (2003) declares that all steel systems used in construction are usually highly produced through modern manufacturing processes, whereby these systems according to Wells (2005) are; highly pre-fabricated, minimize on-site process and impact beneficially on sustainability of construction. Moreover, Schimid (2003) admits that given that steel components used in construction are designed through Computer Aided Design, it increases efficiency, reduces waste and improves quality. Subsequently, the components of steel are usually delivered in time to the construction site and installed rapidly by cranes, which helps to lower cost in site management since no personnel may be employed to watch over the materials (Hodges, 2010). This helps to reduce the aspect of storage, resulting in a more productive construction process and shorter construction time in comparison to site-intensive building, thus ensuring the risk to client is reduced by programme predictability and the client can expect an earlier return on the investment costs (Hodges, 2010).

In addition, there are also other benefits resulting from the usage of steel components in sustainable construction. Bout et al (2000) affirms that the use of the components ensures material usage is minimized making it suitable for construction. While Irurah (2001) notes that there is minimal transport of waste to landfill-sites which is achieved through off-site construction. At the same time, steel construction technologies requires fewer workers on site since the components are already prefabricated and not much labor would be required, this means fewer journeys would be made to site, thus less demand for local car parking (Randall et al, 2012). On the other hand, deliveries to site can be timed to suit local traffic conditions thus reducing both local congestion and pollution (Irurah, 2001; Randall et al, 2012). It should be appreciated that dry construction minimizes water, while slag from steel production is used as cement replacement and road sub-base (Zhou, 2009). Also, according to Zhou (2009) it can be used as a fertilizer since it is not a pollutant. Socially, there is excellent acoustic insulation which is achieved using lightweight heating costs (Singh, 2007).

Singh (2007) argues that designers as well as owners are realizing that with due attention and meticulous planning, buildings can be designed to save energy, decrease impact on the environment, be more people-friendly and reduce lifecycle costs. In addition, he indicates that sustainability in construction is all about following suitable practices in terms of choice of materials, their sources, construction methodologies as well as design criteria so as to be able to improve performance, decrease the environmental burden of the project, minimize waste and be ecologically friendlier (Singh, 2007). Subsequently, sustainability in construction technologies is any construction practices that meet the requirements stated above.

2.4.3 Criteria for Evaluating Sustainable Steel Construction Technologies

In the spirit of embracing sustainable construction, Crocker (2002) found out that in developed countries sustainability tends to emphasize more on the environmental footprints of construction rather than its social and economic impacts, while Gibbered (2003) asserts that it ensures the maximum beneficial social and economic impacts of any investment rather than merely concentrating on minimizing its environmental loads. However, according to Kobet (2002) sustainability in developed countries focuses largely on the reduction of energy, materials and resources consumption to more acceptable levels. On the other hand, focusing on Africa as part of the developing world, Irurah (2001) indicates that the continent still needs to do more and be aggressive in terms of incorporating sustainability in construction processes. Apparently some of the African countries specifically Kenya, from a study on the construction industry by Watuka and Aligula (2002) revealed a relatively high level of awareness on sustainable construction practices. Unfortunately, the study attributes the weak responsiveness of the industry to sustainability to the marginality of application of sustainable practices, and the negative attitude of the participants in the construction industry Watuka and Aligula (2002).

Nevertheless, the quantification of sustainability as an indicator of technological, economic and social impacts of construction is more complex because it is based on a range of issues related to choice of materials, energy use in building operations and impacts on the local environment (Hill & Bowen, 1997). According to Singh (2007), these issues may be expressed in terms of specific criteria like efficient material use, waste minimization, reduction in primary energy use and pollution, and other impacts coupled with social issues related to reduction in transport and improvement in quality of life, well being and biodiversity (Singh, 2007). Various environmental assessments methods have been developed such as Building Research Establishment EcoHomes (BRE, 1999). They provide means of assessing the impact of a project in terms various sustainability metrics.

In addition, other than the three common pillars of sustainable construction identified by Hill and Bowen (1997) namely social, economic and biophysical, proposals were made to include community and cultural indicators to measure sustainability in construction (Ofori et al, 2000). Between January and March 1999, the Building Research Establishment (BRE) did a work on behalf of the Department of Environment Transport and Regions (DETRE) all of UK, on the topic: sustainable construction – the data, as part of a project entitled “sustainable construction – Developing an industry agenda”. Overall, 7 key data categories were identified: economic, social, construction materials and resources, construction activity, building operation, recycling and disposal (Howard, 2000). Consequently, Howard (2000) concludes that the combined performance of these issues represents the sustainability of construction and the built environment. Furthermore, at a national sustainable building workshop in Michigan, 1999, 30 sustainability indicators were identified together with their individual criteria for assessments (Arbor, 1999). These were grouped into five categories: environmental assessment, economic, code issues, organizational condition, stakeholder and public education.

Currently, the mobile sector operates in a volatile business environment because of the political anxieties, competition from new entries, globalization and technological advancements (Sonnenschein et al, 2009). However, network coverage is essential for the prosperity of each operator; hence the use of steel in the GSM base stations of the mobile operators is very significant because of predictability and flexibility. In addition, the operational benefits of steel construction include energy efficiency, building envelopes, flexibility in long-term use, non combustibility and freedom from rot and shrinkage (Jim, 2010; Wells, 2005). Also, there is ease of extension and adoption, and ultimately refurbishment, recycling and re-use which leads to reduction of maintenance cost. As a result, since the mast siting committee usually prepares the guidelines for constructing communications base stations, towers, masts and safe use of mobile telephones (Watuka & Aligula, 2002) for sustainability of steel, they have to look at engineered steel that takes fewer raw materials, but gives the required strength (Watuka & Aligula, 2002) which are properties derived from the advantages of employing steel in construction.

For instance, Mabati rolling mills Kenya (MRM) in conjunction with Falmek of South Africa have developed trussed components which are light weight but strong compared to traditional construction. The components have a high level of fire resistance provided by plasterboards, which makes it an efficient material in GSM industry, especially in the installation of Base Transceiver Stations (BTS) which are sometimes located to the interior parts (Watuka & Aligula, 2002). According to Bout et al (2000), there are excellent training and job opportunities which are maintained by factory-intensive construction and specialist installation teams. Also, pressure on landfill sites due to wastage of materials is reduced in steel construction; this is a crucial aspect considering that there are over 3000 BTS for Safaricom Company across the country.

In telecommunications industry, the concept of reduction in building additional base stations required in meeting their expansion objectives in an attempt to slow down energy consumption, and quality degradation of the visual environment would be unrealistic. Reduction in this context would focus on achievement of lower energy consumption and wastage rates in their construction activities of the sites while meeting expansion objectives. Taylor (2002) on the other hand, notes that the re-use of steel depends on the form in which it is used. The mobile industry uses a lot of steel towers which are manufactured in the workshop and site assembled through bolting. To protect the steel against corrosion and prolong its lifespan, the fabricated members are usually galvanized through a chemical process of zinc coating, so that in this case surface coating should be derived from natural sources with low levels of volatile organic compounds (Taylor, 2002).

2.5 Critique of Existing Literature Relevant to the Study

Generally, there is tremendous wealth of literature that has been accumulated over the past few years on the term sustainability in constructution. Many authors as a result, have identified critical elements of sustainable steel construction technologies, which would assist construction processes to generate products that are sustainable. Definition of sustainable products are many, but in one way or the other they are basically generated using processes and systems that are non-polluting, that conserve energy and natural resources in economically viable, safe and healthy ways for consumers, and which are socially and creatively rewarding for all stakeholders for the short and long term future (Glavic & Lukman, 2007, Mora, 2007; Zhou, 2009; Ljungberg, 2007).

However, much of this literature work has not been devoted to use of steel in the construction involving GSM technology (Sonnenschein et al, 2009). According to Sonnenschein et al (2009) the main focus has been on the normal steel construction that is used in heavy industrial processes and buildings. Moreover, Ashby (2009) who classifies steel as a quasi-sustainable material, points out that its application in structural framing, art and function can come together in limitless ways to offer new solutions and opportunities. Consequently, in as much as the GSM industry employs the use of steel in the construction of telecommunication masts in base station sites, its application is totally different from how it is utilized in the normal industrial and building construction.

Normally, the quantity of steel used per base station site construction is smaller as compared to the quantity used in one site of an industrial construction. In the long run though, given that the number of sites required by the telecommunication masts are many, the cumulative quantity of steel consumed could be so huge. Subsequently, a proper and efficient technique needs to be explored and applied for the purpose of rolling out the large number of sites such as; modularization of steel designs which is the production of repeatable modular units that are used for height flexibility, prefabrication of steel units and off-site manufacturing of steel, to eliminate storage on site and prevent pilferage through theft (Annie & Jaya, 2011; Irurah, 2001; Randall et al, 2012), suitable prior planning for components of steel to be delivered in time to the construction site and installed rapidly by crane or other equipment (Bout et al, 2000), and these deliveries to site according to Irurah (2001) can be timed to suit local traffic conditions to reduce congestion and pollution.

Lastly, the literature has so far not indicated much on how governing policies affect sustainable steel construction technologies in construction of telecommunication masts. Usually, the process of setting up a cell site for mobile communications attracts an elaborate logistical procedure instigated by the prevailing governing rules, and according to Bout et al (2000), sometimes this can lead to longer time to market and increase in cost incurred in the form of interest on loans and the inactivity of capital. Much needs to be done to investigate how governing policies can assist in promoting sustainable construction.

2.6 Research Gaps

The above discussion is a good indicator which reveals that there has been no particular attention that has been given to probe the sustainability of steel construction technologies in the GSM industry specifically here in Kenya, yet it is one of the major consumers of steel in its effort of rolling out of sites that constitutes telecommunication masts. The aspect of sustainability of steel construction has quite been generalized in the construction field and has not explicitly been addressed in the mobile telecommunication sector (Sonneschein, et al 2009). Therefore, it is towards filling up this research gap that there was a need to undertake the study, in order to investigate the extent to which the industry was employing this technology, in building telecommunication masts found in GSM mobile base stations and its contribution towards sustainable development in Kenya.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This section presents an overview of the method used to collect and process data in the study, for purposes of fulfilling the research questions. As a result, the areas covered included research design, population, sample and sampling techniques, data collection and analysis. According to Horn and Salvendy (2006) numerous methods for gathering data have been developed such as interviews, feedback, databases, scenarios, protocol analysis and questionnaires. Hence, the selection of the method used depends on the type of information to be gathered (Horn & Salvendy, 2006). In this research study, the questionnaire was used as the only tool to collect data due to time constraints.

3.2 Research Design

Research design provides a plan for answering the research questions. According to Mugenda (2003) it gives the overall plan and spells out the strategies that the researcher uses to develop accurate objective. The study chose a quantitative descriptive design in order to evaluate the extent of sustainability of steel construction technologies, used in the mobile telecommunication industry in Kenya, specifically focusing on Safaricom Ltd. The study therefore assessed various factors influencing the use of sustainable steel construction technologies in Safaricom base station sites. Consequently, the study was designed to achieve the specific research objectives that had been set out. The study also aimed to formulate evaluation criteria used in Safaricom to measure sustainability of steel construction technologies as the largest mobile operator in the telecommunication industry in Kenya.

3.3 Target Population

Statistical population is the specific population from which information is desired (Lapin, 1993). According to Mugenda and Mugenda (2003), a population is a well defined set of people, services, elements, event, and group of things or households that are being investigated. They further note that, population studied are more representative because everyone has equal chance to be included in the final sample that is drawn (Mugenda &

Mugenda, 2003). At the time of the study there were four GSM service providers namely; Safaricom Ltd, Airtel Networks Kenya Ltd, Telkom Kenya Ltd (Orange) and Essar Telecom Kenya Ltd. However, according to CCK 3rd quarterly sector statistics report (2012) Safaricom Ltd was found to be the largest mobile telephone operator in Kenya, as it commanded 65% of the market share by percentage of mobile subscription. Due to its dominance of the market, the target population for the study was drawn from Safaricom Ltd including firms contracted by Safaricom Ltd to deliver construction related services.

The construction of BTS sites basically involves the civil works and equipping it with various electronic gadgets so as to make it fully functional. As a result, Table 3.1 shows the names of the firms, including the in house team from Safaricom Ltd who are dedicated in facilitating the mobile operator in constructing a fully equipped GSM mobile base station (refer to Appendix 3; GSM Architecture) and it also indicates the number of experts, whose total of three hundred and five makes up the population from where the study obtained its target population.

Table 3.1: Target population

	Project Management	Acquisition	Consultancy	Suppliers	Contractors	Total
Safaricom	38	13				51
Alan Dick					33	33
Netsol				22		22
Linksoft				36		36
Broadcom				28		28
Reime					54	54
Adrian					18	18
Rayden		26				26
Strana			37			37
Total	38	39	37	86	105	305

Source: Safaricom Company

3.4 Sample Frame

Sampling frame is a physical representation of the target population and comprises all the units that are potential members of the sample (Kothari, 2003). Given that there were a total of three hundred and five subjects providing services to Safaricom Ltd with respect to civil works and equipping a fully functional BTS sites, the study sampled from the population of those experts that are directly linked to the construction of civil works components including telecommunication masts. For the purpose of this study, the units of analysis comprised subjects in the construction field including those employed or contracted by Safaricom Ltd such as project managers, engineers, suppliers, site supervisors and acquisition experts derived from the list of firms on Table 3.1.

Table 3.2 shows a total of one hundred and six subjects comprising thirty two project managers, thirteen acquisition experts, eighteen engineers, fifteen suppliers and twenty eight site supervisors drawn from nine firms including in-house team from Safaricom Ltd. These teams are dedicated in facilitating the construction of BTS sites across the country.

Table 3.2: Experts in construction of BTS sites

	Project Managers	Acquisition Experts	Engineers	Suppliers	Site Supervisors	Total
Safaricom	32	6				38
Alan Dick					10	10
Netsol				3		3
Linksoft				8		8
Broadcom				4		4
Reime					12	12
Adrian					6	6
Rayden		7				7
Strana			18			18
Total	32	13	18	15	28	106

Source: Safaricom Company

As mentioned earlier, construction of a BTS site involves civil works and equipping it with various systems (refer to Appendix 3: Architecture of a GSM Base Station) in order to make it fully functional. As a result, the sampling frame looked at the subjects who are involved in the civil works and erection of the telecommunication masts which are mainly constructed using structural steel. These subjects normally combine their multi-skills and knowledge in order to achieve the project objectives assigned to them by Safaricom Ltd.

3.5 Sampling Technique and Sample Size

According to Mugenda (2005), sample size determines the precision within which population value can be estimated, hence, experts emphasize that the sample has to be reasonably large to obtain accurate estimates. The study employed a random sampling technique where it targeted 67 subjects who were selected from the list of experts on Table 3.2, comprising a sample frame of one hundred and six subjects.

Subsequently, the study investigated from them sustainability of steel construction in building BTS sites across the country, specifically the telecommunication masts. Since Kombo and Trump (2006) recommend that for such small population, all items be studied so that all their responses are considered in the analysis, these respondents were randomly selected to ensure that adequate data is collected for the study.

Table 3.3: Sample Size

Expert	Target Population	Sample Population	Pilot Population
Project Managers	32	24	3
Engineers	18	14	1
Site Supervisors	28	15	3
Suppliers	15	8	1
Acquisition	13	6	2
Total	106	67	10

Source: Safaricom Company

3.6 Data Collection Procedure

In order to test the sustainability measure of steel construction technologies in mobile telecommunications industry in Kenya and to better understand the factors that could influence sustainability perceptions, a survey questionnaire was used. The use of the survey questionnaire is an approach to capture all the dimensions of sustainability (Horn & Salvendy, 2006). The results were intended to reveal sustainability perception of the subjects on steel construction technologies in mobile telecommunications industry and it's dependent on the selected variables.

Prior to the evaluations, a pre-questionnaire survey was performed by a few selected subjects of the study. Based on the results and findings of the pre-questionnaire study, the adjective pairs were revised, and a final questionnaire prepared for the actual data collection. The survey presented a brief definition of sustainable construction technologies. Finally, E-mails were sent to each prospective subject requesting them to participate.

3.7 Pilot Testing

Pilot study is a small scale preliminary study conducted before the actual research in order to measure the validity and reliability of the data collection instrument (Burns & Grove, 2007). Pilot testing which is also called pretesting, involves the use of a small number of respondents to test the appropriateness of the questions and the perceived comprehension of the respondents. Hence, the study administered the questionnaires to ten respondents involved in BTS sites construction on different parts of study area. The pretest questionnaire was sent out to the identified respondents and this assisted in the verification to iron out any problems with the questions in the instrument, and to also ascertain the level of cooperation and understanding from the respondents. Consequently, this enabled necessary corrections to be made in good time and to foresee and prepare adequately for any other problem that could occur before conducting the actual data collection.

Notably, the above respondents were not included in the final study result as recommended by Kothari (2004). This is attributed to the fact that the intention of the pre-testing tool is to ensure that the items in the tool bear the same meaning to all respondents irrespective of the study area or population, and to also assess the average time that is required to administer the instrument (Mugenda, 2003).

3.8 Data Processing and Analysis

After the collection of raw data, a descriptive approach which draws from both quantitative and qualitative approaches was used to analyze data. The data was coded, organized and entered into Statistical Package for Social Sciences (SPSS) programme from which analysis were run to obtain descriptive statistics where frequencies, percentages and mean were used to describe the response of the participants.

Subsequently, the study utilized descriptive labels and different presentation techniques such as narratives, tables, graphs and charts to attach meaning to the different types of data. These findings were interpreted accordingly from the various analyses that were run and a summary made according to the variables that were under study. Lastly, the study made conclusions, recommendations and suggested on areas that required further study.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter deals with data analysis, presentation and interpretation of the findings. The data presented reflects the study investigation on the steps that the mobile operator was undertaking in adopting sustainable steel construction technologies in construction of telecommunication masts across the country.

4.2 Response Rate, Reliability and Validity

4.2.1 Response Rate

A total of 67 questionnaires were administered to the respondents and only 39 were returned. This represents a response rate of 58.2%, which is adequate to make conclusions for the study. According to Neuman (2000), a 50% response rate is adequate, 60% is good and above 75% is rated as very good. Based on this assertion, the response rate of 58.2% in this case falls in the former category.

The 58.2% response rate can be attributed to the fact that despite having four mobile telecommunication operators in the market, the scope of the study focused on only one mobile operator, Safaricom Ltd. This is because at the time of the study, Safaricom Ltd actually dominated the market by a 65% of market share by mobile subscription as asserted by the CCK 3rd quarterly report (2012). Secondly, this kind of response could have been triggered by the fact that the application of the concept on sustainable steel construction technologies among the mobile operators in Kenya is still new or at an introductory stage.

4.2.2 Reliability

Kothari (2004) defines reliability as a measure of degree to which a research instrument yields constant results or data after repeated trials. Reliability in the study was calculated by applying SPSS Cronbach's alpha on the data obtained from the set of 10 respondents selected in the pilot test. The value of the alpha coefficient in the reliability test ranges from 0 to 1 and is used to describe the reliability of factors under study from the SPSS programme. A higher value of the alpha coefficient indicates a more reliable generated scales for answering questions on the questionnaire.

Subsequently, the reliability analysis on the answered questions revealed a standardized alpha coefficient of 0.8678 for all the variables under study. This means that, since the coefficient obtained was greater than 0.7, a conclusion could be drawn that the instrument had an acceptable reliability coefficient and was therefore appropriate for the study (Kothari, 2004).

4.2.3 Validity

Validity is the degree to which the instrument measures what it is supposed to measure (Kothari, 2004). The study aimed to focus on content validity which is the accuracy with which an instrument measures the variables under study. The research instrument was tested for content validity by administering the questionnaire to the 10 subjects selected for the pilot study. Their responses to the questionnaires together with their opinions assisted in validating the consistency in the research instrument.

4.3 Respondents Profile

4.3.1 Job Description

In order to transmit and receive communication signals to and from the mobile subscribers, Safaricom Ltd requires the services of the construction industry professionals to facilitate the design, supply, erection of masts and mounting of BTS sites across the country. This means that there are a number of professionals who would be involved in such construction projects, including in-house team members who would oversee the implementation process. Table 4.1 below depicts the job description of such professionals that would be involved in project implementation of putting up the BTS sites which comprise telecommunication masts, shelters, generating sets, air-conditioning units, electrical works and security wall fence (refer to Appendix 3, GSM Architecture).

Table 4.1: Profile of respondents

Job Description	Frequency	Percent
Project Managers	14	35.9
Site Supervisors	11	28.2
Consultants	6	15.4
Acquisition Experts	4	10.3
Suppliers	4	10.3
Total	39	100.0

Source: Field Data

The findings from Table 4.1 indicate that the majority of the respondents are from the mobile operator working as project managers and acquisition experts. This could be attributed to the fact that the company is responsible for giving the necessary specifications, procurement and overseeing the projects in setting up the BTS sites according to their subscribers needs, and the rest of the team of experts only aid in specific areas of work. The team of experts from suppliers is the least, because they are only concerned with supplying the specified products to be put up in the already designed BTS sites.

4.3.2 Respondents Role in Mobile Telecommunication Industry

It was necessary for the study to establish the role of the professionals involved in construction of base stations. This is because construction processes normally are undertaken as projects which consist of different members from various fields of professions (Anumba et al, 2005). In so doing, the study would understand their reasoning and opinions as far as sustainable steel construction technologies is concerned.

The results in Figure 4.1 show that the majority of respondents were in project management at 57.5%. Most professionals in these category are from the mobile operator. The project management team are ideally the project overseers in ensuring that the construction of BTS sites are meeting the mobile operator’s specifications and timelines as agreed upon during the design stage. This is the reason as to why they comprise the majority in such ventures and they normally come in as part of management.

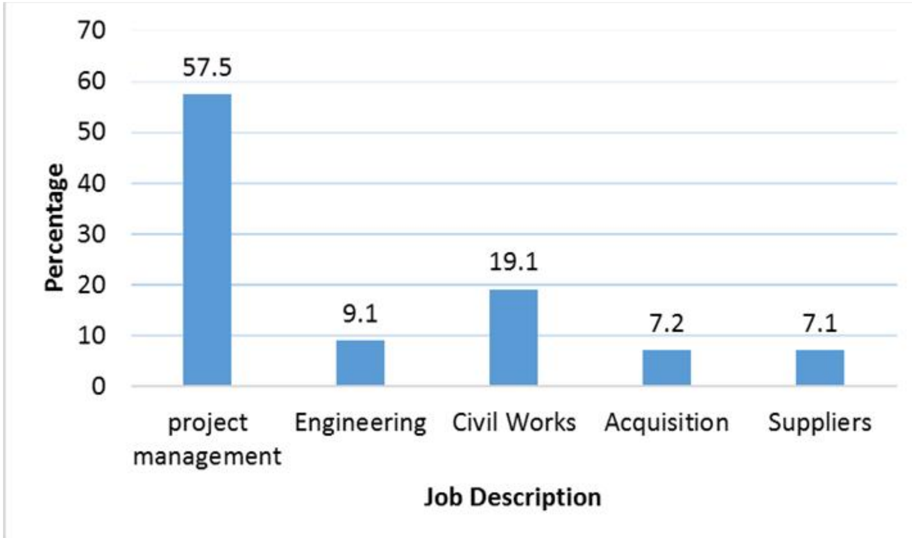


Figure 4.1: Roles in the mobile telecommunication industry

The civil works category are at 19.1% which is the second largest group in the project, and this is because they are the site supervisors who are the construction team on site to supervise the construction of BTS sites. The engineers who are comprised of a team of consultants in the project are at 9.1%. Their percentage could be attributed to the fact that they only come in to assist with consulting services to the mobile operator. Finally, the least representation is the category of respondents from acquisition and suppliers at 7.2% and 7.1% respectively. The smallest percentage of response from acquisition category could be attributed to the fact that acquisition team is only responsible for securing access to the construction sites and facilitating statutory approvals. On the other hand suppliers are charged with the responsibility of ensuring that they procure equipment and systems to be installed in the BTS sites within the prescribed specifications as dictated by the project management team. Moreover, the suppliers' main job is to ensure that they supply the already specified engineering materials for construction.

4.3.3 Years of Service in the Mobile Telecommunications Industry

Figure 4.2 displays the number of years that these professionals have been engaged in their various fields of services, hence depicting the level of their experience which would be useful in gathering information on the research study.

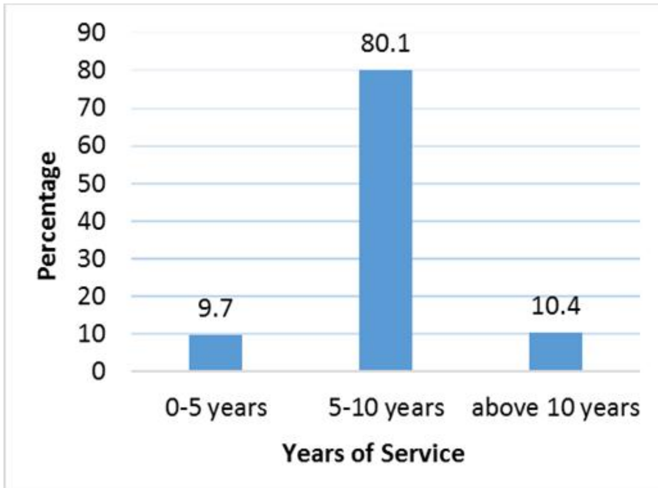


Figure 4.2: Years of service

The results show that majority of the respondents (80.1%) had worked for a period between 5-10 years in the mobile telecommunication industry, while those who had worked for between 0-5 years were 9.7% and above 10 years were 10.4%. It was important for the study to ascertain the level of experience of the respondents in industry. This is because experienced respondents were in better positions to understand the emerging issues in both the mobile telecommunication and construction industry, and were therefore better placed to give more appropriate and weighty responses. Ultimately, this would have given more confidence on the data collected for analysis, so as to draw concrete conclusions and recommendation on the study. These results demonstrate that majority of the respondents had long experience that was considered useful for the study; with 90.5% above 5 years.

4.4 Sustainable Steel Construction Technologies

4.4.1 Awareness on the Concept of Sustainability

In ascertaining awareness on sustainability, the study sought to establish whether the respondents were familiar with the concept or not, thus determining their ability to effectively handle the questions on the questionnaire.

The findings on the respondents' awareness of sustainability indicate that they were all aware of the term sustainability. It was important for the study to establish awareness on sustainability, since according to Sonnenschein et al (2009) much of the literature work had not been devoted to sustainable steel construction technologies involving GSM industry, but rather focused on the normal steel construction that is used in heavy industrial processes and buildings. Also, given that all the respondents were aware of the term sustainability, it could have been due to the fact their focus is on sustainability strategies that are aimed at leveraging the mobile technology in making progress on reducing its carbon emissions (Sonnenschein et al, 2009).

4.4.2 General Understanding of Sustainability in Construction

The study also sought to establish the extent to which sustainable steel construction technology was being employed in the mobile industry, by determining the respondents' level of understanding on the concept of sustainable construction (Table 4.2). A very good understanding of sustainable steel construction would actually imply that the respondents are consciously practicing the concept in construction of GSM stations, while average to poor understanding would mean the concept of sustainability could be there but rather focused on other aspects other than construction or it is not there at all.

Table 4.2: General understanding of sustainability in construction

	Frequency	Percent
Good	14	35.9
Average	23	59.0
Poor	2	5.1
Total	39	100.0

The findings show that 35.9% of the respondents had a good understanding of sustainability, while majority 59.0% had an average understanding. Only 5.0% of respondents had poor understanding of the term sustainability. Given that majority of the respondents had an average understanding and the fact that even those with good understanding are at 35.9%, this implies that workers in the GSM industry had not fully embraced the concept of sustainability in facilitating the establishment of BTS sites. It also indicates that the awareness on the concept was only a general perception as it applies to the construction industry and not specifically to steel construction. These findings are consistent with Sonnenschein et al (2009) who implied that sustainable steel construction technologies had not been devoted to construction process involving GSM industry, but rather focused the normal steel construction that is used in heavy industrial processes and buildings.

4.5 Factors that Influence Use of Sustainable Steel Construction Technologies in the Mobile Industry in Kenya

According to Annie and Jaya (2011) sustainable structures are considered to be of; high quality, energy efficient, long life, and adaptable to future demands and assets to the economic and social life of the community and the built environment. Thus, some of the factors that would commonly influence the use of steel in construction to produce such structures range from; technological advancement, cost of construction and material usage in construction (Well, 2005; Bout et al, 2000). Consequently, the study sort to assess from the respondents what influences them to consider steel for constructing the GSM stations across the country (Table 4.3)

Table 4.3: Factors that influence sustainable steel construction technology in the mobile industry in Kenya

Factors	Mean Rank	Std. Deviation
Highly prefabricated steel	2.68	0.108
Minimal site process	1.02	0.164
Flexibility in mast height changes	2.98	0.102
Programme predictability	1.32	0.176
Flexibility in long term use and re-use	2.21	0.140
Reduced storage space	1.20	0.173

The findings show that majority of the respondents cited flexibility in mast height changes as one of the main reasons as to why they consider steel in the construction of GSM station having a mean rank of 2.98, since it is ideal for achieving varied mast heights that carry telecommunication systems (Schimid, 2003). This is also consistent with Randall et al (2012) who asserts that the nature of steel construction changes in use and loading patterns that can easily be accommodated during a construction design, its initial construction and when it is due for refurbishment. Moreover, Long-span steel construction solutions also generate column-free spaces, which appeals to the users seeking increased flexibility to accommodate tenants and future changes of use (Randall et al, 2012). The respondents also agree that such flexibility is as a result of the fact that the steel components used in their construction processes are highly prefabricated which had a mean score of 2.68 making its use attractive in the industry, since they are easier to work with and adjustments can be made where necessary. According Wells (2005) steel systems are highly pre-fabricated, minimize on-site process and impact beneficially on sustainability of construction. Moreover, Schimid (2003) indicates that design by the Computer Aided Design increases efficiency, reduces waste and improves quality and accuracy in production of steel components to be used in construction making it quite sustainable.

Consequently, it is apparent from the rest of the other results that the respondents could have either consciously or unconsciously selected steel for construction as part of practicing sustainable construction technology or based on the fact that it is a convenient material to use. This has been demonstrated by the outcomes as shown by the mean scores on minimal site process, programme predictability and reduced storage space as 1.02, 1.32 and 1.20 respectively, with the former being least factor of consideration for selecting steel in BTS site construction. In as much as these aspects too also contribute in one way or the other in adding up to sustainability of steel construction, the respondents were not keen on them. It could be an indicator that they may not have fully appreciated the entire aspects of sustainable steel construction, making it seem that their choice for steel is for some specific benefits that they obtain from its use.

4.6 Evaluation Criteria of Sustainability of Steel Construction Technologies

4.6.1 Overview

Hill and Bowen (1997) identified the following attributes that are commonly regarded as the pillars to a sustainable construction. They include social, economic and biophysical (environment) indicators. It was important therefore for the study to establish the level of sustainability of steel construction technology on the mobile industry in an effort of the mobile operators constructing adequate BTS sites to provide services to their customers. Such evaluation could be made possible by referring to the pillars of sustainability (Hill & Bowen, 1997), so as to establish the gains made with respect to the social, economic and environmental aspects in applying sustainable steel construction technologies in construction process.

4.6.2 Economic Contribution of Sustainable Steel Construction

Economic pillar in sustainable construction ensures; financial affordability, employment creation, enhanced competitiveness, client satisfaction and sustainable supply chain management (Hill & Bowen, 1997). The findings with respect to economic evaluation on the impact of sustainable steel construction technologies are shown in Table 4.4.

Table 4.4: Economic contribution of sustainable steel construction technology in telecommunication masts construction

Economic Contribution of SSCT in Mobile Industry	Mean Rank	Std. Deviation
Improved Productivity	2.65	0.107
Minimizing Defects	2.85	0.121
Shorter and More Predictable Completion Time	1.12	0.103
Reduction in Project Costs	1.10	0.173
Consistent Profit Growth	0.75	0.164
Supplier Satisfaction	2.95	0.126
Mobile Service Provider Satisfaction	2.35	0.130
Contribution to Local Economy through Employment	1.01	0.105

The results show that the highest mean score is 2.95 where mostly the respondents indicated that steel is economically viable, followed by 2.85 where they felt that minimized defects on this material also impacted positively, and 2.75 where the respondents felt that it improved productivity probably due to its nature. These responses could be as a result of the fact that steel construction products are industrially produced as highly prefabricated components with the assistance of Computer Aided Designs to increase efficiency, reduce waste and improve on quality and accuracy (Randal et al, 2012; Schimid, 2003). At the same time, there is reduced storage space and minimal on-site construction in steel construction technologies due to the rapid installation of the components by cranes once delivered (Bout et al, 2000). The mobile service provider satisfaction had a mean score of 2.35 which is also pretty high, and their confidence in steel could have further resulted from the fact that its products allow for flexibility in achieving varied mast heights with lean designs and can easily be transferrable or re-used in other areas. This is consistent with Wells (2005) who asserted that sustainable steel construction technology allows for ease of extension and adoption, and ultimate refurbishment, recycling and re-use which leads to reduction of maintenance cost. In addition, the flexibility is also reflected from the fact that the steel components are non combustible and free from rot and shrinkage (Jim, 2010).

However, the other mean scores on; shorter and more predictable completion time, reduction in project costs, consistent profit growth and contribution to local economy through employment are 1.12, 1.10, 0.75 and 1.01 respectively and were found to be pretty lower compared to the other mean scores. These outcomes could have been as a result of the fact that, the industry players in the mobile telecommunication sector may have not fully focused their efforts on the sustainability of steel construction technologies in current use in the construction of mobile communication sites (Sonnenschein et al, 2009). According to Randall et al (2012) some of the key benefits that the respondents might not have appreciated are facts such as; the aspect of fabrication processes for the production of steel components which has the capacity to provide stable, healthy and safe employment which improves a society's social fabric, and given that steel construction products are manufactured off-site, off-site construction gives rise to more predictable construction programmes which can reduce projects delivery, thus impacting positively on its costs and profit margins.

4.6.3 Environmental Contribution of Sustainable Steel Construction

This is the biophysical pillar which is focused on the quality of human life within carrying capacity of supporting ecosystems (Cole & Larsson, 1999). According to Cole and Larsson (1999) they point out that this pillar ensures that sustainability puts in place; waste management, prudent use of the four generic construction resources namely; water, energy, material and land, while avoiding environmental pollution. Subsequently, the findings on how sustainable steel construction impacts environmentally are shown in Table 4.5.

Table 4.5: Environmental contribution of sustainable steel construction technology in telecommunication masts construction

Environmental Contribution of SSCT in Mobile Industry	Mean Rank	Std. Deviation
Minimizing Polluting Emissions	2.99	0.107
Noise Prevention	1.44	0.121
Dust Prevention	1.74	0.173
Waste Minimization	2.96	0.101
Protection of Sensitive Ecosystems	1.80	0.126
Reduced Energy Consumption	1.20	0.140
Use of Local Supplies	0.82	0.102
Lean Designs	2.94	0.105
Maximization of Resource Re-use	1.30	0.107
Better Land Use	2.85	0.101

The findings show that a high mean score on lean design, waste minimization better land use and minimizing polluting emissions as; 2.94, 2.96, 2.85 and 2.99 respectively, with the latter having the highest score. Just like in the previous case, it seems like the respondents employ the use of steel in BTS site construction as a material that is convenient to work with but might not really be focusing on sustainability issues (Sonnenschein et al, 2009). The preference for steel at this point could be consistent with the findings of Steel Construction Sector Sustainability Committee (2002) based in UK who established that steel accounts for very little of the 100 million tonnes of construction waste that goes to landfill sites each year in the UK, due to its inherent value and long established recovery infrastructure. By contrast, concrete is estimated to contribute two-thirds by weight of all construction and demolition materials transported to landfill (Randall et al, 2012). Moreover, the mobile operator's priority has been to always ensure the protection of the environment by engaging in activities that try as much to minimize on carbon emission, thus providing a healthy surrounding to the society (Sonnenschein et al, 2009).

Moreover, with respect to better land use, steel components contribute to leaner structures that can easily be adjusted to achieve the desired design (Randall et al, 2012; Wells, 2005). Construction components that contribute to lean structures assist the mobile operators to be able to acquire small parcels of land or space to build GSM base stations (Randall et al, 2012; Wells, 2005). This can also be achieved by roof-top extensions and generally using lightweight construction of steel to ensure that the existing structure is not overloaded (Cagan & Vogel, 2002), thus utilizing minimal space. These could be some of the environmental aspects that the respondents could have envisioned in their quest to make GSM sites have less potential burden on the environment.

On the other hand, the minimal scores on noise prevention (1.44), dust prevention (1.74), protection of sensitive ecosystems (1.80), reduced energy consumption (1.20), use of local supplies (0.82) and maximization of resource re-use (1.30) might have not counted as some of the potential benefits that are derived from use of steel for construction to most respondents, due to lack of focus on steel in sustainable construction, but rather focus on other sustainability strategies in ensuring that the mobile technology is providing the necessary solutions to the subscribers (Sonnenschein et al, 2009). Furthermore, in the construction of GSM base stations steel systems in actual sense may contribute a smaller portion in the building process in one given site. It is important to note that there are other systems in place during the construction process that might also be affecting the environment in one way or the other, prompting the response to vary a lot on these environmental aspects.

4.6.4 Social Contribution of Sustainable Steel Construction

The social pillar is based on the notion of equity and social justice, where sustainability in construction is expected to propagate social progress which recognizes the needs of everyone in the society (DETRE 2000). A similar scenario is still replicated whereby the respondent were seen to give responses on preferential use of steel not focusing on its sustainability but rather on other strategic issues which would make operations within the mobile telecommunication sector profitable. The findings are shown on Table 4.6, and they indicate a high mean score for provision of effective training, building long-term relationship within the industry, and health, safety and working environment as 2.44, 2.44 and 2.85 respectively, with the latter scoring the highest.

Table 4.6: Social contribution of sustainable steel construction technology in telecommunication masts construction

Social Contribution of SSCT in Mobile Industry	Mean Rank	Std. Deviation
Provision of Effective Training	2.44	0.106
Provision of Equal Opportunities	1.15	0.111
Health, Safety and Working Environment	2.85	0.105
Minimizing Local Nuisance	1.05	0.101
Participation in Decision Making	0.85	0.126
Building Long-term Relationship within the Industry	2.44	0.102

The high mean scores imply that the players in the sector are definitely keen in ensuring that their members are well trained in order to execute construction processes at the sites properly. At the same time they are definitely careful to work with materials that propagate a healthy and safe environment, as their sustainability strategies are aimed at leveraging mobile technology to make progress on reducing its carbon emissions, and through innovation develop services that enable more efficient and effective healthcare and other mobile solutions (Sonnenschein, et al 2009). Also, members involved in BTS sites construction projects usually work as a team so as to foster a relationship amongst themselves in order to finish the construction process successfully (Anumba et al, 2005). This could be a reason as to why the response on long term relationship gathered a means score of 2.44 which is pretty high compared to the other factors on the social impact.

Conversely, provision of equal opportunities, minimizing local nuisance and participation in decision making gathered a mean score of 1.15, 1.05 and 0.85 respectively which compared to the other factors looked at during the study to have acquired a lower mean score. Again, this could be pointers to the fact that the current use of steel in the industry could not have been focusing holistically on sustainable steel construction technology (Sonnenschein, et al 2009; Wells 2005). According to Crocker (2002) sustainability lays more emphasis on environmental footprints; hence, other personnel are able to participate in decision making regarding use of steel construction in telecommunication masts.

However, the respondents still went ahead and ranked participation in decision making process with a mean score of 0.85 which was the least. This could have been triggered by the fact that decision making processes are entirely based on the structures and style of management in an organization and therefore might not be triggered by certain aspects found in a construction process. Sustainable steel construction technology also tends to minimize local nuisance through low disruptions, but the mean score showed 1.05. Apparently, steel construction is usually designed for whole-life cycle, which lessens demountability of the structures constructed (Taylor, 2000) thus minimizing disruptions. Finally, on provision of equal opportunities, it was also ranked minimally at 1.15, yet socially the industrial production of fabricated steel components has the capacity to provide stable, healthy and safe employment which improves a society's social fabric (Randall et al, 2012).

4.7 Sustainable Product

The level of sustainability achieved in creating sustainable structures can be assessed by carrying out evaluation test which shows that there are two extreme sides that is either positive or negative, which are essential in the growth and economic development of various states (Miyatake, 1996). There are various indicators that can be used to measure sustainability in construction. Such indicators according to Miyatake (1996), CIB (1999) and DETR (2000) are meant to portray in general; improved profitability and competitiveness, client's and stakeholder satisfaction, best value and quality in creating the built environment or the products, maximization of resource reuse, use of renewable and recyclable resources, protection of the natural environment, and minimization of impact on energy consumption and natural resources, as a result of embarking on sustainable construction technologies (Miyatake, 1996; CIB, 1999 & DETR, 2000). These indicators are an integration of the social, economic and biophysical aspects in generating sustainable structures (Hill & Bowen, 1997).

According to Harris (1997) the social and economic assessment of sustainability might be easily quantified through analyzing certain growth index like Gross Domestic Product (GDP) or income per capita, but the extent of sustainability from an environmental perspective might prove to be difficult and is not normally based on comparing calculated index with an objectively defined level indicating a sustainability threshold.

Consequently, the study simply looked at the attainment of sustainability within the mobile telecommunication sector by the effect created in and by the product resulting from the construction process. According to Cagan and Vogel (2002) Products are normally expected to have specific perceived characteristics that contribute to their success or failure. Such product characteristics include; good value (financial), quality, meet stakeholder’s needs, unique features or solve problems other products do not, safe, efficient, satisfying to use, durable and serviceable (Cagan & Vogel, 2002). In the sector, the mobile operator’s GSM stations are the products of a construction process that is comprised of many systems, in which telecommunication masts made of steel is just one of them (refer to Appendix 3 GSM Architecture). So far, the respondents gave responses to imply that their choice for steel in BTS sites construction is due to certain attributes that they find convenient in the erection of telecommunication masts, where high mean scores on elements such as; lean design (2.98), waste minimization (2.96), improved productivity (2.65), minimizing defects (2.85), supplier satisfaction (2.95), high fabrication (2.68) and flexibility in mast height changes (2.98) indicate that the material provides products that satisfy the mobile operator. In essence, these factors are just but a few reasons as to why steel is considered highly in achieving sustainable construction. It is obvious, if the respondents could have been employing use of steel specifically focusing on sustainability, then their products would be more sustainable.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter discusses the summary of the study, implications of the findings, conclusion, recommendation and further studies to fill the gaps which were identified during the research study.

5.2 Summary

5.2.1 Overview

This study sought to investigate the Sustainability of Steel Construction Technologies in mobile telecommunication industry in Kenya. Firstly, it was important for the study to establish the level of understanding of the respondents on the concept of sustainability. The study analyzed for steel sustainability in construction focusing on Safaricom BTS sites and the factors that influenced the use of steel in these sites. In addition, the study formulated the evaluation criteria in sustainability of steel construction technologies.

The questionnaires were subsequently used as the only instrument of data collection from the field. The sampled subjects filled the questionnaires and the study assumed that all the information collected was true and without any biasness. Apparently, all the respondents were aware of the term sustainability, which put them in a better position to at least respond to the questions on the research instrument, coupled with the fact that more than 95% of them had more than five years working experience in the industry.

5.2.2 Analysis of Sustainability of Steel Construction Technology

In establishing the extent to which sustainable steel construction technology was being employed in the industry, it was important to determine the respondents' level of understanding on the concept of sustainable construction. This would mean that very good understanding of sustainable steel construction would actually imply that the respondents are consciously practicing the concept in BTS sites construction, while average to poor understanding would mean the concept of sustainability could be there but rather focused on other aspects other than construction or it is not there at all.

Consequently, majority of the respondents had a fair understanding of the concept on sustainability especially when it comes to construction processes. This implies that workers in the GSM industry had not fully embraced the concept in facilitating the establishment of the base stations. It also indicates that the awareness on the concept was only a general perception as it applies to the construction industry and not specifically to steel construction. These findings are consistent with Sonnenschein et al (2009) who implied that sustainable steel construction technologies had not been devoted to construction process involving GSM industry, but rather focused on the normal steel construction that is used in heavy industrial processes and buildings.

5.2.3 Analysis on Factors that Influence use of Steel in Construction

While it may seem that majority of the respondents preference for steel could be driven by certain specific characteristics such as; flexibility, highly fabricated, re-usable, minimized defects and so on, their considerations might not be fully focused on all the factors which collectively, would make it highly beneficial to sustainable construction. Therefore their choice for steel apparently may not be fully informed and made from sustainable steel construction technology perspective as shown by the low mean scores on the other factors that can also be considered for selecting steel that too support sustainable construction. This is affirmed by Sonnenschein et al (2009) who asserts that the main focus has been on the normal steel construction that is used in heavy industrial processes and buildings, and not devoted to construction in the GSM industry.

Majority of the respondents cited flexibility in mast height changes as one of the main reasons as to why they consider steel in the construction of GSM station, since it is ideal for achieving varied mast heights that carry telecommunication systems (Schimid, 2003). Randall et al (2012) also indicates that the nature of steel construction changes in use and loading patterns that can easily be accommodated during construction design, its initial construction and when it is due for refurbishment. Moreover, Long-span steel construction solutions also generate column-free spaces, which appeals to developers seeking increased flexibility to accommodate occupiers and future changes of use (Randall et al, 2012). Such flexibility is achievable due to the fact that steel components used in construction processes are highly prefabricated, making them easier to work with in achieving varying mast heights. The respondents' preference to steel could also have been driven by the fact that pre-fabricated systems do minimize on-site processes, and thereby impacting beneficially on sustainability of construction. Other factors that could have driven the respondents desire for steel in construction of masts in GSM stations, is indicated by Schimid (2003) whereby he mentions that steel components are designed using computer aided designs (CAD) in order to increase efficiency, reduces waste and improves quality and accuracy in their production.

5.2.4 Analysis on the Evaluation Criteria of Sustainable Steel Construction Technologies

The evaluation on the level of impact brought about by sustainable construction can be made possible by considering the three pillars of sustainability; the social pillar, economic pillar, and environmental pillar (Hill & Bowen, 1997). The study found out that there was improved productivity in using steel construction technologies which could have triggered a high response in both the mobile operator and supplier's satisfaction with respect to economic aspects of sustainability. This may have been as a result of the fact that steel products used in the construction of masts in BTS sites are industrially produced as highly prefabricated components which increase efficiency, reduce waste and improve quality and accuracy (Randal et al, 2012; Schimid, 2003). In addition, the mobile service provider satisfaction, according to the study, could have further been triggered by the fact that steel products allow for high flexibility in achieving varied mast heights with lean designs and can easily be transferrable or re-used in other sites. This is consistent with Wells (2005) who asserted that sustainable steel construction technology allows for ease of extension and adoption, and ultimate refurbishment, recycling and re-use which leads to reduction of maintenance cost.

Socially, the study established that manpower training is key in ensuring that construction processes at the sites are properly executed. Construction of BTS sites usually involves many players who work as a team in order to successfully complete the construction process (Anumba et al, 2005). This could have triggered the high response on long term relationship between team members which gathered a high mean score of 2.44 compared to the other factors on the social impact. Conversely, there was low response on people's participation in decision making regarding use of steel in construction of masts. This could have been triggered by the fact that decision making processes are entirely based on the structures and style of management in an organization and therefore might not be triggered by certain aspects found in a construction process. Provision of equal opportunities also ranked minimally, yet socially the industrial production of fabricated steel components has the capacity to provide stable, healthy and safe employment which improves a society's social fabric (Randall et al, 2012). Again, such responses that fail to recognize the entire outfit on sustainable use of steel in construction points out the fact that its use has not been fully realized (Sonnenschein et al, 2009; Wells 2005).

Environmentally, the preference for steel in the GSM sector could be consistent with the findings of Steel Construction Sector Sustainability Committee (2002) based in the UK who established that steel accounts for very little of the 100 million tonnes of construction waste that goes to landfill sites each year in the UK, due to its inherent value and long established recovery infrastructure. In addition, steel components contribute to leaner structures that can easily be adjusted to achieve the desired design (Randall et al, 2012; Wells, 2005) thus contributing to better land use. On the other hand, noise prevention, dust prevention, protection of sensitive ecosystems, reduced energy consumption, use of local supplies, maximization of and resource re-use might not have been considered as some of the potential benefits that are derived from use of steel for construction to most respondents, due to lack of focus on steel in sustainable construction, but rather focused on other sustainability strategies in ensuring that the mobile technology is providing the necessary solutions to the subscribers (Sonnenschein et al, 2009). Furthermore, in the construction of GSM base stations steel systems in actual sense may contribute a smaller portion in the building process in one given site. It is important to note that there are other systems in place during the construction process that might also be affecting the environment in one way or the other, prompting the response to vary a lot on these environmental aspects.

5.2.5 Analysis of Sustainable Products

The level of sustainability achieved in creating sustainable structures can be assessed by carrying out evaluation test which shows that there are either positive or negative sides which are essential in the growth and economic development of various states (Miyatake, 1996). There are various indicators that can be used to measure sustainability in construction. Such indicators according to Miyatake (1996), CIB (1999) and DETR (2000) are meant to portray in general; improved profitability and competitiveness, client's and stakeholder satisfaction, best value and quality in creating the built environment or the products, maximization of resource reuse, use of renewable and recyclable resources, protection of the natural environment, and minimization of impact on energy consumption and natural resources, as a result of embarking on sustainable construction technologies (Miyatake, 1996; CIB, 1999 & DETR, 2000).

According to Harris (1997) the social and economic assessment of sustainability might be easily quantified through analyzing certain growth index like GDP or income per capita, but the extent of sustainability from an environmental perspective might prove to be difficult and is not normally based on comparing calculated index with an objectively defined level indicating a sustainability threshold. However, it was not easy for the study to measure and evaluate the extent of sustainability from the mobile operator, due to logistical reasons that render most documentation especially on financial reports and designs to be strictly confidential since the sector is highly competitive, and information leakage is highly guarded.

Consequently, the study simply looked at the attainment of sustainability within the mobile telecommunication sector by the effect created in and by the product resulting from the construction process. The study found out that the choice of steel in construction of masts in BTS sites is due to certain economic, social and environmental attributes that that are found to be convenient such as; lean design, better land use, waste minimization, improved productivity, minimizing defects, supplier satisfaction, high fabrication, minimization of polluting emissions and flexibility in mast height changes. This indicates that steel products satisfy the mobile operator in one way or the other. It is obvious, that if only the operators could have been employing use of steel while entirely focusing on sustainability, then their products would be more sustainable.

5.3 Conclusions

BTS sites are constructed all over the country with the aim of providing network coverage to enhance effective communication and other benefits in the telecommunication industry. The mobile operator’s main concern is that the GSM base stations meet specified standards that may render them operational as a long as they assist in providing mobile communication solutions to the society.

1. With respect to exploring the extent of sustainability of steel construction technologies in the mobile telecommunication industry in Kenya, the study was able to establish that there were some strategies that have been put in place to address sustainability. However, most of these strategies have not focused entirely on sustainable steel construction technologies as demonstrated by level of respondents’ understanding on sustainability in construction.
2. Considering that telecommunication gadgets were being supported on steel structures, then steel is a common material in BTS sites constructed across the country. Subsequently, on factors that influence the use of sustainable steel construction technologies, the findings of the study demonstrated that the use of steel seemed to be as a result of its qualities in enabling the operator achieve certain designs of structures within the BTS sites and not necessarily because of its sustainability. The preference of steel could have been driven by certain specific characteristics such as; flexibility, highly fabricated, re-usability and minimized defects.
3. The evaluation criteria on the sustainability of steel construction technologies in the mobile telecommunications industry was formulated with reference to the pillars of sustainability; economic, social and environmental. Consequently, the findings of the study indicated that the use of steel was economically, socially and environmentally viable as a material in the construction of masts in BTS sites. The level of viability as demonstrated by the findings of the study indicated that the choice of steel was as a result of convenience of its use rather than sustainability.

5.4 Recommendations

Majority of the largest mobile telecommunication service providers have tried to make steps towards addressing sustainability. However, none of these efforts have focused on the sustainability of steel construction technologies in current use in the construction of mobile communication sites (Sonnenschein et al, 2009). Consequently, the study recommends the following:

1. There should be increased understanding on sustainable steel construction technologies in order to enhance its practice and realize the maximum benefit accruing from such sustainable construction technologies. This can be achieved through organizing specialized training, conferences, seminars, mentorship programmes and coaching to provide platforms where stakeholders can gather knowledge and skills on sustainable steel construction technologies.
2. In Kenya, there are still areas that are not covered under the network of mobile telecommunication services. Consequently, the mobile industry is still poised to roll out additional BTS stations and this may just turn out to be among the large consumers of steel in the country in erecting and upgrading the base stations. It is therefore apparent, that the industry needs to develop sustainability strategies that are tailor made for the GSM sector in Kenya in order to realize the potential of sustainable steel construction technologies.
3. The study recommends that the mobile industry should partner with the government, in drawing up policies that can assist the stakeholders in entrenching sustainable construction technologies to ensure that the future of the country is safeguarded adequately through the benefits that come along with sustainable steel construction technologies.

5.5 Areas of Further Research

1. There is need to establish the quantity of steel consumed in the mobile telecommunication industry so that stakeholders including the government can be able to track the pattern on consumption of steel and be able to come up with sustainable measures that can adequately assist the industry engage in more sustainable developments in building their infrastructure.

2. In addition studies should be carried out to assess how the country's governing policies can assist in promoting sustainable steel construction technologies in the GSM telecommunication industry.

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APPENDICES

Appendix 1: Letter of Introduction

Dear Sir/Madam,

I am undertaking a master's degree course in construction engineering and project management at Jomo Kenyatta University of Agriculture and Technology. Currently I am doing a thesis titled: **Investigation of Sustainability of Steel Construction Technologies in Kenya.**

Sustainability is about meeting the needs of the present without affecting the needs of future generations. The main objectives of this survey are:

1. To explore the extent of sustainability of steel construction technologies in mobile industry in Kenya.
2. To identify factors influencing the use of sustainable construction technologies in the mobile industry in Kenya
3. To formulate evaluation criteria to measure sustainability of steel construction technologies in mobile industry in Kenya.

This questionnaire is purely for academic reasons of collecting data. Please fill in the questionnaire, the information you give will be treated with confidentiality.

Your cooperation in answering this questionnaire is highly appreciated.

Thank you.

Maurice Akech Otieno

Student

Appendix 2: Questionnaire

Section One: General Information of the Respondents

1. Please state the area of profession you are involved in the Mobile Telecommunications industry.

[ ] Project Manager
[ ] Site Supervisor
[ ] Consultancy
[ ] Acquisition Expert
[ ] Supplier

2. Please state your role in the Mobile Telecommunications Industry.

[ ] Project Manager
[ ] Engineering
[ ] Civil Works
[ ] Acquisition Expert
[ ] Civil Work Contractor
[ ] Site Supervisor

3. Kindly indicate your years of involvement in the Mobile Telecommunications Industry.

[ ] 0 – 5 years
[ ] 5 – 10 years
[ ] Above 10 years

Section Two: **Sustainable Steel Construction Technologies**

4. In general, have you ever heard of sustainability?

   Yes [ ]   No [ ]

5. How can you rate your understanding of sustainability?

   Good [ ]   Average [ ]   Poor [ ]

Please give your view by filling the blank spaces or by putting a tick [√] in the appropriate box in the table that agrees with your response.

Section Three: Factors That Influence Use of Sustainable Steel Construction Technologies in the Mobile Industry in Kenya

6. Which factors have promoted the advancement of Steel construction technologies in the mobile telecommunication industry,

6.1 Highly prefabricated steel

Yes [ ] No [ ]

6.2 Minimal site process, reduced waste and improved quality and accuracy

Yes [ ] No [ ]

6.3 Reduced storage space

Yes [ ] No [ ]

6.4 Reduced risk of delays due to programme predictability

Yes [ ] No [ ]

6.5 Flexibility in mast height changes

Yes [ ] No [ ]

6.6 Programme predictability

Yes [ ] No [ ]

Section Four: Evaluation criteria of Sustainability of Steel Construction Technologies

7. To which extent has the use of steel in construction of telecommunication masts **economically** contributed to the following

No.	STATEMENT	Very high degree	High degree	Medium degree	Low degree	Very Low degree
7.1	Improved productivity					
7.2	Minimizing Defects					
7.3	Shorter and More Predictable					

	Completion Time					
7.4	Reduction in Project Costs					
7.5	Consistent Profit Growth					
7.6	Supplier Satisfaction					
7.7	Mobile Service Provider Satisfaction					
7.8	Contribution to Local Economy through Employment					

8. To which extent has the use of steel in construction of telecommunication masts **Environmentally** contributed to the following

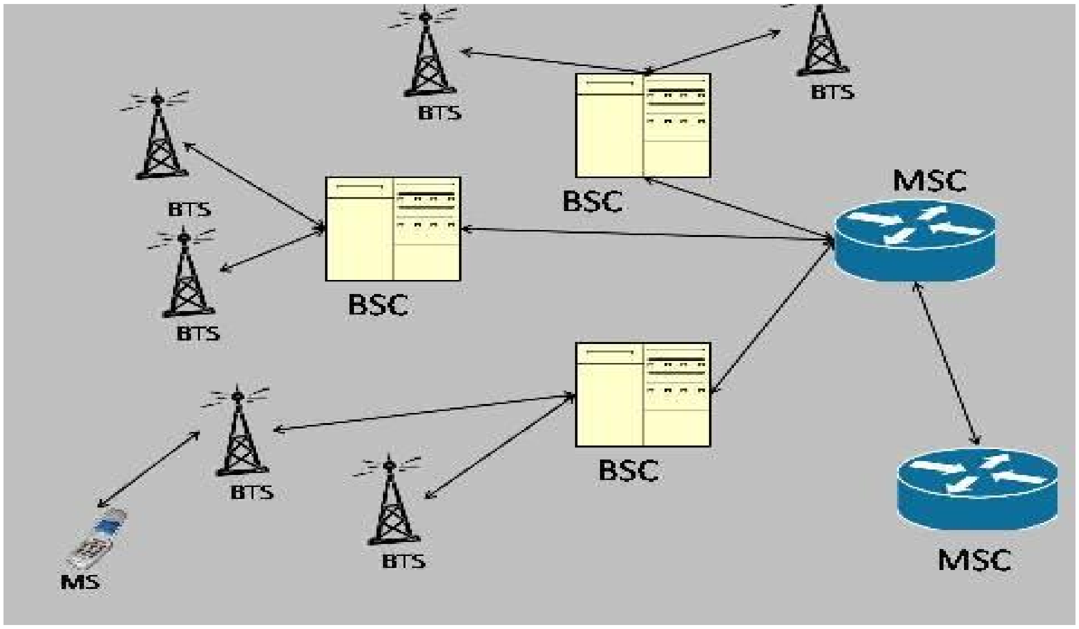
No.	STATEMENT	Very high degree	High degree	Medium degree	Low degree	Very Low degree
8.1	Minimizing polluting emissions					
8.2	Noise Prevention					
8.3	Dust Prevention					
8.4	Waste Minimization					
8.5	Protection of Sensitive Ecosystems					
8.6	Reduced Energy Consumption					
8.7	Use of Local Supplies					
8.8	Lean Designs					
8.9	Maximization of Resource Re-use					

8.10	Better Land use					

9. To which extent has the use of steel in construction of telecommunication masts **Socially** contributed to the following.

No.	STATEMENT	Very high degree	High degree	Medium degree	Low degree	Very Low degree
9.1	Provision of effective training					
9.2	Provision of equal opportunities					
9.3	Health, safety & conducive working environment					
9.4	Participation in decision making					
9.5	Minimizing local nuisance and disruption					
9.8	Building long-term relationship with mobile service providers					

Appendix 3: GSM Architecture



Source: www.gsmfordummies.com