INVESTIGATING FACTORS THAT AFFECT ADOPTION OF INNOVATIVE CONSTRUCTION TECHNOLOGIES IN NAIROBI

NICKSON AMUHAYA SAGINI

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Investigating Factors That Affect Adoption of Innovative Construction Technologies in Nairobi

Nickson Amuhaya Sagini

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DECLARATION

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

Signature: ……………………………………………Date: ……………………………..

Amuhaya Sagini Nickson

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

Signature:………………………………………….. Date: ………………………………

Prof. Stephen Diang'a, PhD

JKUAT, Kenya

Signature: ……………………………………………..Date: ……………………………

Dr. Titus Kivaa Mbiti, PhD

JKUAT, Kenya

DEDICATION

This thesis is dedicated to my dear wife Alice and children Isaias, Josiah and Elisha who have given me the best gift of my life.

And to God be all the Glory!

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ABSTRACT

The construction industry is perceived to have low levels of innovation when compared to the fast paced industries like Information Technology and the Motor Industry. This has been attributed to several aspects of the industry's structures, regulations and characteristics of construction innovations which lean more towards conventional methods. Despite the emergence of significant innovations in the industry which include the use of lightweight materials of high strength and stiffness, increased reuse and recycling of construction waste, sustainable construction practices, eco innovation, industrialized building systems and modularization; one significant challenge is the industry's failure to effectively adopt and utilize these innovative construction technologies even though they promise superior performance compared to conventional technologies. The aim of this study was to investigate the underlying factors that significantly influence the adoption of innovative construction technologies within the context of the Kenyan construction industry. The study explored innovation adoption trends by industry practitioners, examined the levels of adoption of innovative construction technologies and described factors that influence adoption and diffusion of selected innovative construction technologies. The enquiry mode was quantitative with a questionnaire survey involving consultants and contractors within Nairobi County. The findings revealed that lack of integration within the industry, lack of adequate information on innovations, traditional procurement systems and building codes had the greatest hindrance on the adoption of innovative technologies. Majority of construction firms within the industry were also found to be slow in tracking trends in construction innovations with low levels of adoption of home grown innovative construction technologies. Lessons from this study will help facilitate the management of innovation and technology flows for the benefit of a more balanced construction industry development.*:*

Keywords: Innovation, Technology, Construction, Adoption and Diffusion.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

World over, there is an increased demand from clients and end users for greater efficiency, value for money, competition, high quality, fewer defects and greater speed of construction. In effect , the construction industry has had to keep up with emerging trends in innovation and its adoption (Hardie, 1996). Areas that have seen significant innovation in construction include the use of lightweight materials of high strength and stiffness, increased reuse and recycling of construction waste, sustainable construction practices, eco innovation, industrialized building systems and modularization (E.U., 2011; Chun, Claisse, Naik, & Ganjian, 2007) .

In this respect, the current global frontier in technological invention, innovation and adoption is dominated by the developed world. The United States of America (U.S.A) and most countries within the European Union (EU) reign supreme in productivity, competitiveness and technological innovation (EU, 2009). Statistics on innovation diffusion within the EU indicate that as high as 39% of EU innovative firms adopt innovations with the rest generating internal innovation (EU, 2009). In the year 2004, penetration rate of innovative construction technologies in the U.S.A. market had reached a record high of 59% (Koebel, Papadakis, Hudson, & Cavell, 2004) .

Data from the innovation survey within the UK construction industry shows that as high as 34 % of the construction firms have innovation activity within their enterprise (Reichstein, Salter, & Gann, 2005). Ling (2003) shows that in Singapore innovation trends represented a good mix of process and product innovations with ‘new processes and designs’ being the largest group at 48.3% . In Canada the level of use for construction innovations was estimated at 38% (Anderson & Schaan, 2001). Results from firms in the Australian Construction industry indicated the rate of firms introducing 'new to the industry' technological innovations as 18 %. According to the results, only 30% of the 20 advanced practices listed in the survey had been adopted by more than 50 % of the industry. A comparison with the aforementioned Canadian survey revealed substantially higher adoption rates for the Australian industry.

However, developing countries have recorded very low levels of technological adoption. For example, between 1975 and 2000, only 9% of developing countries which had a minimum level of technology diffusion (5%) were able to reach a 50% technology penetration threshold, compared to 82% for high income countries (WorldBank, 2008b). In the African Continent, South Africa is listed as one of the countries with significant domestic innovative capacity. South Africa has reasonable access to the latest technology. However, the prevailing levels of technology within the country and overseas tend to limit the scope of the projects that can be undertaken at any one time, with the material, equipment and personnel available. There is also a problem with end-users' perceptions about viable alternative building methods and innovative building systems, (Abimbola & Keith, 2013)

At the local level, the Kenyan government has had several initiatives to identify potential sources of construction innovation. One such effort is the promotion of innovative construction technologies in order to lower the pressure on conventional construction Materials (R.o.K, 2013). Examples of technologies derived from these efforts in include Appropriate Building technology and Materials and adapted technological innovations in steel and plastic materials. These adoptions among other benefits considerably enhance the speed of construction, reduce waste, and add aesthetic value and durability to the constructed facilities.

In respect to innovation in the built environment, the construction industry is widely perceived to lag behind in innovation and its adoption. The industry is viewed as excessively conservative (Miozzo & Dewick, 2004). This has been attributed to several aspects of industry structure, regulations, access to information about new products, exposure to liability and limited financing (Koebel, Papadakis, Hudson, & Cavel, 2004). Studies have also shown that, public policies (Seaden, GuollaM., Doutriaux, & Nash, 2003; Seaden & Manseau, 2001; Blackley & Shepard, 1996) ; and the nature and characteristics of construction innovations (Rogers, 2003) ; have a major influence on construction innovation and its adoption.

1.2 Statement of the problem

While the activity in the Kenyan construction sector has reached record high over the last decade, the industry is still heavily dependent on conventional technologies which do not match market trends, resulting in project delays, high costs, poor quality and low output. The problem investigated in this study is the slow uptake of available innovative construction technologies by the Kenyan construction industry. This study investigated the factors that influence the adoption of innovative construction technologies in Kenyan with an emphasis on Nairobi County.

1.3 Objectives of the study

The main aim of this study was to investigate the factors that influence the adoption of innovative construction technologies within Nairobi County and was guided by the following objectives:

i. To evaluate innovative technologies available for the construction industry in Nairobi County.
ii. To examine adoption trends of innovative construction technologies by firms within Nairobi County.

iii. To describe factors that influencing the rate of adoption and diffusion of innovative construction technologies.

1.4 Research Questions

i. Which innovative technologies are available for the construction industry in Kenya?

ii. What are the levels of adoption of innovative construction technologies within Nairobi County?

iii. What are the trends by firms within the construction industry in tracking information on innovative construction technologies and what are the significant sources of information on innovative construction technologies within Nairobi County?

iv. What approach do firms take in the adoption of innovative construction Technologies within Nairobi County?

v. What factors influence the adoption of innovative construction technologies within Nairobi County?

vi. Who among players in the construction industry has significant influence on decision to incorporate innovative construction technologies in projects in Nairobi?

1.5 Study Significance

In terms of technology application, there has been inadequate assessment and documentation on adoption of Construction Innovation; in effect creating critical gaps of knowledge in the understanding of technological diffusion in the Kenyan Construction Industry. By providing stakeholders with an insight on innovative construction technology and its adoption, this study contributes towards the realization of an innovative industry. The study through its recommendations also suggests ways of increasing adoption of technological innovations in construction projects through change and development of policy. The specific findings of this study will enable stakeholders in the construction industry be in a position to explain, predict and account for the factors that impede or facilitate the adoption in the industry.

1.6 Study Justification

There is a general consensus among scholars on the importance of innovation and its adoption for long term economic growth, and competitiveness (Freeman, 1982). Innovation and its adoption enables organizations to improve the quality of their output, revitalize businesses, enter new markets, try out new technologies, and develop alternative applications for existing product categories in effect enhancing business performance (Dougherty, 1996). In Kenya innovation in its broad perspective is one of the major foundations for the pillars of vision 2030. However, despite these efforts, there is an ever widening technological gap between Kenya and the more advanced nations due to their ability to constantly upgrading their technological capabilities through research and innovation. In this respect, the amount of local innovative activity and the ability to exploit external innovative technologies through adaption and subsequent adoption is of great significance. This study contributes to the extension of knowledge on technological innovation and its adoption.

1.7 Delimitations of the study

In order to achieve the purpose of the study in the given time frame, certain limitations were adopted in this study. First, the measure of adoption was set to indicate extent of new technology utilization by firms. Second, whereas there is a wide range of innovations in the construction sector for adoption in the form of products and process, the study was limited to product innovations and specifically adoption of technological innovation. Third, while there exist many factors that impact adoption, the study focused on innovation attributes and contextual factors. Forth, whereas the ideal study would have been a mixed method approach (qualitative and quantitative), quantitative design was adopted in this study due to budgetary and time constraints.

1.8 Limitations of the study

To investigate factors that influence the adoption of innovative construction technology, this study was confined to participants with registered offices within Nairobi County. Further, although there are many stakeholders involved in the construction process, this study focused on NC1 category of contractors (building, electrical and mechanical); and professionals who are registered with relevant professional and regulatory bodies within the construction industry.

1.9 Assumptions of the study

The study assumed that stakeholders who were not limited to developers, Architects, Real estate professionals, Contractors, Engineers in the construction industry were aware of the benefits of innovative construction technologies practices and had incorporated some of the technologies in their projects. It was therefore assumed that there was some level of adoption of these technologies in construction projects within Nairobi County. It was further assumed that participants will answer honestly, due to the level of anonymity and confidentiality preserved during the study. The participant firms were assumed to be knowledgeable in the area of study.

1.10 Definition of key terms

1.10.1 Innovation

The application of new knowledge to industry, and includes new products, new processes, and social and organizational change. In the context of the construction industry, innovation is defined as the improvement of a building component, or technology used to construct buildings with respect to its characteristics or intended uses (OECD, Oslo Manual, 2005)

1.10.2 Adoption

Adoption is defined as the ultimate making full use of a new idea action as the best course of action available. (Rogers & Shoemaker, 1971)

1.10.3 Diffusion

Diffusion can be interpreted as aggregate adoption (David & Zilberman, 2000)

1.10.4 Technology

In the context of this study, Technology is defined as the scientific method and material used to achieve a commercial or industrial objective. Technological innovations comprise new products and processes and significant technological changes of products and processes.

1.10.5 Adaption

Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

1.10.6 Construction

In the context of this study, Construction is the process by which material, equipment, machinery is assembled into a permanent facility.

1.11 Study Outline

This thesis was organized into five main chapters, which are structured as follows. Chapter 1 provides an introduction to the general subject domain and identifies the aim and objectives. It justifies the need for the research and sets it within an industrial context. Chapter 2 discusses the literature and related work on innovation and its adoption within the construction industry. Chapter 3 briefly explores the different types of methods available and describes the portfolio of methodologies used in the study. It explains methodological approaches that were used to achieve the research aim and objectives. Chapter 4 presents and analyses data gathered at the survey stage of the research. Guided by the methodology, the raw data captured by the research instrument are analyzed and the findings discussed in line with the research objectives. Chapter 5 discusses the key findings of the research. It contains the major conclusions to have arisen as a result of this study. It also makes a number of recommendations for the construction industry and for further research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Chapter one laid the background to this study, stated the objectives and the research questions. The main purpose of this Literature Review chapter was to provide a comprehensive review of the existing literature pertinent to the fundamental aspects of innovation and its adoption. The chapter reviewed relevant literature on the innovation concept, innovative construction technologies and adoption in the construction industry; drawn from theoretical and empirical ideas by various researchers, analysts, and authors in line with the objectives of this study.

2.2 The Innovation Concept

In the broad perspective, an innovation is defined as any idea, practice or technology perceived to be new by the organization involved (Rogers E. , 1983). In others words, it matters little whether or not the idea is objectively new. As long as such an idea is perceived to be new by the individual or organization, it is an innovation. In an attempted to account for the project based nature of the construction industry, the Organization for Economic and Co-operation and Development (OECD, Oslo Manual, 2005) defines innovation as the improvement of a building component, or technology used to construct buildings with respect to its characteristics or intended uses. In this context, the focus is on the successful development and/or implementation of new ideas, products, processes or practices to increase an organizations' efficiency and performance (Seaden, GuollaM., Doutriaux, & Nash, 2003; Ling, 2003). OECD, Oslo Manual, 2005 classifies innovation in two dimensions as either *Product* (making beneficial changes to physical products); or *Process* (introduction of a new or significantly improved production method or delivery of output that adds value to the organization).

Slaughter (1998), further presents a typology of innovations within the construction industry as *incremental* (small change with limited impacts on surrounding elements); *modular* (significant change in the basic concept, but also with limited impact on its surroundings); *architectural* (a small change in the respective component, but with many and strong links to other surrounding components); *system* (multiple, linked innovations); and *radical* (breakthrough in science or technology). Unlike many other industries, innovation in the construction industry tends to occur through problem-solving exercises, is typically project specific and is constrained by client needs and circumstances pertaining to project conditions. Studies have shown that *incremental* and *modular* innovations are the most prevalent in the construction industry (Pries, 2005) . This is attributed to the fact that often; conventional technologies are used alongside newly developed technologies during the construction process.

2.3 The Technological Innovation concept

The early theory of technological innovation assumed a linear model. In this model, the stages in the generation of technological innovation ranged from *discovery* (characterized by the emergence of a concept or results that establish the innovation); D*evelopment* (where the discovery moves from research to the field, is scaled up, commercialized, and integrated with other elements of the production process); and *marketing* which is characterized by education and demonstration that is followed by sales and eventual adoption (Sunding & Zilberman, 2000).

However, changing trends and more interactive models of *technology push, market pull* and *Complex product Systems* have dominated the market as amplified by (Slaughter, 1998).The logic behind market pull is that technology diffusion is guided by the demand from the potential users whereas technology push starts at the production end of the supply chain where the product is introduced to the market (Tangkar & Arditi, 2000). Complex Product Systems is a generic model of innovation and it develops with the interaction between suppliers of innovation and end users. This model involves close interactions and negotiations between key actors in the market and the end users are more involved in the actual design of the product to their test and preference.

The most significant model for innovation development process that relates to adoption was proposed by Everett Rogers. In this linear model innovation entails six developmental phases starting with the emergence of *need*, *research*, *development*, *commercialization*, *adoption* and *diffusion* and lastly *consequence of acceptance or rejection* (Rogers, 2003). The principal focus of this study was the adoption and diffusion phase. It is a crucial phase to any organization in the innovation process, because the socio-economic benefits of an innovation can only be realized after it is adopted by potential end users.

2.4 The Adoption and Diffusion of Innovation concept

Diffusion can be interpreted as aggregate adoption (David & Zilberman, 2000). According to Dooley (1999), diffusion research originated from French sociologist Gabriel Tarde in 1903 and later 1940's, Bryce Ryan and Neal Gross who renewed interest in the diffusion process. Popular models of diffusion were developed by Everest Rogers in 1962, Frank Bass in 1969 and Lawrence Brown in 1981.

The Bass model is a useful tool for forecasting the adoption of a new innovation for which no closely competing alternatives exist in the marketplace (Lilien, Rangaswamy, & Bruyn, 2007)). Brown (1981) model of diffusion is applicable to diffusion of technological innovation among firms and focuses on communication and information flow process where the diffusion of technological innovation is viewed from the perspective of the adoption behavior of the firms using the innovation (Songip, Lau, Jusoff, & Hayati, 2013). Brown thus examines the actual usage of innovation in contrast with Rogers's framework in which the perceived innovation attributes are emphasized. According to Brown (1981), the adoption decision is influenced by four main factors:

characteristics of the innovation, industry characteristics, institutional effects, and firm characteristics.

In Rogers (2003) , adoption is viewed as a decision of full use of an innovation as the best course of action available and rejection is a decision not to adopt an innovation. In this perspective, the Measure of adoption is an indication of both the timing and extent of new technology utilization by individuals (David & Zilberman, 2000). For example, one measure of adoption of a technology is a discrete variable denoting if this technology is being used at a certain time. Another measure could be what percentage of specific projects is using the technology. The adoption rate theory seeks to explain how the use of new innovative technologies, spreads through a social system, and why they are adopted over old methods. Rate of adoption is the relative speed with which an innovation is adopted by members of a social system (Rogers, 1995); measured as the number of individuals who adopt a new idea in a specified period. In this theory, there are several variables that determine the rate of adoption of an innovation among them; the innovation attributes; the type of innovation decision, the communication channels used to spread information about the innovation, time and the nature of the society to whom it is introduced (Rogers, 1995).

2.5 The Construction Industry System and Innovation Adoption

The construction process may be regarded as an archetypal network or system, since construction projects are planned and executed in the context of inter-organizational decisions, relations and activities (Miozzo & Dewick, 2004). Adoption of innovation occurs within a social system or network. In effect, increased interaction around an innovation in a social network increases likelihood of adoption (Pittaway, 2004). Many of the problems of the underperformance of the construction industry stem from inadequate inter-organizational co-operation (Miozzo & Dewick, 2004). The key to innovation and adoption of technology is therefore in the creation of a powerful enough consortiums of actors to carry it through, and when an innovation fails to be taken up, this can be considered to reflect on the inability of those involved in the construction of the necessary network of alliances amongst the other actors (McMaster, Vidgen, & Wastell, 1997) . This approach to innovation and its adoption requires the construction of networks and alliances to support and embed the changes in order to make them durable.

It is increasingly accepted that construction innovation and its adoption encompasses a wide range of participants within a product system (Marceau, et al., 1999) . In effect, there is a broad range of actors who impact on adoption of innovations in the construction industry. These include Developers/Clients, Buyers/ end user, the Government and project based service providers (contractors, consultants and Manufacturers/ Suppliers). Figure 1 shows a representation of the breadth of participants in the construction industry. Table 2.1 illustrates strength and weakness in the linkages deduced from construction actor network.

The clients' role in the innovation process takes different facets. Clients may dominate the process by driving innovation; play a co-production role by working with project based service providers to drive innovation; or be passive and allow the project team to drive innovation (Brandon & Ling, 2008). The client's interest in innovation ranges from impeding to insisting on innovation. The client's relationship with other stakeholders in the industry include representing the owners/financiers, identifying and communicating users requirements and interests and influencing project delivery structures through various procurement methods (Brandon & Ling, 2008) . In respect to innovation and its adoption within the Construction industry, the key roles of the client include the provision of financial incentives, capability to manage risk in innovation, being a change agent, providing leadership, aiding in dissemination of innovation and being a source of knowledge for innovation (Brandon & Ling, 2008) .

The Government plays the central role as regulator, sponsor, client and policy maker. According to Blayse and Manley (2004), the regulatory framework in the industry is provided by the government agencies, manufacturing industry and professional bodies. However, in an increasingly privatized system the role of government is changing fast. Hence the knowledge and capability to drive innovation rests in the private sector. In this respect, Consultants, Contractors and Manufacturers provide a body of knowledge about innovation that is extremely useful for improving innovation performance in the construction sector. These service providers with advanced technologies sometimes initiate innovative process and in the long run influence the adoption process.

In this network, contractors are important sources and adopters of innovations that improve construction technologies. They also act as important mediators of the different flows of technology and information in the construction industry. Contractors are not only mediators in the project coalition but, especially large contractors, can also be an important source of innovation to a much greater extent than is usually recognized (Slaughter, 1993). For example, a survey in Germany found that approximately 60 per cent of contractors with 200 or more employees were innovative (developing either product or process innovations), (Cleff & Cleff, 1999).

Other actors not always considered in industry analyses include educational institutions and Research and Development institutions (R&D). Education institutions are equally important as they are key in provide up-to-date training opportunities to match the demands of emerging innovations. R&D institutions, on the other hand, play a direct role in developing, co-developing, and/or testing innovations.

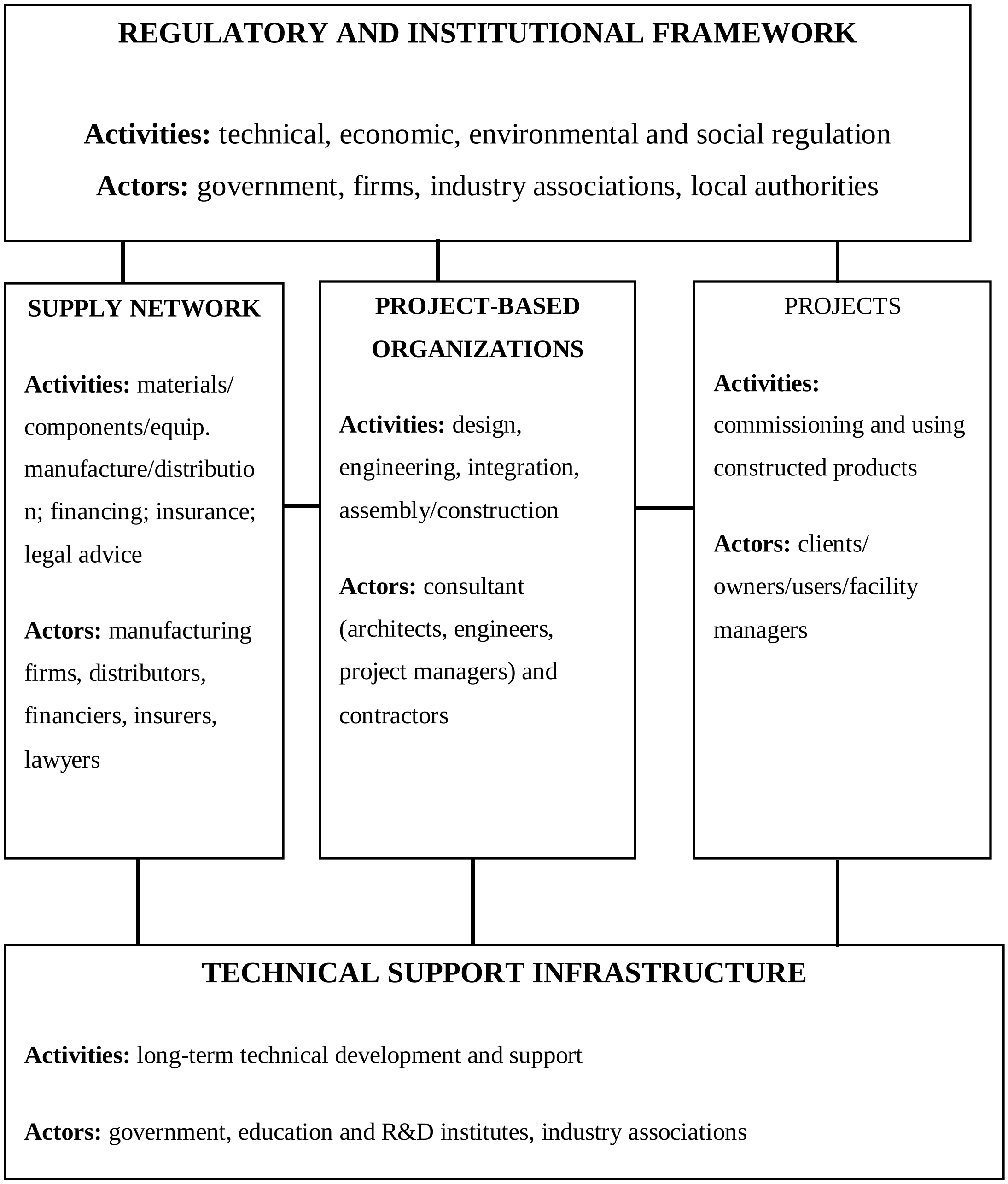


Figure 2.1: Actors in the Construction Innovation System

Source: (Gann & Salter, 2000)

Table 2.1: Strength and weakness in the construction industry networks

ACTOR	STRENGTH	WEAKNESS
Owners, public& private investors	• Own capital • Prime beneficiaries from successful innovations	• Usually less experience and less knowledgeable
Consultants	• Close to capital owner • Knowledgeable and experienced • Beneficiaries from successful innovations	Risk averse
General contractors	• In charge of all construction activities • Knowledgeable about all aspects of construction and therefore major linkage to adopters	• Labour restrictions • Capital intensive • Complex legal responsibilities • The looser in case of failure
Sub-contractors	• Expertise in a particular specialty	• Labour restrictions • Capital intensive • Complex legal responsibilities • The looser in case of failure
Suppliers	• Relationship with General contractors, Consultants and subcontractors • Well connected to manufacturers	Weak relationship with owner
Manufacturers Research institutions	• Provide Research and Development • Offers new products	• Weak relationship with owner
Government	• Policy and framework	• Weak relationship with owner

Source Author 2015

2.6 Innovation and innovation adoption trends in the construction industry

Innovation and its adoption is a source of competitive advantage for firms seeking to accommodate the rapid changes embodied in their complex products and processes (Manseau, 2005) .The construction industry is increasingly being challenged to successfully innovate in order to improve its competitiveness as well as satisfy the aspirations and needs of society. The industry faces the challenge of minimising the environmental impact of its consumption of materials and energy hence the need to become more innovative to meet this challenge. Opportunities for innovation and improving performance are available in all aspects of the industry in product and process; and these include, the use of lightweight materials of high strength and stiffness, increased reuse and recycling of construction waste sustainable construction practices, eco innovation, industrialized building systems and modularization (E.U., 2011; Chun, Claisse, Naik, & Ganjian, 2007).

2.6.1 Innovation in the construction industry

World over, there is increased reuse and recycling of construction and demolition waste from timber, steel and concrete. Improvements to construction material have had significant changes to traditional products such as fiber-reinforced concrete and plastic-reinforced wood; and development of completely new technologies. New technologies such as engineered wood products are being widely employed to make use of materials formerly perceived as waste. There are increased studies and research on new and innovative ways of achieving sustainability of construction materials and technologies. These include sustainable use of recyclable resources such as fly ash, ground municipal waste slag, pozzolana, rice-husk ash, silica fumes, gypsum plasterboard and lime in construction; sustainable mortar, concrete, bricks, blocks, and backfill; use of construction and demolition waste, and organic materials (straw bale, hemp, etc.) in construction; sustainable use of soil, timber, and wood products. In Europe under the platform of Eco Enovation, there are initiatives to substitute resource intensive materials with Eco materials which include eco cement, building with straw based materials and clay, use of lightweight materials with high strength and stiffness, using and reusing resources efficiently by embracing industrial building systems, process improvement through automation, Information management, standardization and data exchange, Safety, business competitiveness, and management strategies.

2.6.2 Adoption of innovation in the construction industry

The capacity to innovation and adopt has been attributed to research, education, infrastructure, business incentives, promotion of exports , access to foreign markets, structure of corporate taxes, and an effective intellectual property regime (USA, 2012; EU, 2009) . Data from the innovation survey within the UK construction industry based on the core Eurostat Community Innovation Survey shows that as high as 34 % of the construction firms have innovation activity within their enterprise. The reported levels for each of the six indicators of innovation activity within construction firms revealed that 6% of the respondents had introduced a new product or process; 3% reported having co-operation agreements on innovation activity with business partners and/or counterparts; 7 % reported innovation activities not yet completed or abandoned; 27 % reported spending on innovation; and 3 % reported having long-term innovation activities (Reichstein, Salter, & Gann, 2005).

The level of innovation within the Singaporean construction industry; reported as part of the survey on managing the implementation of construction innovation conducted by Ling (2003) show that innovations represented a good mix of process and product innovations with ‘new processes and designs’ being the largest group at 48.3% .Similar studies were conducted in Canada for construction industry-specific innovations survey to gauge the level of innovation in construction firms using the ‘current use’ and ‘intention to use within 2 years’ of advanced technologies and advanced practices criteria (Anderson & Schaan, 2001). According to Anderson and Schaan, (2001), of all the advanced technologies surveyed, three technologies had the highest percentage of use: email (38%), company computer network (25%), and CAD (23%).

The most relevant innovation survey was carried out by the Cooperative Research Centre for Construction Innovation under the BRITE Project within the Australian construction industry in 2004. It encompassed technological and organizational innovations and the adoption and introduction of innovations that were new to the world or new to the industry or business concerned. Regarding technological innovations, the survey results indicated the rate of firms introducing ‘new to the industry’ technological innovations as 18 %, whereas 6 % of the respondents reported the introduction of ‘new-to-world' technological innovations. In addition, 25% of the industry appeared to invest in R&D, a key indicator of technological innovation. According to the results, only 30% of the 20 advanced practices listed in the survey had been adopted by more than 50 % of the industry. A comparison with the aforementioned Canadian survey revealed substantially higher adoption rates for the Australian industry.

2.6.3 Innovative Construction Technologies in Kenya

Kenya has had several initiatives to identify potential sources of Construction Innovation. One such effort is the promotion of appropriate technologies in order to lower the pressure on Conventional Construction Materials (R.o.K, 2013). In 2006, the Ministry of Housing rolled out the Appropriate Building Materials and Technology (ABMT) Programme; which refers to building processes, materials and tools that are cost-effective, safe, innovative, environmentally friendly as well as acceptable to the climate, socio-economic conditions, and natural resources of an area. (R.o.K., 2013). These included Stabilized Soil Blocks (SSBs), Micro-Concrete Roofing (MCR) Tiles and Pozzolana/Rice Husks Cement. The Ministry has utilized local and global research findings through networking to continue running the ABMT Programme and has been able to establish the Regional ABMT Centre at Mavoko in Nairobi, 9 county ABMT Centres and 63 Constituency ABMT Centres. Training workshops have been conducted throughout the country to transfer skills and empower community groups to construct affordable houses, social facilities and other utilities. (R.o.K., 2013). To facilitate the use of new and viable ABMT, the Ministry has spearheaded the revision of the current Building Code to enable their acceptance in designated areas within the local authorities.

With these efforts and with collaboration with private sector, there is a range of local and adapted innovative construction technologies available in Kenya. This include Plastics, Stabilized soil blocks, Rammed earth walling, Bamboo, Wood wool slabs, Micro-Concrete Roofing Tile, Light Steel Frame, Expanded Polystyrene (EPS) technology, Solar water heating and lighting, Waffle slabs, Fibre mesh, and recycling of grey water. This study focused on selected cases innovative construction technologies (see Table 2 below).

Table 2.2: Innovative Construction Technologies in Kenya

No	Element	Traditional Technology	Innovative Technology	Description	Selected Local Suppliers
1	Concrete reinforcement	Fabric reinforcement	Fibre mesh in slabs	Primary function is to modify the properties of fresh concrete. It increases the homogeneity, reduce, cracking bleeding, plastic settlement and shrinkage. In hardened concrete it reduces permeability, and increase resistance to impact, abrasion and shatter, sparling of concrete in fire situations	Doshi
2	Concrete mixing	Mixing plant on site	Premix	delivery in trucks	Bamburi Cement
3	Walling	Stone, concrete block, brick work	Expanded Polystyrene (EPS) panels	A type of foamed plastic formed by the expansion of polystyrene resin beads in a moulding process. System is composed of a factory produced panel of undulated polystyrene covered on both sides by an electro welded zinc coated square mesh. Panels are assembled on site and in situ poured concrete (for double panel, floors, stairs) and shot Crete concrete (for single panel) to realize the different elements of the building. The use of EPS panels as a substitute to traditional materials reduces construction periods as well as direct and indirect building costs.	National Housing Corporation
4	Walling	Stone, concrete block, brick work	Interlocking Stabilized soil blocks	Stabilization helps in achieving a lasting structure from locally available soil, including better mechanical characteristics, cohesion and improved resistance to wind	Makiga industries

				and rain erosion and reduced use of mortar.	
5	Roof structure	Timber, hot rolled structural steel sections	Lightweight steel frames	Consists of structural wall frames and roof trusses manufactured from cold-formed light gauge galvanised steel sections. Construction is fast, durable and produces little waste, immune to termites and other insects and rot. Structure also adapts to major refurbishment and rehabilitation.	Mabati Rolling Mills
6	Roof covering	Clay and concrete tiles, Galvanised and pre-painted iron sheets	Stone coated roof cover	Deck cores to all sheets are made of high-quality Aluzinc alloy coated steel sheet with a 0,5 mm thickness UV and weather-resistant ,surface coating, It is durable, inhibiting moss and lichen growth, weather resistant, light, of low maintenance, ease of installation and reduced on-site labour.	Mabati Rolling Mills Tack Tile, Space and Style, Metro tile
7	Finishes	Block board, chipboard, timber boards.	Gypsum	Raw gypsum ore is processed gypsum wallboard. Widely used for erecting lightweight fire-resistant non-load bearing interior walls, partition walls, cavity walls, skin walls and pillar casing indoors, lining of walls, ceilings, adaptable moulding and shaping.	Timsales Kenya TanaRiver Industries
8	Doors and windows	Timber, steel casement, aluminium	Plastic doors, windows, ceiling	Lightweight and durable materials readily moulded to find use in a wide range of applications. Plastic resilient, weather-resistant, and impervious to rot, mildew, and termites and do not require high maintenance or regular repainting or staining. Highly attractive with a wide variety of design and appearance.	Vista Industries, Ecopost Industries
9	Flooring	Tiling, woodblocks, terrazzo , granolithic floor, screed	Laminate flooring	Typically consisting of a medium- or high-density fibreboard base that incorporates a transparent wear layer, a decorative layer, and a moisture-resistant backing. Generally installed as a "floating" floor—not attached with nails or glue to the floor.	Wood products K.Ltd
10	Water	Electricity,	Solar water	Works by transferring heat from a solar panel	Solar World

	heating	Kuni boosters	heating	to the tank via the water medium. Mainly installed in residential houses, catering facilities, hotels, educational facilities, hospitals and public amenities. Reliable technology, cost effective and eco-friendly	EA ltd, Chloride Exide
11	Lighting	Electric grid, diesel engine	Solar lighting	Sources of energy directly attributed to the light of the sun or the heat that sunlight generates. Classified as passive and active; thermal and photovoltaic; And Concentrating and non- Concentrating. Theoretically, solar energy has resource potential that far exceeds the entire global energy demand.	Solar World EA ltd, Chloride Exide
12	Plumbing pipework	Galvanized iron piped, metal pvc, copper	PPR	PPR can be used for cold water and hot water piping PR pipe interface with hot-melt technology, fully integrated between the tubes together. So once installation and pressure test passed are leak proof Moderate price, stable performance, heat insulation, corrosion resistance, smooth inner wall, safe and reliable and can last up to 50 years	Metro Plastics
13	Joinery fittings	Solid Timber, block board, aluminium	medium density fibreboard (MDF)	MDF board is a dry-formed panel product manufactured from lignocellulose fibres combined with a synthetic resin or other suitable binder. The panels are compressed to a density of from 496 to 801 kilograms per cubic meter. MDF has more uniform density throughout the board and has smooth, tight edges that can be machined. It can be finished to a smooth surface and grain printed, eliminating the need for veneers and laminates.	Timsales Kenya Tana River Industries
14	Waste water treatment	Septic tank, treatment plant and ponds, cess	grey water recycling plant (bio digester)	Bio digesters for domestic waste water treatment enable 100% recycling of domestic waste water. Waste water is treated by aerobic or anaerobic means. With aerobic	Ecomaji Africa

pit		treatment, oxygen or air must be present. Anaerobic decomposition however can take place without the presence of oxygen.

Source (R.o.K., 2013) *Government of kenya Ministry of Housing Website.* Retrieved april 28, 2013, from http://www.housing.go.ke

2.7 General actors Influencing the Adoption of Innovations.

Adoption is a variable of great interest to innovators, since it is a reflection of the extent to which an innovation diffuses in asocial system. The importance of innovation has prompted considerable research into what stands in the way of implementation and adoption of new products and processes. Research findings suggest that there are many factors that influence innovation and its adoption. These are however not specific to the construction industry. Examples include access to information about new products; the nature and characteristics of innovations (Rogers, 2003); industry structure, procurement systems, exposure to liability and limited financing (Koebel, Papadakis, Hudson, & Cavel, 2004) ; and public policies (Seaden, GuollaM., Doutriaux, & Nash, 2003; Seaden & Manseau, 2001; Blackley & Shepard, 1996) ; industry characteristics, institutional effects, and firm characteristics (Brown, 1981).

2.7.1 Information flow and adoption of innovation

The information awareness model of Rogers & Shoemaker, (1971) conceptualizes the decision to adopt an innovation as a function of various stages of information gathering and decision making until the potential adopter reaches a psychological decision regarding adoption of the innovation. This view assumes that access to information is the principal determinant of the adoption decision, which is sequenced by awareness, interest, evaluation, trial and eventual adoption. It focuses on the role of different information and communication channels in each stage of the adoption process.

Adoption and diffusion is a type of communicative process which involves an individual or other unit of adoption that has knowledge of, or has experience using the innovation (also known as change agent); and another individual or other unit that does not yet have knowledge of or experience with the innovation. The aim is then to pass this knowledge between these two individuals or adoption units; hence a communication channel is the means by which the new idea or knowledge about the innovation gets from one individual to another (Rogers, 2003). The communication channels range from interpersonal to mass media. The communication channels used to diffuse an innovation influence innovation's rate of adoption. (Rogers, 1995) Indicates that mass media channels, such as magazines have been found to be satisfactory for less complex innovations, but interpersonal contact with extension change agents is more important for innovations that are perceived as more complex. This implies that use of mass media channels of communication for complex innovations, would result in a slower rate of adoption. In effect, while many individuals may initially hear about an innovation through mass communication channels, it is the interpersonal communication that is likely to influence adoption decisions (Mark, 2001) .

There is therefore need for more effective exchange of information between project participants within the construction industry. With an emphasis on the flow of information, Winch and Courtney (2007) examines the mechanisms that make innovation happen at an organizational level and the catalytic role of information brokers which provide the necessary information to support knowledgeable decisions surrounding adoption and implementation. One of the primary issues identified is the ability to effectively manage the information that is required for a new process to succeed in practice. Brandon , (2008) identifies how the client can impact innovation within the construction industry and acknowledges some of the basic mechanisms required to facilitate the flow of information, such as establishing and measuring performance metrics and the subsequent dissemination through best practice. In effect a necessary step towards achieving the desired integration is to maximize the flow of the information. The co-ordination within actors and the integration across partners are critical in effective adoption of innovation. Sharing information is a key component for tight integration to optimize adoption. The quality of information received, the timeliness and the manner it is received and the cost-effectiveness in obtaining the information determines the efficiency of a project partners (Titus & Bröchner, 2005).

According to Bossink (2004), firms external knowledge and information sources plays a significant role in driving innovation adoption and exchanging existing knowledge stimulates the development of new knowledge about innovation . Dikmen, Birgonul, & Artuk (2005) came to the same conclusion and stated that the core sources of knowledge (clients, consultants, and suppliers) enhanced adoption of innovation. Therefore, innovations are not only influenced by the individual behavior of participants but also by the knowledge transfer that results from the collaborative relationships among them. The communication gap between innovation suppliers and consumers may be linked to the ineffective flow of knowledge and limited knowledge integration.

2.7.2 Firms' culture /approach towards innovation adoption

A study on technology adoption by Mitropoulos and Tatum, (1999) highlighted a number of factors affecting the adoption of innovation among them the firm's culture and attitudes towards new technology. The liabilities of the construction industry with respect to innovativeness are mainly related to the organizational culture and actors involved in the construction process. According to Rogers, potential adopters of an innovation must learn about the innovation, be persuaded as to the merits of the innovation, decide to adopt, implement the innovation, and confirm (reaffirm or reject) the decision to adopt the innovation. This requires a collaborative organizational culture. Innovation adoption decision could be individual, collective or by authority. The type of innovation-decision is related to an innovation's rate of adoption since innovations requiring an individual-optimal innovation-decision have been found to be adopted more rapidly than when an innovation is adopted by groups or organizations (Rogers, 1995).

Innovativeness provides an insight into understanding the desired and main behavior in the innovation-decision process. Innovativeness is the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system (Rogers, 2003). Rogers (2003) defined the adopter categories as the classifications of members of a social system on the basis of innovativeness. This classification includes innovators, early adopters, early majority, and late majority and Laggards. According to Rogers (2003), innovators are willing to experience new ideas and are prepared to cope with unprofitable and unsuccessful innovations, and a certain level of uncertainty about the innovation. Compared to innovators, early adopters are more limited with the boundaries of the social system and are more likely to hold leadership roles in the social system so that other members come to them to get advice or information about the innovation.

Rogers (2003) claims that although the early majority has a good interaction with other members of the social system, they do not have the leadership role that early adopters have. However, their interpersonal networks are still important in the innovation-diffusion process. Similar to the early majority, the late majority includes one-third of all members of the social system who wait until most of their peers have adopted the innovation. Although they are skeptical about the innovation and its outcomes, economic necessity and peer pressure may lead them to the adoption of the innovation. To reduce the uncertainty of the innovation, interpersonal networks of close peers should persuade the late majority to adopt it.

Laggards have the traditional view and they are more skeptical about innovations and change agents than the late majority (Rogers, 2003). As the most localized group of the social system, their interpersonal networks mainly consist of other members of the social system from the same category. They do not have a leadership role. Because of the limited resources and the lack of awareness knowledge of innovations, they first want to make sure that an innovation works before they adopt. Thus, laggards tend to decide after looking at whether the innovation is successfully adopted by other members of the social system in the past. Due to all these characteristics, laggards' innovation-decision period is relatively long. Figure 2 below illustrates adopter Categorization on the Basis of Innovativeness.

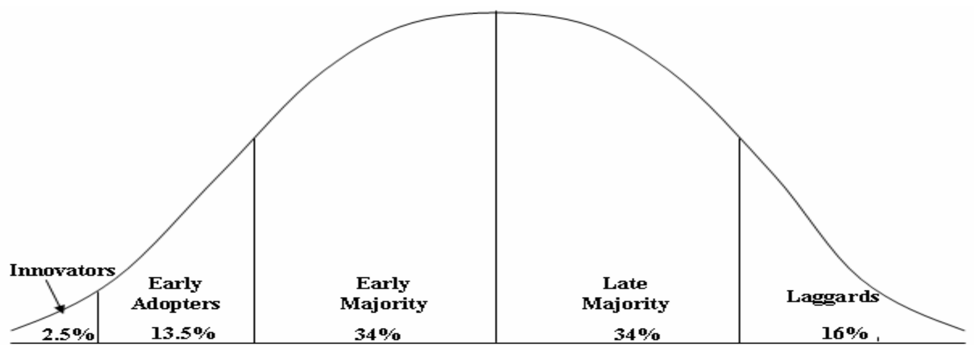


Figure 2.2: Adopter Categorization on the Basis of Innovativeness

Source: (Rogers, 2003)

The construction industry has often been described as a *laggard* in the introduction and diffusion of new technology (Tatum, 1987). The industry is project-based and involves numerous individuals from different companies working together at a construction site towards completing one product. (Dubois & Le, 2002). The general lack of coordination between the large number of actors and activities involved in building construction and the division of work into different phases and discrete packages prevents a comprehensive overview of the complete project, and leads to insufficient cooperation between actors. The temporary and on-site nature of building projects limits opportunities for knowledge development, effective communication, and knowledge transfer both within and between projects, and as such limits the opportunities for innovations to diffuse (Blayse & karen, 2004; Dubois & Le, 2002; Nam & Tatum, 1988). Each party is an independent organizational entity that pursues its own interests and expected end incentives from the project (Ofori & Moonseo, 2006). In addition, one of the most significant features of the construction industry is the supply chain, which is more fragmented than nearly any other industry. The variety of knowledge, materials, technologies, and skills applied in different organizations makes it hard to achieve efficient internal cooperation.

2.7.3 Perceived attributes of innovations

Brown, (1981) and Rogers, (1995) approaches agree to the fact that characteristics or attributes of an innovation is a significant factor that influences adoption. Other studies have also depicted perceived attributes of the innovation as the most prevalent factor (E.g. (Rogers, 2003; Ostlund, 1974; Moore & Benbasat, 1991). According to Rogers (1995) , 49% to 87% percent of the variation in the rate of adoption is explained by the perceived attributes of the innovation. However, whereas under this variable, Rogers (1995) further provides five analytic concepts of an innovative technology as its relative advantage, compatibility, complexity, trialability and observability; Brown (1981) depicts main characteristics as profitability or cost savings and the required investment. Relative advantage refers to the perceived value of an innovation in relation to the previous idea used to perform the same tasks. The advantages are not those dictated by the producers, but those perceived by the adopter. Relative advantage can be measured in economic terms, social prestige, convenience or satisfaction. To increase the rate of adopting innovations and to make relative advantage more effective, direct or indirect financial payment incentives may be used to support the individuals of a social system in adopting an innovation. For example, reduction in the price of a new product may lead to a rapid rate of adoption.

Complexity is the degree to which an innovation is perceived as difficult to use and understand (Rogers, 2003). This can be translated as the "ease of use", which is measured by source of frustration, degree of mental effort required, degree of learning required and ability to control outcome (Moore & Benbasat, 1991). Complexity is negatively related to the rate of adoption of an innovation and acts as a barrier to the interaction with the innovation (Rogers, 2003). Any innovation therefore quickly gains a reputation as to its ease or difficulty of use. Thus, excessive complexity of an innovation is an obstacle in its adoption. For example, a complex technological innovation in construction might confront adopters with the challenge of changing their construction methodologies to integrate the innovation into their system.

Trialability is the degree to which the potential adopter has an opportunity to try out and experiment with the innovation before the adoption decision. According to (Rogers, 2003), innovations that are accessible to the potential adopters for experiments are more rapidly adopted. Trialability is positively related to the rate of adoption of an innovation and is measured by the ease with which an innovation is available for trial before the adoption decision and the time span of the trial period (Moore & Benbasat, 1991).

Rogers (2003) defined observability as the degree to which the results of an innovation are visible to others. Role modeling (or peer observation) is the key motivational factor in the adoption and diffusion of technology. Similar to relative advantage, compatibility, and trialability, observability is positively correlated with the rate of adoption of an innovation.

In summary, (Rogers, 2003) argues that innovations offering more relative advantage, compatibility, simplicity, trialability, and observability will be adopted faster than other innovations. The rate of adoption will therefore be high (a high rate means a larger percentage of the social system members adopting the innovation in a relatively short period of time) when the perceived attributes of the innovation are consistent with the central values of the social system; and low when the perceived attributes of the innovation are inconsistent with the central values of the social system. Perceived attributes is an important variable in explaining the rate of adoption of an innovation (Rogers, 1995).

(Miozzo & Dewick, 2004) recognizes the nature of the constructed product itself as being ill suited to creating the conditions necessary for innovation as built structures are generally expected to be highly durable which creates a preference for tried and tested techniques. Although the use of innovative technologies has tremendously increased in the developed world, liability conscious designers and contractors are reluctant to try technologies which have not yet been tried due to uncertainties about the material performance (Augenbroe & Pearce, 1998). For the adoption of an innovation, trial is an important factor which is especially helpful for later adopters. Rogers states that earlier adopters see the trialability attribute of innovations as more important than later adopters.

2.7.4 Nature of the construction industry

Rogers (1995) defines a social system as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal. Members of a social system can be individuals, informal groups, or organizations. Stakeholders in the construction industry can be categorized as members of a social system. Diffusion of construction innovation within this social system is dependent upon the social structure (The formal arrangement of units within the social system), norms within the system (the established behavior patterns and beliefs that are common amongst the members of the social system); the informal, interpersonal networks which link the social systems members, and opinion leaders (Rogers, 1995). Of special importance are the norms of the system as they provide guidelines for acceptable behavior and also affect diffusion. A social system is similar to the actor network in an innovation system which forms a network of interelated individuals, organisations and enterprises who share a common field of knowleged and interest regarding innovation in acertain domain in this case the construction industry (Malerba, 1999) .

Brown, (1981) and Rogers, (1995) concur on the view that adoption of an innovation and its diffusion is accomplished through human interactions and communication between members of a social system of practice. Slaughter (1998) presents a multifaceted approach towards innovation and its adoption that suite the construction industry modeled under Market pull, Technology push and Complex Product Systems concepts. Through these concepts, Brown (1981) discerns that Rogers (1995) is biased towards the adopters of innovation, or the demand side of innovation in effect ignoring influence of factors from the innovation developers and promoters, which constitute the supply side of innovation. In this perspective, (Rogers, 1995) theory appear to be relevant only to Market pull (client driven) innovations which may be least applicable to technological innovations as these types of innovation are subjected to more consideration and influenced by external factors.

If the construction industry is viewed as asocial network, or system, interactions within and without bring to the fore other contextual factors that affect the rate of adoption and diffusion of innovation. For example, Blayse and Manley, (2004) points out the fragmented and one-off nature of construction projects, clients and manufacturers, the structure of production, relationships between individuals and firms within the industry, relations between the industry and external parties, procurement systems, regulations or standards, and the nature and quality of organizational resources as major determinant factors that influence innovation and its adoption in the construction industry. Through the analysis of the industry characteristics and the unique features of construction products other studies have other variables that that influence the diffusion process which include: Industry characteristics (cyclical market; industry fragmentation), building codes; regulation and firm size, (Blackley & Shepard, 1996); cyclical market

(Winnch, 1998);Public policy (rules and regulation) and relative advantages of innovation (Seaden & Manseau, 2001); Traditional procurement practice, (Ling, 2003); building codes Koebel *et al* (2004). Bwisa & Gacuhi (1999) at the local setting further relates other deficiencies that impact on innovation and its adoption as absence of technical and economic feasibility studies on innovations, lack of market analysis to assess the product or process potential, unwillingness of the users of technologies to take risks on unproven technology, lack of adequate financing mechanisms, and lack of capabilities by research institutes to transfer complete research results as a package acceptable to the users.

2.7.5 Change agent and adoption

A change agent is an individual who influences innovation-decisions in a direction deemed desirable by the individual/organization driving the innovation (Rogers, 1995). In the construction industry this could be a client, manufacturer, policy maker or consultant. The relationship between rate of adoption and change agent efforts is not direct and linear (Rogers, 1995). The success of change agent efforts is related to a number of factors including: the extent of change agent effort in contacting adopters, timing of adopter contact, having close relationship and credibility with adopter. One factor in change agent success is the amount of effort spent in communication with adopters. In terms of actors, construction clients are perceived as having the greatest influence on innovativeness (Hampson, 2005) .

2.8 Theoretical framework

The early theory of technological innovation assumed a linear model suggesting that technological innovation starts with basic research, continues through applied research and then enters the development phase (Godin, 2013) This has been replaced by more interactive models of technology push, market pull and Complex Product Systems as amplified by Slaughter (1998) .The logic behind Market pull is that technology diffusion is guided by the demand from the potential users. The Market pull school of thought suggests that firms perceive profit opportunities in the market and it is with this perspective that technology is developed and adopted. Marketing plays the leadership role: and Research and Development responds with appropriate technologies (Tangkar & Arditi, 2000).

The technology push school of thought is rooted in Schumpeter's ideas, and places the major role of innovation creation on technology. In this perspective, new technologies are created through technical knowledge and, if necessary, consumer needs, awareness, and interests are developed along with new products (Tangkar & Arditi, 2000). Technology push therefore requires a clear in depth understanding of the market and the consumer tastes and preferences and therefore dependent on consistent contact with the market and feedback.

To be truly competitive the producer or supplier of the technology needs to be able to demonstrate to the market the benefits of the new product. This puts into focus the actor network theory (Crawford, 2004) . The theory emphasizes the roles that both human actors and non-human agents play in the performance and outcomes of interactions. The actor network theory analyses situations in which the actors have variable forms and competencies (Tangkar & Arditi, 2000). Actor network theory is a theoretical frame for exploring collective sociotechnical processes and therefore applicable in the construction industry. This sociotechnical processes include diffusion and adoption of construction innovations.

Popular models of diffusion (aggregate adoption) were developed by Everest Rogers 1962, Frank Bass 1969 and Lawrence Brown in 1981. The Bass model is a very useful tool for forecasting the adoption (first purchase) of an innovation (more generally, a new product) for which no closely competing alternatives exist in the marketplace Lilien et al (2007). A key feature of the model is that it embeds a "contagion process" to characterize the spread of word of mouth between those who have adopted the innovation and those who have not yet adopted the innovation. Brown (1981) model of diffusion is intended for diffusion of technological innovation among firms. It differs from the diffusion of consumer innovation and focuses on communication and information flow process where the diffusion of technological innovation is viewed from the perspective of the adoption behavior of the firms using the innovation (Songip et al (2013). Brown (1981) thus examined the actual usage of innovation in contrast with Rogers's framework in which the perceived innovation attributes are emphasized. According to Brown (1981), the adoption decision is influenced by four main factors: characteristics of the innovation, industry characteristics, institutional effects, and firm characteristics. Rogers' diffusion theory is one of the widely used theoretical frameworks in the study of complex phenomena . In 1962 Everett Rogers, published his seminal work on Diffusion of Innovations from over 508 diffusion studies from which four major sub theories that guide the concept of diffusion of innovation (Rogers, 1995) emerged: The innovation decision process theory, the individual innovativeness theory, theory of Perceived Attributes and Theory of Rate of Adoption. The application Adoption theory to innovation in this study is useful for examining how innovators can apply it to increase the adoption of innovations. The adoption rate theory seeks to explain how the use of new innovative technologies, spreads through a social system, and why they are adopted over old methods. Rate of adoption is 'the relative speed with which an innovation is adopted by members of a social system' (Rogers, 1995), measured as the number of individuals who adopt a new idea in a specified period. It is a numerical indicator of the steepness of the adoption curve for an innovation.

2.9 Conceptual framework

The proposed conceptual model for adoption of innovative construction technologies is modeled on theoretical perspectives put forward in the innovation theory, the actor network theory and rate of adoption theory. The logic behind the demand approach is that technology diffusion is guided by the demand from the potential users while the supply side provides the availability of technology for its adoption and diffusion. *Demand* by the adopters is based on the attributes of the innovation and this makes Rogers's framework significant in understanding why innovative technologies will be adopted by potential users. However, this study focused on the technology supply side of innovation which makes Browns approach equally relevant as it focuses on both factors relating to the characteristics of innovation on one hand and industry, institution and adopting firms on the other hand. In this respect, the responsibility to adopt is shifted from the adopters to the innovation developers.

The variables in the study were derived from Brown and Rogers's perspective with rate of adoption of innovative technologies as the dependent variable. The Measure of adoption was set to indicate extent of new technology utilization by individuals. This dependent variable was depicted through the exploration of set of cases of innovative construction technologies in the Kenyan construction industry; derived from case selection for elements in a typical building ranging from the substructure, superstructure, roof and services which comprise Fibre mesh, EPS panels, stone coated roofing tiles, solar water heating, solar lighting, gypsum products, plastic products and MDF products. The independent variables were deduced from the literature review modeled under Rogers and Browns frameworks and grouped under *Information flow; Firms' Innovative culture, ; Innovation attributes* (Relative advantage, compatibility, complexity); *Industry characteristics* (Fragmentation, the structure of production, relationships, Procurement systems, Cyclic market ,technologies risks, Communication channels, Uncertainty, Innovation decision) ; *Change agent* ; and *Institutional effects* (Regulations and laws, approval systems, financing mechanisms, Building codes).

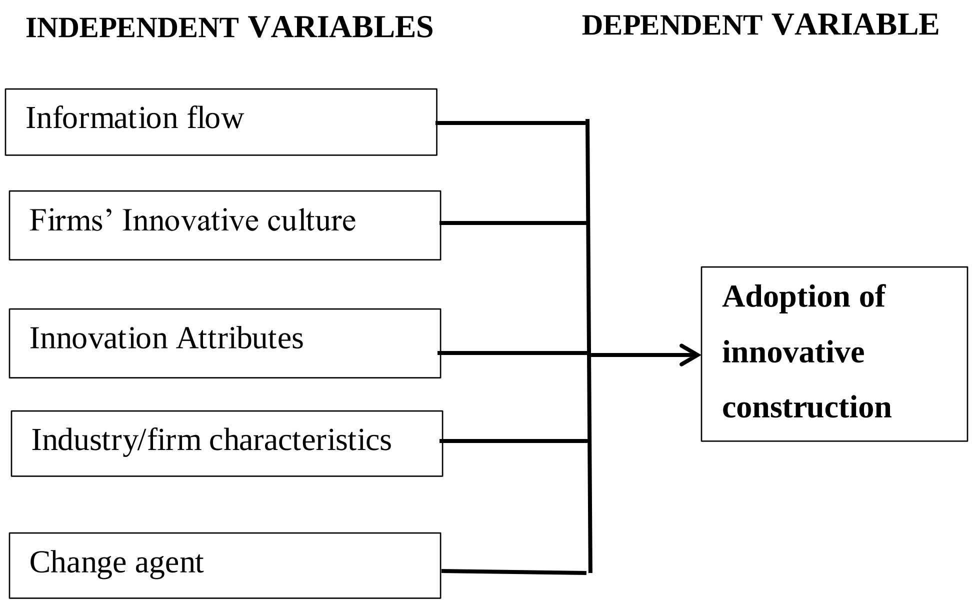


Figure 2.3: Conceptual framework

Source Author

Consistent with the study objective, the framework focused on the extent of adoption as the dependent variable. Essentially, it was theorized that the interaction among factors Information flow, Firms' Innovative Culture, Innovation Attributes, Industry Characteristics and Change agent initiated the adoption process. The extent of adoption (measured as number of adoptions by firms) was caused by the forces of technology push and demand pull created by their interaction. Moderating factors of Environmental factors were theorized to influence the diffusion process much later, resulting in significant changes.

2.10 Summary

This chapter discussed innovation, technology and adoption concepts in particular their application in the construction industry. Construction Industry System and how they affect Innovation Adoption trends were highlighted. This chapter provided information about available trends and innovative technologies within the construction industry for adoption. The comparison between different combinations of materials was limited to few criteria in relation to their attributes. Indeed, the assessment of the appropriateness of any building technology should not, by any means, be limited to these criteria only. Nevertheless, the nature of this study required limiting the scope of the study. Any other evaluation criteria were beyond the scope of the subject research. Factors affecting the adoption of innovations were identified and reviewed along theoretical grounding for each concept. The overrating variables were identified and there after conceptualized. The current Chapter dwelt on the literature review on the factors that affect adoption of innovations.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This section provides the conceptual structure within which this study was conducted and includes ways of obtaining, organizing and analyzing data. This chapter discusses research design, sample design, data collection, processing and analysis. It further addresses the reliability and validity of the research instrument; and ethical considerations pertaining to the study.

3.2 Research Strategy and design

The quantitative approach was adopted in this study. This study involved identification of attributes of a particular phenomenon and therefore the survey design was adopted (basic research method that examines the situation, as it exists in its current state). The survey was cross-sectional where by data was collected at one point in time. The advantages of this design include economy and the rapid turnaround in data (Creswell, 2003).

3.3 Sample Design

The population in this study was obtained from a list of registration and accredited institutions for the respective consultants' and Contractors' firms. The choice of the population was based on the fact that these actors play a major role in the initial conceptualization of construction projects and on a large extent influence the specification of quality of materials and workmanship in construction projects. The target population was obtained from register of firms for Architects, Quantity Surveyors, Structural, Electrical Engineering and Mechanical Engineering from the respective bodies governing their registration; and List of National Construction Authority Class 1 building Contractors and Services Sub-Contractors registered with the national Construction Authority.

3.3.1 Sampling Technique

Probability sampling was adopted in this study owing to the fact that it eliminates the danger of researchers biasing the selection process because of their own opinions or desires. For economic purpose, time constrains and ease of access, this study considered firms with Physical location within the Nairobi County. The sampling frame for Architects and Quantity Surveyors was obtained from the Board of registration of Architects and Quantity Surveyors (BORAQS's). According to the records, retrieved on 31st August 2015, there were 121 registered Architectural firms and 108 registered Quantity Surveyors firms within Nairobi County. The sampling frame for Structural, Electrical and mechanical Engineers was obtained from the data base containing a list of members of the Engineers Registration Board of Kenya (ERB) retrieved on 31st October 2015. According to the register, there were 35 Structural Engineering firms and 26 Mechanical and Electrical Engineering firms based in Nairobi. Table 3 shows the total population for consultants in Nairobi.

Table 1.1: Total population for consultants firms in Nairobi

Category	**Population**
Architects	121
Quantity Surveyors	106
Structural Engineers	35
Mechanical and electrical Engineers	26
Total	**288**

Source Author 2015

The sampling frame for contractors was obtained from the National Construction Authority data base containing a list of registered contractors. According to the records, retrieved on 31st October 2015, there were 14,443 contractors with NCA within Nairobi County. For economic purpose and time constrains, this study considered category 1 (NCA 1) contractors for building, mechanical and electrical services. Table 4 shows the total population for NC1 contractors in Nairobi.

Table 3.2: Total Population for NC1 Contractors in Nairobi

Class	**Population**
Building contractors	206
Mechanical Sub contractors	55
Electrical Sub contractors	103
Total	**364**

Source Author 2015

3.3.2 Consultants Sample size

A sample can be defined as a small proportion of a population selected for observation and analysis (Haber et al, 1998). Bryman (2012) indicates that, in any research, a researcher should develop a sampling technique that will give a representative sample of the population. The sample size can be calculated through the following equation for 95% confidence level:

According to Assaf et al (2001),

Sample size, $n = n'/ [1+ (n'/N)]$

Equation 1

Where:

N = Total number of population

n' = Sample size from infinite population = S2/V2; where S2 is the variance of the population elements and

V = Standard error of sampling population. (Usually S = 0.5 and V = 0.05)

Table 5 below shows a summary of proportionate samples for each stratum of consultants

Table 3.3: Proportionate sample for Consultants

Class	Population (N)	Proportionate sample *(ps)* =*N* x *sf*
Architects	121	31
Quantity Surveyors	106	27
Structural Engineers	35	9
Mechanical and electrical Engineers	26	7
Total	**288**	**74**

n= 74 N= 288 s f= 0.26

Source Author 2015

3.3.3 Contractors Sample size

The population was stratified first into categories from NCA category1 to NCA category 8. This study focused on NCA category 1 building works, mechanical engineering and electrical engineering contractors within Nairobi County. There were 628 NCA 1 contractors within Nairobi County (206 building works, 55 mechanicals, 103 electrical and 264 others). Thus, for 364 NCA 1 building works, mechanical engineering and electrical engineering contractors within Nairobi County. Table 6 below shows a summary of proportionate samples for each stratum of contractors.

Table 3.4: Proportionate sample for Contractors

Class	**Population (N)**	**Proportionate sample *(ps3 89) =N* x *sf***
Building contractors	206	44
Mechanical Sub contractors	55	12
Electrical Sub contractors	103	22
Total	**364**	**78**

n= 78 N= 364 s f= 0.21

Source: Author 2015

3.4 Data collection

Fink, (2002) identifies four forms of data collection; self-administered questionnaires, interviews, structured record reviews and structured observation. This study involved collection of both primary and secondary data and therefore two forms of data collection were employed. Structured record reviews were used to obtain data from secondary sources that include government records, private firms, periodicals, journals books and previous research findings. Primary data was obtained through structured questionnaires. A five-point Likert scale (Kothari, 2003) was used. Testing of the questionnaire was carried out to ensure that the questions were well understood by industry respondents.

Table 3.5: Summary of Data Collection Methods

NO	Objective	Method	Type of data	Source of information
01	• To evaluate innovative technologies available for the construction industry in Nairobi County.	• Questionnaires	• Statistical data on case innovative construction technologies • To examine the levels of adoption of innovative construction technologies in Nairobi over the last ten years	• Architects, Engineers and Quantity Surveyors • Specific manufacturers/ leading local dealers of the innovations
02	• To examine innovation adoption trends by firms in the construction industry within Nairobi County	• Questionnaires	• Prevailing viewpoints and perceptions on firm's trends innovation and its adoption	• Specific manufacturers/ leading local dealers of the innovations
03	• To describe factors that influencing the extent of adoption and diffusion of innovative construction technologies	• Questionnaires	• Hindrances to uptake of innovative construction technologies and their level of influence.	• Architects, Engineers and Quantity Surveyors • Contractors

Source: Author 2015

3.5 Data Processing and Analysis

This included, coding classification and tabulation of collected data. Coding entails the process of assigning some symbols to the answers so that the responses can be recorded into a limited number of classes or categories. Data classification involved the arranging of data in groups or classes on the basis of some characteristics. Data analysis was carried out using a computer program (SPSS).

3.6 Research validation

This section presents the principles that were used to judge the quality of the research and to ensure valid propositions, inferences and conclusions. The major issues of quality include reliability and validity and ethical considerations.

3.6.1 Reliability

In the survey, the Cronbach's alpha was employed as an estimator of reliability as it is the most widely used in research. Based upon the formula,

Cronbach's alpha coefficient $\boldsymbol{\alpha} = rk / [1 + (k - 1) r]$:

Equation 2

Where k is the number of items considered and r is the mean of the inter-item correlations

Twenty-one items were used in this test and the results obtained from SPSS analysis scales summarized in table 8.

Table 3.6: Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.710	0.878	21

Source: Author (2015)

3.6.2 Validity

Validity refers to the extent to which a measure, indicator or method of data collection possesses the quality of being sound or true as far as can be judged. Categories of validity include content validity, conclusion validity, external and internal validity. This study focused on content validity, which refers to the accuracy with which an instrument measures the factors under study. Content validity was concerned with how accurately the questions asked tended to elicit the information sought. The research instrument was tested for content validity through a pilot study.

3.6.3 Ethical Considerations

Ethical Considerations can be specified as one of the most important parts of the research. Ethical considerations by Bryman & Bell (2007) were used a guideline to ensure professionalism. In this study, permission to carry out the study was obtained the board of postgraduate studies of the Jomo Kenyatta University of Agriculture and Technology. A permit was obtained from the National Commission for Science technology and innovation. This provided a basis for informed consent by the participants. Adequate level of confidentiality and anonymity of individuals and organizations participating in the research was maintained throughout the survey.

3.7 Chapter Summary

This section described the methodology used to carry out the study the study on the factors affecting the adoption of technological innovation in selected organizations in Nairobi. It started with a brief introduction highlighting the general methodology and structure of the chapter. The chapter also highlighted the method that was used to conduct the research and its use justified. The target population, sampling technique, technique and sample size were defined and described. Finally, the data collection techniques that were used and research procedures have been discussed including measures taken to ensure validity in relation to reliability, validity and ethical considerations. The output data will be presented in tables and charts. The following section presents Chapter Four which concentrates on presenting the results and findings of the data collected through the questionnaires.

CHAPTER FOUR

DATA ANALYSIS, INTERPRETATION AND DISCUSSION

4.1 Introduction

Chapter Three presented a systematic way of carrying out the study. It gave the research design adopted. It also illustrated the study population, sampling design, data collection method, research procedure and the analysis methods. This chapter presents the study findings in line with the study objectives. Data was collected using a structured questionnaire which were administered both through mail and hand delivery. The collected data was coded and analyzed using Google forms, Microsoft Excel 2010 and the Statistical Package for Social Scientists (SPSS) version 20. The overall response rate for the survey was 80%, for a total of 147 completed questionnaires.

4.2 Profile of Respondents

Figure 4 provides a summary of respondent's profile. Contractors (19%) and Architects (18%) recoded the highest response. Figure 5 indicates that Majority of the respondents (81%) had working experience of between 6 and 20 years an indication that the firms had experienced and knowledgeable respondents. Figure 6 shows majority of the respondents were technical staff at 46% followed by medium level management and supervisory staff at 20% and 19% respectively an indication of their ability to grasp technical issues.

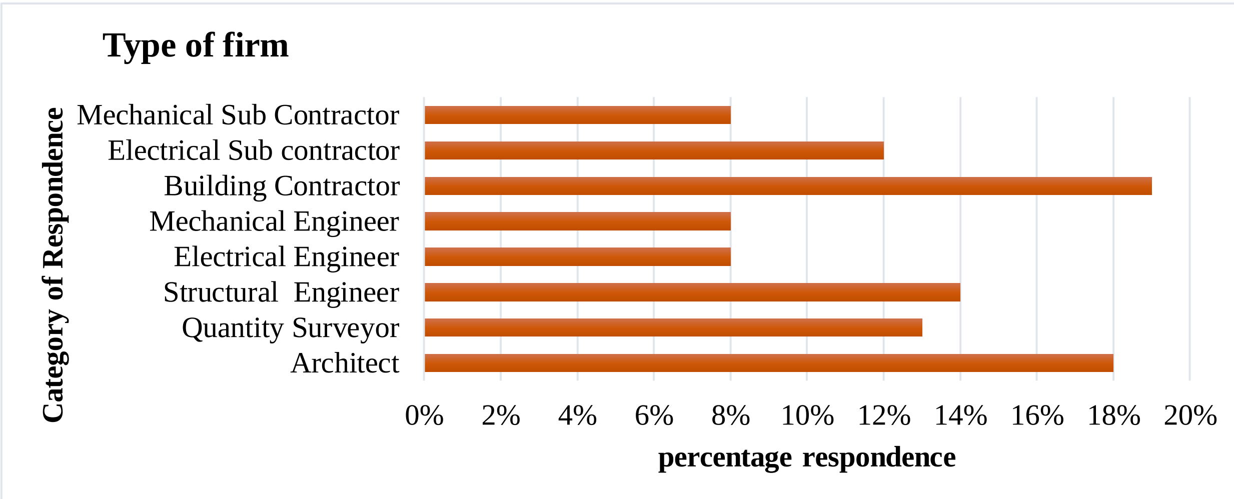


Figure 1.1:Percentage profile of respondents by Firm

Source: Author 2015

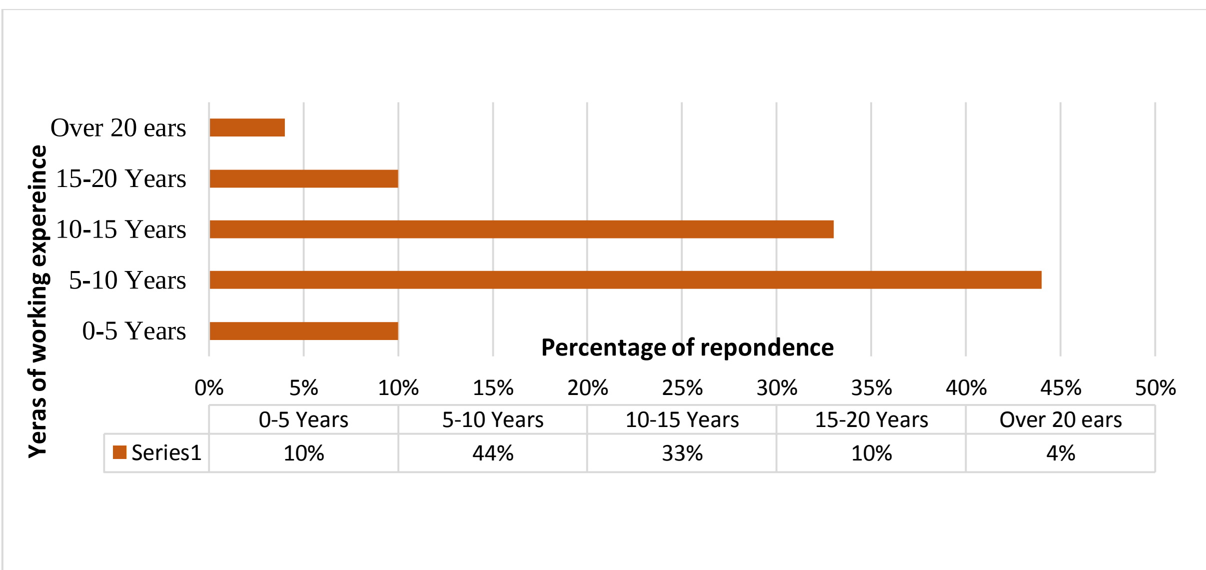


Figure 4.2: Respondents' years of working Experience

Source: Author 2015

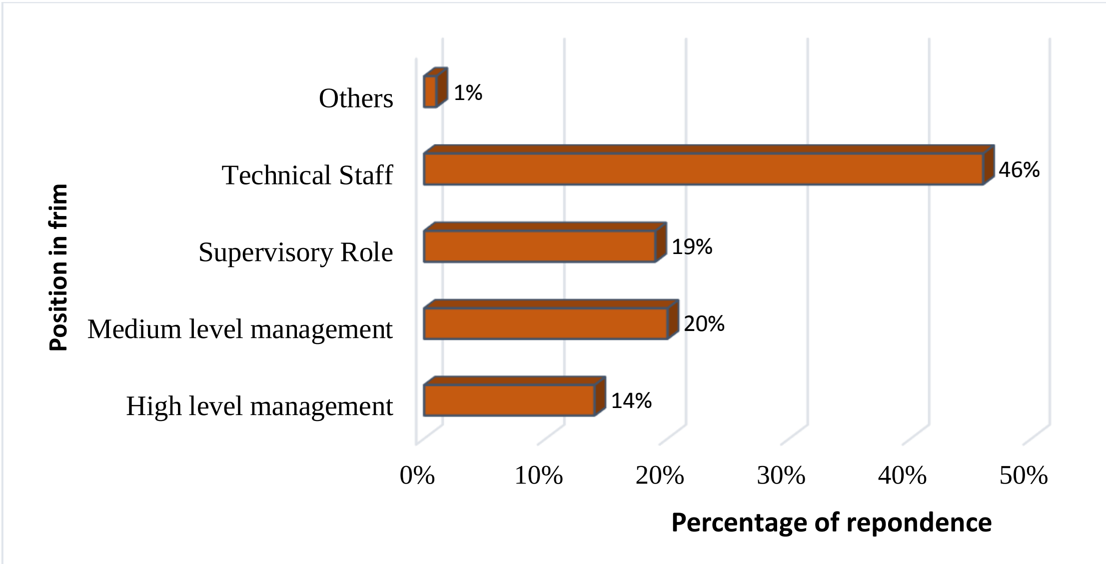


Figure 4.3: Respondents' position in firm

Source: Author 2015

4.2 Evaluation of available innovative construction technologies in Nairobi

The first objective of this study sought to evaluate available innovative construction technologies for the construction industry in Nairobi and establish the extent of incorporation in construction projects. To achieve this, a populated list of innovative construction technologies obtained from the Ministry of Housing data base (R.o.K, 2013) was presented to the respondents. (See table 2.2 for description of the technologies). The respondents were asked to indicate the number of projects in which they had incorporated each of the innovations. The respondents were also asked to indicate the prevalent attributes that could likely have influenced the incorporation of the technologies in construction projects.

4.2.1 Incorporation of Innovative Construction Technologies in projects

The diffusion of innovations through adoption behavior is essential to the maximization of benefits flowing from original innovation. The respondents were asked to indicate the number of projects in which they had incorporated each of the innovations. Figure 7 below provides a summary of the response. The table shows the highest level of incorporation for most innovations was in the range of 1-10 projects. The least incorporated were concrete waffles, EPS panels and interlocking stabilized soils blocks. 50% of the innovations had been incorporated in more than 30 projects with gypsum board recording the highest adoption. In this study, technologies had the least incorporation into projects were viewed as having the lowest level of adoption. The findings showed that 53%, 87%, 77%, 74%, 75%, 72% and 88% of the respondents had never incorporated Fibre mesh, interlocking stabilized soil blocks, expanded polystyrene panels (EPS), Precast Concrete Panels, New build Construction Technology and Concrete Waffles respectively in projects; an indication of low levels of adoption of home grown innovations. Of all the technologies surveyed, Light steel frame, Plastics products (e.g. ceiling, skirting, cornice), Laminate flooring boards, Gypsum board, PPR plumbing pipes, Bio-digester on site Sewer System, Concrete and Solar water heating had the highest percentage of use at over 75%. The results were indicative of an increase in adoption of plastic products and renewable energy.

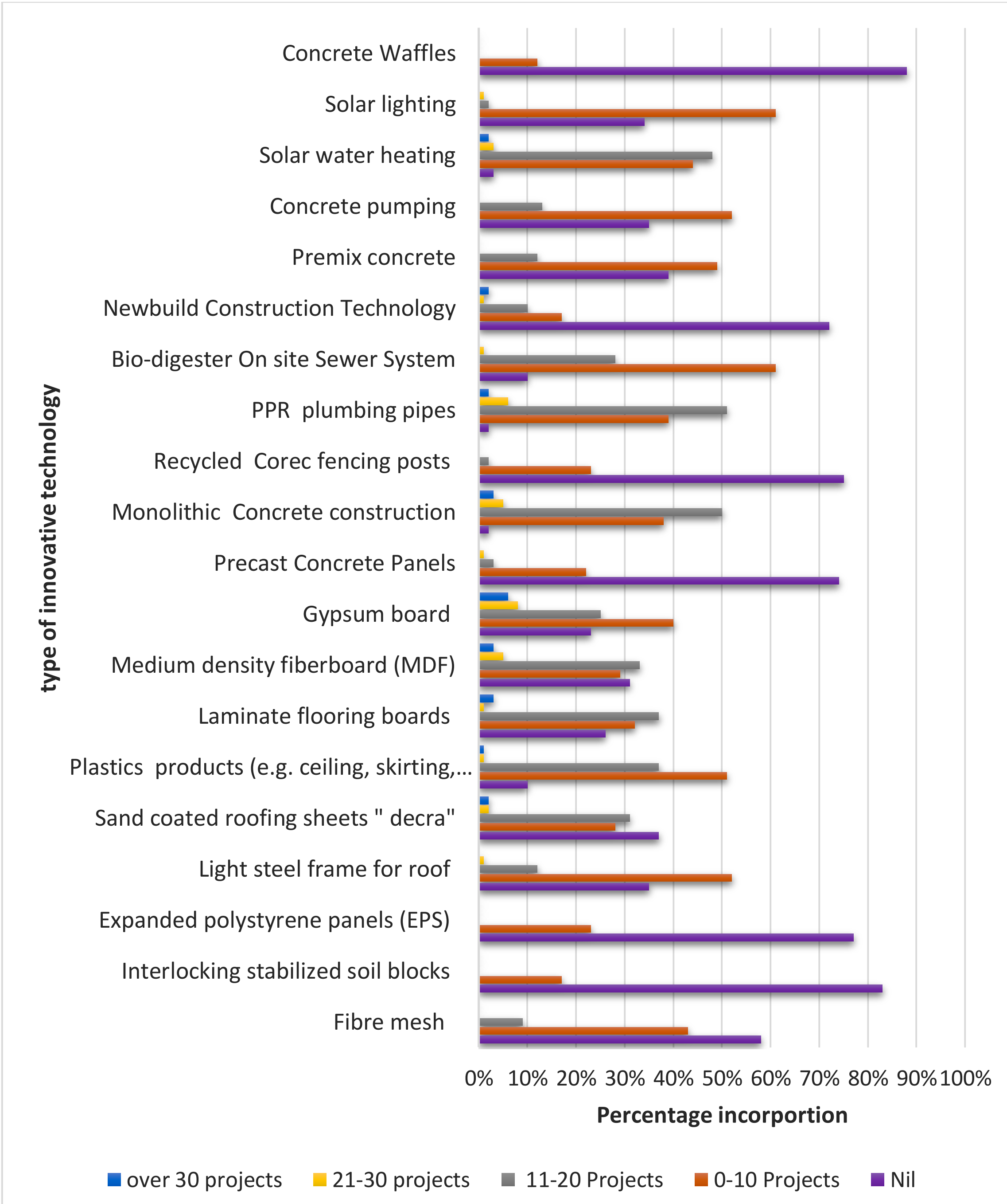


Figure 4.4: Incorporation of innovative construction technologies in projects

Source Author 2005

4.2.2 Attributes that influence adoption case of Innovative construction technologies

A list of 20 innovative construction technologies was presented to respondents against attributes that influence their adoption over traditional technologies. Respondents were asked to rate the attribute that were most significant for each of the innovative construction technologies. Figure 8 and Figure 9 below presents a summary of the results. Majority of the respondents indicated relative advantage as the major attribute that influenced the use of the selected technologies. MDF, Light steel frame for roof, Gypsum board Bio-digester solar water heating and lighting were noted to have the highest rating of relative advantage over traditional technologies. However, although fibre mesh and stabilized soil blocks recorded high levels of relative advantage, they depicted low levels of adoption.

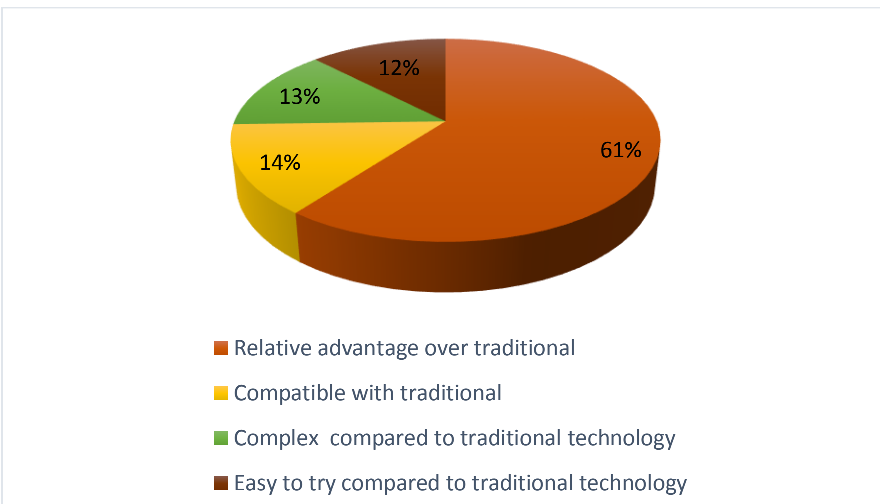


Figure 4.5: Prevalence of attributes of innovation

Source Author 2015

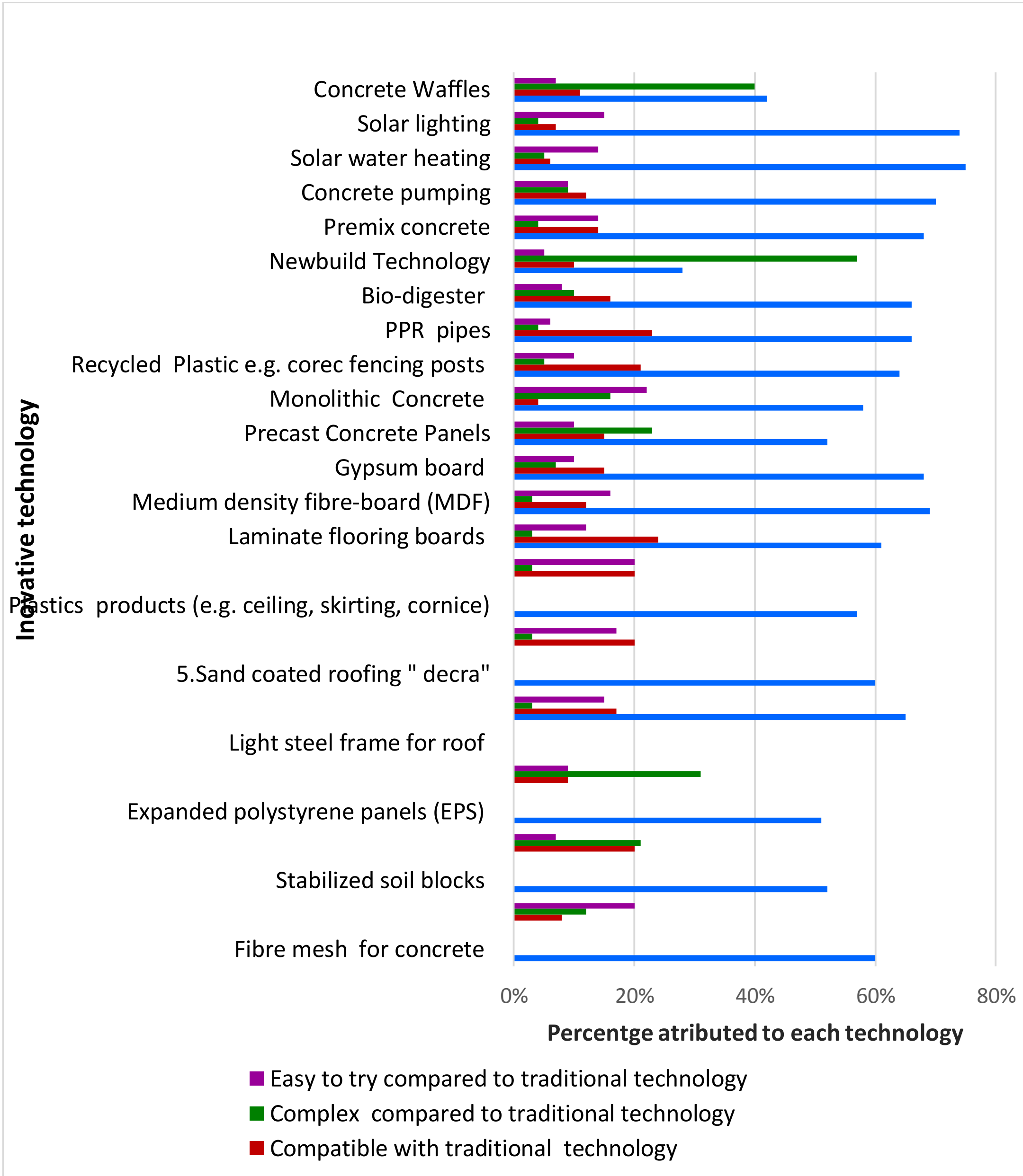


Figure 4.6: Prevalent Attributes of Innovation applicable to case innovative technologies

Source Author 2015

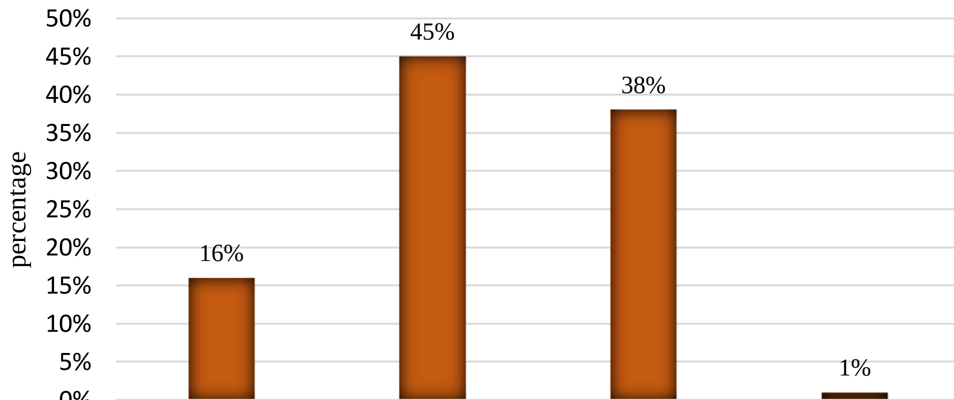
4.3 Innovation adoption trends by key players in the construction Industry

The second objective of this study was to examine the adoption trends by key players in the construction Industry. The study sort to establish the firms' culture in tracking innovative construction Technologies and their approach towards adoption of innovative construction technologies.

4.3.1 Culture in tracking innovative construction technologies

To establish firms' trends in tracking information on innovative construction technologies, a combination of self-evaluation criteria was set to measure the firms' culture. Respondents were asked to indicate the amount of time their firms spend on tracking changes and innovative trends in the marketplace. Figure 10 shows the summary of response in which 45% of the respondents indicated to have spent minimal time whereas 38% spent average time and only 16% spent lengthy time tracking changes and innovative trends in the construction marketplace. These results show key players of the construction industry in general are slow in tracking changes in the market place which in effect undermines the decision to adopt innovations. This results are consistent with Empirical studies conducted by Reichstein et al, (2005) which found out that construction firms in the UK were less open to the external environment and they tended to have poorly developed research and development (R&D), with low capacity to absorb ideas from external sources.

An innovative firm must be able to effectively evaluate information on innovation (through awareness), adopt and diffuse technologies over its entire life. In Rogers and Shoemaker, (1971) model, access to information is a principal determinant of the adoption decision, which is sequenced by awareness, Interest, Evaluation, trial and eventual adoption. Although this model tends to focus on the role of different information and communication channels, Neely, (2001) suggests that one of the major factors that indicate a firms innovativeness is its capacity to integrate information from diverse sources and collaboration. A study on technology adoption by Mitropoulos and Tatum, (1999) highlighted a number of factors affecting the adoption of innovation among them the firm's culture and attitudes towards new technology. From this perspective, it can be argued that adoption is related to the strategic approach of firms in particular, their level of awareness and enthusiasm towards changes within their industry. Studies examining innovation processes in design and construction practice identify the use of use of digital tools or products such as building information modelling (BIM) as important for sharing knowledge in project based firms (Whyte & Lobo, 2010)



	Lengthy	Minimal	Average	Sporadic
Percent	16%	45%	38%	1%

Figure 4.7: Innovative culture in tracking information on trends

Source Author 2015

4.3.2 Approach towards adoption of innovative construction Technologies

When asked about their approach towards innovativeness, 39% of the respondents conformed to specifying technologies that meet minimum standards whereas 20 %

encouraged their clients to stick to tried products (Figure 10). 19% of respondents waited for other institutions to specify or use innovations before they adopted. This depicts the industry's tendency to stick to traditional construction technologies. According to Rogers (2003) whereas innovators are willing to experience new ideas and are prepared to cope with a certain level of uncertainty about the new innovation, Laggards have the traditional view and they are more skeptical about innovations. Because of lack of awareness on new innovations, they first want to make sure that an innovation works before they adopt. Thus, laggards will take a decision to adopt after examining the level of successfully adopted by other members of the social system in the past. According to Nam & and Tatum (1997) the construction industry is known for conservatism with professionals clinging to an accepted industry practice and norms in fulfilling client's need and changes are taken as a threat. These views are consistent with results of the study that depicted 69% of the respondents unwilling to face uncertainties. The focus on short-term costs and time constraints in the building project is frequently argued to create incentives to avoid risk associated with innovative technologies and preferences for proven or tried and tested materials and techniques technology ((Nam & Tatum, 1988; Blayse & karen, 2004; Reichstein, Salter, & Gann, 2005; Kadefors, 1995; Nam & Tatum, 1988).

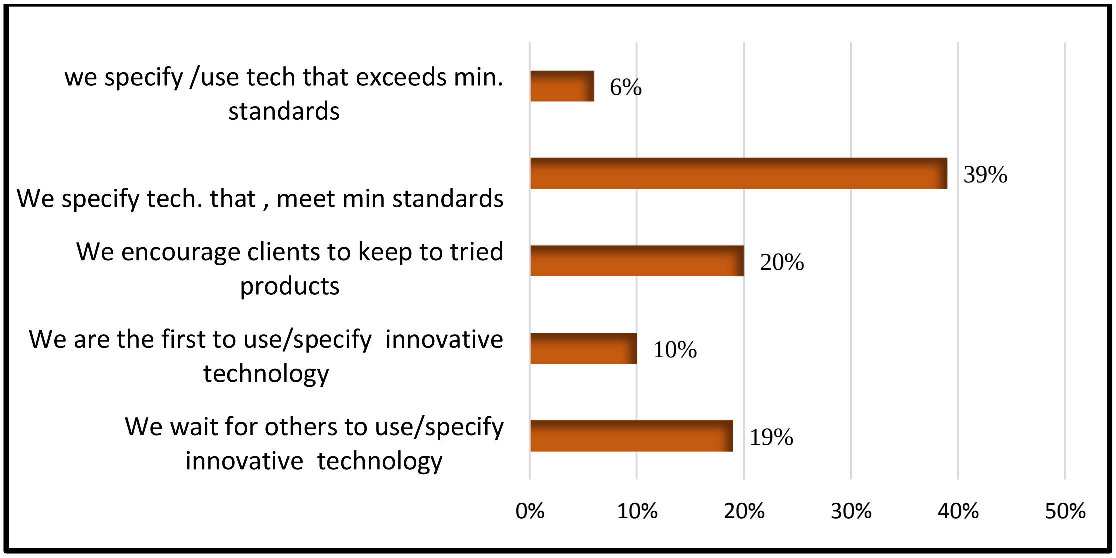


Figure 4.8: Firms approach towards Innovation

Source Author 2015

4.4 Factors that influence the incorporation of innovative construction technologies

The third objective of his study sort to describe factors that significantly influenced the adoption of innovative technologies. This was achieved by first, analyzing possible hindrances towards adoption and thereafter identifying actors in the industry with significant influence on adoption.

4.4.1 Hindrances to adoption of innovative construction technologies

Respondents were asked whether or not a number of factors were hindrances to adoption of innovative construction technologies. A set of statements concerning factors that influence the adoption of innovative construction technologies were presented to the respondents. Respondents were asked to rate on a five Likert scale whether they strongly agreed or disagreed with the statements. Figure 12 presents a summary of the results. Up to 79% of the respondents strongly agreed or agreed with the statements with a paltry 3 % dissent. 62 % of the respondents reported the lack of integration within the industry as a major setback towards adoption of innovative technologies. Lack of adequate information on innovations and procurement systems were equally noted as major influence on adoption of innovative construction technology. 49% of the respondents strongly perceived that building codes having the greatest negative influence on adoption of innovative technologies. The results were consistent with views by Blackley & Shepard (1996), Koebel et al (2004) and (Ling, 2003) on fragmentation, Building codes and Traditional procurement practice respectively.

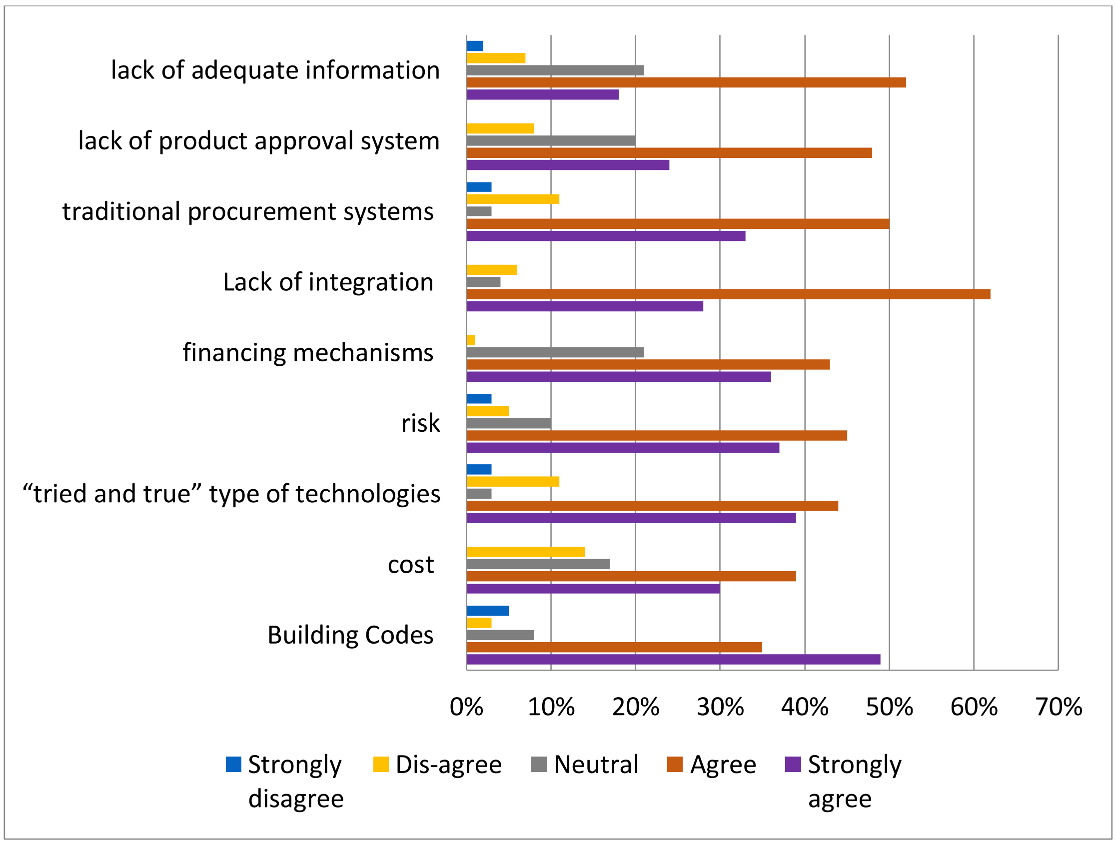


Figure 4.9: Factors that influence the adoption of innovative construction technologies

Source Author 2015

4.4.2 Influential source of information on innovative construction technologies

The choice to adopt a new technology requires knowledge that it exists and some information about its suitability to the potential adopter's situation. An important determinant of diffusion is information about the innovative technology. Respondents were therefore asked to rate their sources of information on Innovative construction technologies on a Likert scale from least influential to most influential Source. Figure 13 provides the percentage rating of each source of information. The study found out that Developers, Architects and Suppliers of technologies were rated as the most influential source at 48%, 59% and 45% respectively. According to Reichstein et al. (2005) suppliers, customers, industry groups, specialized organizations and technical standards are common sources of knowledge for innovation in project based firms. Project Manager, Quantity Surveyor Engineers and Contractor were perceived as influential sources. Learning institutions and Government were the least influential.

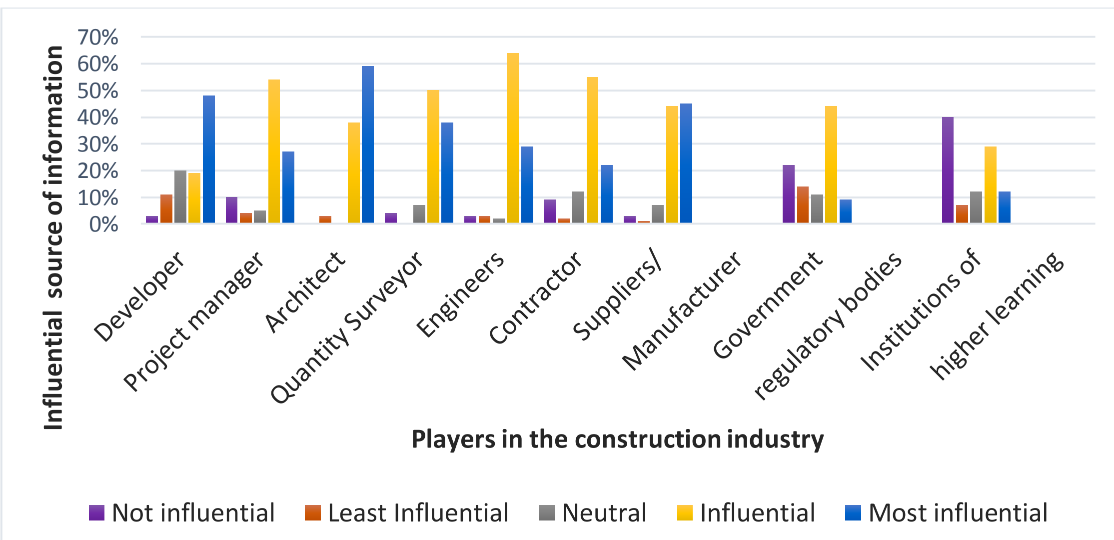


Figure 4.10: Sources of information on innovative construction technologies

Source Author 2015

4.4.3 Influence on decision to adopt innovative construction technologies.

The results in Figure 14 summarize perceptions by the respondents on actors with significant influence on decision to incorporated innovative construction technologies in projects. Construction developers were perceived as having the greatest influence (67%) on decision to incorporate innovative construction technologies in projects. These findings confirm the idea of construction clients as potential change agents and drivers of innovation in the built environment by Brandon & Ling, (2008) and Vennstrom (2008) . This is an indication that an effective innovation program for construction firms should focus, where possible, on cultivating deeper and broader relationships clients or developers. Architects at 63% were also perceived as having a large influence on decision to incorporate innovations in projects. The influence of suppliers on decision to incorporate innovations in projects was rated higher at 52% compared to that of the contractors at 42% and interpretation that respondents recognized the potential of suppliers to provide innovative solutions. These results are consistent with views by Blayse and Manley (2004) that Construction clients and suppliers are identified as key actors in driving the adoption of innovations in the construction sector. Learning institutions were rated the least influential. This may be attributed to the fact that the institutions are not directly involved in project implementation but play a major role in research.

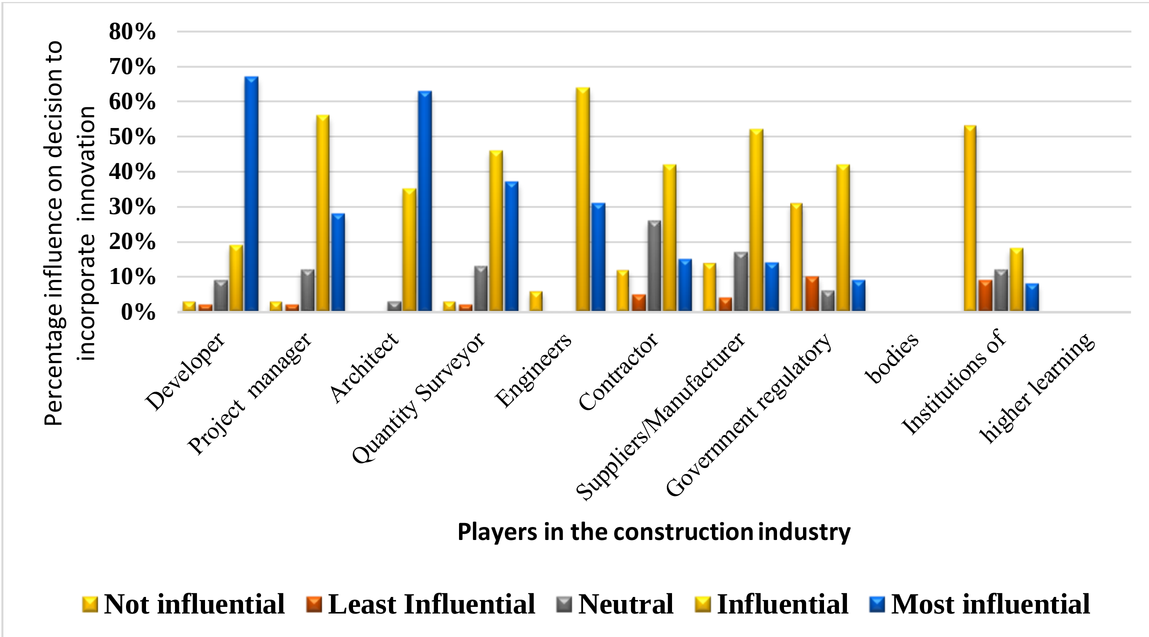


Figure 4.11: Influence on decision adopt innovative construction technologies

Source Author 2015

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the research work undertaken, and on the basis of the study findings draws conclusions about the study's aim and objectives; and makes recommendations.

5.2 Summary of findings

Below is a summary of findings in line with objectives of the study:

5.2.1 Level of adoption of Innovative Construction Technologies

The first objective of this study sought to establish the extent to which selected innovative construction technologies had been incorporated in construction projects. 50% of the innovations had been incorporated in more than 30 projects with gypsum board recording the highest adoption. The findings revealed low levels of adoption of home grown innovations. Of all the technologies surveyed, Light steel frame, Plastics products (e.g. ceiling, skirting, cornice), Laminate flooring boards, Gypsum board, PPR plumbing pipes, Bio-digester on site Sewer System, Concrete and Solar water heating had the highest percentage of use at over 75%. Majority of the respondents indicated relative advantage as the major attribute that influenced the use of the selected technologies.

5.2.2 Innovation adoption trend by key players in the construction Industry

The second objective of this study was to explore innovation adoption trends by key players in the construction Industry. To achieve this, the study sort to establish firms' culture in tracking innovative construction technologies and their approach towards adoption of innovative construction technologies.

In relation to Culture in tracking innovative construction technologies, the study revealed that only 16% of players spent lengthy time in tracking changes and information on innovative trends in the construction marketplace. These results showed that 38% of key players within the industry are slow in tracking changes in the market place with low levels of awareness and enthusiasm towards changes within their industry which in effect undermines the decision to adopt innovations.

On player's approaches towards adoption of innovative construction technologies, the study found out low levels of innovativeness (10 %). Majority of respondents lagged behind in innovation and its adoption by specifying technologies that meet minimum standards (39%), encouraged their clients to stick to tried products whereas (20 %) and waiting for other institutions to specify or use innovations before they adopted (19%). This depicts the industry's tendency to stick to traditional construction technologies and unwillingness to face uncertainties in effect negatively affection innovation and its adoption.

5.2.3 Factors that influence the incorporation of innovative construction technologies

The third objective of this study sort to identify factors that significantly influenced the adoption of innovative technologies. This was achieved by first analyzing possible hindrances towards adoption and thereafter identify actors in the industry with significant influence as a source of information on innovations and decision to adopt or incorporate innovations in projects.

The study found out that lack of integration (62%) within the industry as a major hindrance to adoption of innovative construction technologies. Lack of adequate information on innovations (52%) and traditional procurement systems (50%) were equally noted as major influences on adoption of innovative construction technology. 49% of the respondents strongly perceived that building codes had the greatest influence on adoption of innovative technologies.

The study found out that Architects (59%), Developers (48%) and Suppliers of technologies (45%) were rated as the most influential sources of information on innovative construction whereas learning institutions and Government were the least influential sources.

The study further revealed that Construction developers were perceived as having the greatest influence (67%) on decision to incorporate innovative construction technologies in projects followed by Architects at 63%. The influence of suppliers on decision to incorporate innovations in projects was rated higher at 52% compared to that of the contractors at 42% an interpretation that respondents recognized the potential of suppliers to provide innovative solutions. Learning institutions were rated the least influential. This may be attributed to the fact that the institutions are not directly involved in project implementation but play a major role in research.

5.3 Conclusions

A large and growing body of research shows that construction innovation faces many challenges. Although research on innovation takes different perspectives, the major concern is the successful development and implementation of innovation in the industry. This study investigated factors that influence the rate of adoption if innovative construction technologies. The following conclusions were drawn from the findings of the study.

1. The findings revealed low levels of adoption of home grown innovations.

2. Majority of firms within the industry are slow in tracking trends in construction innovations which in effect leads to low levels of adoption in the industry.
3. Majority of firms were risk averse in adopting new technologies
4. Lack of integration within the industry, lack of adequate information on innovations and traditional procurement systems had negative influences toward adoption of innovative construction technologies.
5. Architects, Developers and Suppliers of technologies were rated as the most influential sources of information on innovative construction technologies.
6. Construction developers, Architects and suppliers were perceived as having the greatest influence on decision to incorporate innovative construction technologies in projects

5.4 Recommendations

Innovative construction technologies have been identified as a viable option to lower pressure on traditional construction technologies within the Kenyan construction industry especially in the light of increasing housing demand. It is this potential that informed this study's primary research aim of identifying factors that significantly influence the adoption of Innovative construction technologies. The study employed quantitative research strategy and descriptive survey research design to achieve its aim. Based on the results of this study in Chapter four and the conclusions drawn from the study, the following recommendations are drawn with the view of enhancing adoption of innovative construction technologies:

Table 5.1: Summary of Recommendations

	Objective	Finding	Section	Recommendation
1	**To evaluate the adoption of innovative construction technologies in Kenya.**	Low levels of adoption of home grown innovations.	**4.2.2** **Fig. 9**	Building codes and legislation in the local construction industry should set stronger demands for the use of innovative technologies in projects E.g. Regulations on solar water heating
2	**To examine innovation adoption trends by firms in the Kenyan construction industry**	Majority (83%) of key players within the industry lag behind in tracking changes and information on innovative technologies.	**4.3.1** **Fig. 8**	Integrate information technologies (IT) with standardized process in design and construction practices for example Building information modelling (BIM). The BIM data base will help in providing handy information to project team about trends in the industry
		Low levels of innovativeness (10 %)	**4.3.2** **Fig10**	Knowledge gained from experience in previous projects and the influence of Architects, Developers and innovation suppliers should be used to help overcome the uncertainties and risk averseness.
3	**To describe factors that significantly influencing the adoption and diffusion of innovative construction technologies.**	**1. Hindrances to adoption of innovative construction technologies** • Lack of integration • Lack of adequate information on innovations • Procurement systems • Building codes	**4.4.1** **Fig. 11**	Actors in the construction industry need to consider life-cycle costs and choose contracts or procurement forms that facilitate increased cooperation between involved actors in order to spur innovativeness Building codes and legislation

				should be updated and aligned to the incorporation of innovative construction technologies in projects
		2. Influential source of information on innovative construction technologies • Developers • Architects	**4.4.2** **Fig. 12**	Simultaneously integrate and share knowledge between projects and from the firm 's institutional environment. Architects, Developers and innovators should be used be involved more in promotional efforts for innovative technologies.
		3. Influence on decision adopt incorporated innovative construction technologies.	**4.2.3** **Fig. 13**	Champions (architects and Developers) and innovative firms should focus on Constantly seeking out and promoting new ideas/knowledge.

5.5 Areas of Further Study

This study explored innovation adoption trends by firms in the Kenyan construction industry; described the adoption of innovative construction technologies; and evaluated factors that significantly influencing the rate of adoption and diffusion of innovative construction technologies. The study further identified various models that attempt to explain the innovation adoption process mainly from academic literature. These include the linear model, technology push, market pull and Complex Product Systems. In the present age, there are high levels of interaction amongst players in the construction industry which makes innovation and its adoption even more complicated as it rarely proceeds in a straight line. There is need for further research to analyze the evolution of these various models and their limitations in order to develop relevant models and tools for measuring innovation in the built environment. There is also need for studies into progressive analysis of the rate of adoption and the factors that influence it in the construction industry; and trends analysis of the rate of adoption for each innovative technology in the construction industry.

In relation to policy and framework, the complex dynamics of fostering innovation adoption aimed at economic growth involves the joint participation, coordination, and articulation of policies that incentivize actors into developing a favorable environment which involves economic stability, respect for intellectual property, public-private partnerships, and trade regulations, among others. Current implementations of innovation policy in developing countries face the challenges of how institutional framework may enhance or inhibit the innovation adoption capabilities. Further studies should focus on how policy and institutional framework strengthens innovation adoption capabilities.

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APPENDICES

Appendix I: Letter of introduction

JOMO KENYATTA UNIVERSITY
OF
AGRICULTURE AND TECHNOLOGY
DEPARTMENT OF CONSTRUCTION MANAGEMENT
P.O. BOX 62000-00200, NAIROBI, KENYA. TEL: (020)-8008485
Fax: (067)-5352711 EXT 2475 Thika. Email: conmgmt@sabs.jkuat.ac.ke

Director General

National Commission for Science, Technology & Innovation

P.O. Box 30623 – 00100

NAIROBI

9th November, 2015

Dear Sir/Madam

REF: AMUHAYA SAGINI NICKSON- AB343-2017/2012

The above named is a bonifide student of Jomo Kenyatta University of Agriculture and Technology pursuing a master's degree in Construction Project Management.

She is currently undertaking a research thesis titled **"Investigating Factors that Influence the Adoption of Innovative Construction Technologies as Case of Nairobi County"**.

Any assistance accorded to her will be highly appreciated.

Yours faithfully.

CONSTRUCTION MANAGEMENT DEPARTMENT CHAIRMAN JKUAT SABS

Dr. A. Alkizim
COD, CONSTRUCTION MANAGEMENT

JKUAT is ISO 9001:2008 & ISO 14001:2004 Certified
Setting trends in higher Education, Research and Innovation

Appendix II: Research Permit

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471, 2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/16/13118/9599**

Date: **4th April, 2016**

Amuhaya Sagini Nickson
Jomo Kenyatta University of Agriculture
And Technology
P.O. Box 62000-00200
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on "***Investigation of factors that influence the rate of adoption of innovative construction technologies in Kenya,***" I am pleased to inform you that you have been authorized to undertake research in **Nairobi County** for a period ending **1st April, 2017.**

You are advised to report to **the County Commissioner and the County Director of Education, Nairobi County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Nairobi County.

The County Director of Education
Nairobi County.

National Commission for Science, Technology and Innovation is ISO 9001: 2008 Certified

Appendix III: Questionnaire

INVESTIGATING FACTORS THAT INFLUENCE THE RATE OF ADOPTION OF INNOVATIVE CONSTRUCTION TECHNOLOGIES IN KENYA

* Required

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY P.O. BOX 62000-00200, NAIROBI, KENYA, TEL: +254-20-08008488, FAX: (67) 52437 SCHOOL OF ARCHITECTURE AND BUILDING SCIENCES DEPARTMENT OF CONSTRUCTION MANAGEMENT

To our esteemed participants,

This research titled, 'Investigating Factors that Influence The Rate Of Adoption Of Innovative Construction Technologies In Buildings In Kenya' is being conducted by Amuhaya Sagini Nickson, a student of Masters of Construction Project Management at Jomo Kenyatta University of Agriculture and Technology (JKUAT).

The main aim of this study is to investigate the factors that influence the rate of adoption of innovative construction technologies in buildings in Kenya, with a view to prepare a framework for enhancing the adoption trends in the construction industry. This survey has been approved by the Board of Postgraduate Studies of JKUAT.

All of the responses in the survey will be recorded anonymously and with utmost confidentiality. Thus, there are no risks associated with participating in this study. Moreover, the findings of this study shall be used for academic purposes only. If you have any questions regarding the survey or this research project in general, please contact Amuhaya Sagini Nickson at email: amuhayan@gmail.com or phone 0720495341.

Thank you for accepting to participate in this study.

1. **Which of the following best describes your firm?**
(Please check the one that fits best.)
Mark only one oval.

- Architects
- Quantity Surveyors
- Structural & Civil Engineers
- Electrical Engineers
- Mechanical Engineers
- Building Contractor
- Electrical Sub Contractor
- Mechanical Sub Contractor
- Developer

2. **Please indicate your position in the firm**
Mark only one oval.

- Top Level management
- Medium Level management
- Supervisory Role
- Technical staff
- Other: ____________________

3. **Please indicate your years of Working Experience from the following range**
Mark only one oval.

- 0-5
- 5-10
- 10-15
- 15-20
- Above 20

4. **Which of the following best describes the amount of time your firm spends on tracking changes and innovation trends in the construction marketplace?**
(Please check one only)
Mark only one oval.

- Lengthy: We are continuously monitoring the marketplace.
- Minimal: We really don't spend much time tracking market changes and trends.
- Average: We spend a reasonable amount of time monitoring the marketplace.
- Sporadic: We sometimes spend a great deal of time tracking the marketplace

5. **Please indicate which of the following statements best describe your firm's approach towards adoption of innovative construction technologies.**
(Please check one only)
Mark only one oval.

- ( ) We wait until other actors have successfully used innovative construction technologies specify them.
- ( ) We are often the first in our area to specify/use a new and innovative construction technology
- ( ) We encourage our clients to stick with "tried and true" materials and products.
- ( ) We prefer to specify/use innovative construction technologies that meet, but not exceed, market expectation.
- ( ) We prefer to specify/use innovative construction technologies that exceed current market expectations

6. **Please indicate the number of projects in which your firm has INCORPORATED the highlighted innovative technologies in Question 7 above** *
Mark only one oval per row.

	Nill	1-10 projects	11-20 projects	21-30projetcs	Over 30 projects
1. Fibre mesh for concrete works	( )	( )	( )	( )	( )
2. Interlocking stabilized soil blocks	( )	( )	( )	( )	( )
3. Expanded polystyrene panels (EPS)	( )	( )	( )	( )	( )
4. Light steel frame for roof construction	( )	( )	( )	( )	( )
5. Sand coated roofing sheets " decra"	( )	( )	( )	( )	( )
6. Plastics products (e.g. ceiling, skirting, cornice)	( )	( )	( )	( )	( )
7. Laminate flooring boards	( )	( )	( )	( )	( )
8. MDF board	( )	( )	( )	( )	( )
9. Gypsum board	( )	( )	( )	( )	( )
10. Precast Concrete Panels	( )	( )	( )	( )	( )
11. Monolithic Concrete construction	( )	( )	( )	( )	( )
12. Recycled Plastic Products e.g. corec fencing posts	( )	( )	( )	( )	( )
13. PPR plumbing pipes	( )	( )	( )	( )	( )
14.Bio- digester Onsite Sewer System	( )	( )	( )	( )	( )
15. Newbuild Construction Technology	( )	( )	( )	( )	( )
16. Premix concrete	( )	( )	( )	( )	( )
17. Concrete pumping	( )	( )	( )	( )	( )
18 Solar water heating	( )	( )	( )	( )	( )
19. Solar Lighting	( )	( )	( )	( )	( )
20 Concrete waffles	( )	( )	( )	( )	( )

7. **The following attributes have been found to influence customer's interest or willingness to accept new technologies over traditional ones. Please highlight the atribute that are applicable for each of the following innovative technologies**

Please highlight where applicable

Mark only one oval per row.

	Relative advantage over traditional technology	Compatible with traditional technology	Complex compared to traditional technology	Easy to try compared to traditional technoloy
1. Fibre mesh for concrete works	◯	◯	◯	◯
2. Interlocking stabilized soil blocks	◯	◯	◯	◯
3. Expanded polystyrene panels (EPS)	◯	◯	◯	◯
4. Light steel frame for roof construction	◯	◯	◯	◯
5. Sand coated roofing sheets " decra"	◯	◯	◯	◯
6. Plastics products (e.g. ceiling, skirting, cornice)	◯	◯	◯	◯
7. Laminate flooring boards	◯	◯	◯	◯
8. MDF board	◯	◯	◯	◯
9. Gypsum board	◯	◯	◯	◯
10. Precast Concrete Panels	◯	◯	◯	◯
11. Monolithic Concrete construction	◯	◯	◯	◯
12. Recycled Plastic Products e.g. corec fencing posts	◯	◯	◯	◯
13. PPR plumbing pipes	◯	◯	◯	◯
14.Bio- digester Onsite Sewer System	◯	◯	◯	◯
15. Newbuild Construction	◯	◯	◯	◯
16. Premix concrete	◯	◯	◯	◯
17. Concrete pumping	◯	◯	◯	◯
18 Solar water heating	◯	◯	◯	◯
19. Solar Lighting	◯	◯	◯	◯
20 Concrete waffles	◯	◯	◯	◯

8. **Several statements about your firm's consideration of factors that influence the incorporation of innovative construction technologies in construction projects are presented below.**

(Please indicate how strongly you agree or disagree with each statement.)
Mark only one oval per row.

	Strongly agree	Agree	Neutral	Dis agree	Strongly disagree
i) Building Codes impede adoption of innovative Construction technology.	⬭	⬭	⬭	⬭	⬭
ii) Innovative construction technology generally cost more than the ones we currently use.	⬭	⬭	⬭	⬭	⬭
iii) Our customers prefer the "tried and true" type of technologies	⬭	⬭	⬭	⬭	⬭
iv) It is risky to be among the first firms who try new products in our market.	⬭	⬭	⬭	⬭	⬭
v) Lack of adequate financing mechanisms impede adoption .	⬭	⬭	⬭	⬭	⬭
vi) Lack of integration in the construction industry impede adoption of innovation	⬭	⬭	⬭	⬭	⬭
vii) The prevalence of traditional procurement systems impede adoption of innovations	⬭	⬭	⬭	⬭	⬭
viii) There is generally lack of product approval system	⬭	⬭	⬭	⬭	⬭
ix) There is lack of adequate information about new products	⬭	⬭	⬭	⬭	⬭

9. **Who in your firm's opinion is a significant source of information in keeping you up to date on new innovative construction technologies ?**

(Please rate from Least significant to Most significant)
Mark only one oval per row.

	Least Significant	Not Significant	Neutral	Significant	Most Significant
Developer	⬭	⬭	⬭	⬭	⬭
Project or construction manager	⬭	⬭	⬭	⬭	⬭
Architect	⬭	⬭	⬭	⬭	⬭
Quantity Surveyor	⬭	⬭	⬭	⬭	⬭
Engineers	⬭	⬭	⬭	⬭	⬭
Contractor	⬭	⬭	⬭	⬭	⬭
Suppliers/Manufacturer	⬭	⬭	⬭	⬭	⬭
Government regulatory bodies	⬭	⬭	⬭	⬭	⬭
Institutions of higher learning	⬭	⬭	⬭	⬭	⬭

10. **Who in your firm's opinion would have significant influence over a decision to use a new innovative construction technology in construction projects?**
(Please rate from Least influential to Most influential)
Mark only one oval per row.

	Least Influential	Not Influential	Neutral	Influential	Most influential
Developer	◯	◯	◯	◯	◯
Project or construction manager	◯	◯	◯	◯	◯
Architect	◯	◯	◯	◯	◯
Quantity Surveyor	◯	◯	◯	◯	◯
Engineers	◯	◯	◯	◯	◯
Contractor	◯	◯	◯	◯	◯
Suppliers/Manufacturer	◯	◯	◯	◯	◯
Government regulatory bodies	◯	◯	◯	◯	◯
Institutions of higher learning	◯	◯	◯	◯	◯

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