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A SURVEY OF THE PERCEPTION OF QUANTITY SURVEYORS REGARDING TENDER-PRICE INDICES IN SOUTH AFRICA

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ABSTRACT

Different indices are encountered in the building industry for use by built environment professionals, such as input-price indices, output-price indices and seller's-price indices. Currently there is only one tender-price index (or output-price index) that is published on a regular basis in South Africa, through the University of Stellenbosch Bureau of Economic Research (BER) building cost index. This article is based on information gathered from two questionnaire surveys conducted among quantity surveyors in South Africa regarding their perception of tender-price indices (TPI) in South Africa. The research findings indicate that a TPI is an important tool for use by quantity surveying practices. One of the problems related to the accuracy of the BER index is the lack of information provided by quantity surveying practices. A suggested remedy for this problem can be the involvement of the ASAQS. There may be room for a new, alternative TPI, based on recent information, in the South African building industry.

Keywords: building industry, quantity surveying, tender-price index

1. INTRODUCTION

According to Seeley (1996), the labour and material content of every building differs and these cost variations must be taken into account when cost planning for buildings is done. The best way to adjust the available data is through the compilation of indices of building cost. One of the problems encountered in the literature is that different authors use different terminology to describe what essentially is the same concept. Fleming and Tysoe (1991) and Davis Langdon Management Consultancy (2008) for example, state that there are three main types of indices used in the construction industry, namely:

- Building cost indices
- Tender-price indices
- Output indices

In contrast Eurostat (2008) as well as Statistics Norway (2007) mention that construction price indices can be grouped into three main types:

- Input indices
- Output indices
- Seller's indices

To clarify these conflicting terms, Eurostat (2008) state that the terms "cost index" and "price index" should be considered from the point of view of a contractor. Each of these index types can be briefly described as follows:

Input-price index: Input price indices, also called construction cost indices (Asworth, 1991) are, according to Statistics Norway (2007), representative of the construction process inputs such as material, labour, machinery, transport, energy and other costs. Marx (2005) is of the opinion that such indices can be used to determine contract price adjustments after a tender has been awarded.

Output-price index: From the literature it is evident that tender price indices and output price indices are essentially the same concept. McCabe, O'Grady and Waller (2002) state that output price indices attempt to measure the total cost of construction of a completed structure in each location, meaning that these indices reflect the location conditions specific to each project. Marx (2005), states that the factors influencing such indices are the contractor's profit and overheads costs as well as competition in the tender market as this has an influence on the profit margin of tenders. Seeley (1996) define a tender-price index (TPI) to be an attempt to represent the level of prices agreed between clients and contractors.

Seller's-price index: This type of index is not much used in the South African building industry. According to Statistics Norway (2007), seller's-price indices include not only all the cost of the completed construction project such as all the cost of labour and materials paid to the contractor, but also the cost of land, direct and indirect selling expenses, finance costs, professional fees, VAT, as well as the seller's profit

Van der Walt (1992) stated that no officially published building cost related indices existed in South Africa until the 1960's. Some local quantity surveying firms developed their own indices; mostly by re-pricing existing bills of quantities, but these were never officially published.

Currently there is only one TPI that is published on a regular basis in South Africa, viz. the University of Stellenbosch Bureau of Economic Research's (BER) building cost index. This index was developed in the early 1960's for use by the then National Department of Public Works (DPW). The BER was looking for a deflator for building prices in the mid-1960's and, according to Kilian (1980), obtained permission from the DPW to take over this index.

Yu and Ive (2006) is of the opinion that that TPI's attempt to measure the inflation of the contract prices between clients and contractors for constructing new buildings. The four important uses of a TPI, as indicated by Yu and Ive (2006), are as follows:

- Deflation of building sector components of the nominal national product
- Capturing inflation in the building industry for assessments and forecasting of market conditions
- Updating historical cost data for cost planning and estimating
- International comparisons of the level and growth of price, output and productivity in building industries.

Because of the perceived importance of the use of especially TPI's in the building industry, a survey was conducted among quantity surveyors in South Africa.

This survey (hereinafter referred to as survey one) formed part of research towards a PhD degree study on the possible establishment of a new TPI for the South African building industry. The objective of survey one was to gauge the perception of these quantity surveyors towards the use of TPI's in general, and the BER index in particular, taking into account that that this is the only TPI available in South Africa, as well as the relative "age" thereof.

2. METHODOLOGY

The population for survey one could theoretically consisted of all the built environment professionals such as architects, engineers, quantity surveyors, landscape architects, town and regional planners and project managers, as well as other building professionals such as contractors, developers, etc. Apart from the fact that this population would have been very big in size, making the survey logistically very difficult, the issue in question was how many of these people are using TPI's on a regular basis?

After taking the above into consideration, it was decided to draw the sample from only quantity surveying practices in South Africa. The reason for this decision was based on the fact that quantity surveyors, as construction cost advisors, use TPI's on a regular basis, more so than any of the other built environment professionals. Another factor playing a role in the decision was that a TPI is in most instances based on information obtained from priced bills of quantities that are produced by quantity surveying practices; therefore it was assumed that such practices would have a special interest in a questionnaire related to TPI's.

A sample of South African quantity surveying practices can be considered to be representative of the population of all built environment professionals in South Africa, as it consist of practices of different sizes that are spread geographically throughout the country. Furthermore, the sample size (all quantity surveying practices registered with the Association of South African Quantity Surveyors (ASAQS)); can be regarded as adequate to meet the objectives of the survey.

The questionnaire was drawn up and submitted to the ASAQS who agreed to distribute it to all quantity surveying practices registered with the ASAQS. Questionnaires were subsequently sent out electronically via email to 741 registered practices on the ASAQS database, with a request that the completed questionnaire be returned on or before a certain date stipulated on the questionnaire.

Of the 741 questionnaires that were distributed, a total of 148 valid responses were received; a response rate of approximately 20%, which can be deemed an adequate response for a survey of this kind.

3. SURVEY RESULTS

Lack of space prevents the discussion of all the questions that were asked in the survey. The following relevant questions, with the response thereof, will be discussed.

- 91% of respondents were familiar with the composition of the BER index. This was a positive indication because it meant that the majority of respondents would have been able to correctly interpret the questions that followed.
- 62% of respondents indicated that they are currently subscribers to the BER/MFA reports. This can be seen as a fairly low percentage in light of the fact that it is the only report of its kind available in South Africa.
- The next question asked respondents, who recently unsubscribed from the BER/MFA report, to supply reasons for ending their subscriptions. Of the 48 practices who responded, 34 (71%) indicated that they did not use the report on a regular basis. This response correlates with the previous question, indicating that not all practices use the report regularly.
- When asked whether practices contribute information on a regular basis the BER index, 95 respondents (64%), indicated that they either "seldom" or "never" contribute to the index. This response correlates with one of the perceived problems of the BER index, namely that it is based on insufficient information.
- Although 95 respondents indicated in the previous question that they "seldom" or "never" contribute information to the BER index, 111 practices responded to the follow-up question that asked for reasons for not contributing. The majority of respondents (50%) gave as reason that they do not have enough information to contribute, while for 18% it was too time consuming. It is rather alarming that 50% of the respondents to this question (and 37% of the total respondents) did not have enough information available to make a contribution as information can be sent to the BER throughout the year for quarterly publication.
- When asked whether a TPI is an important tool that is used by quantity surveyors, developers, etc., the majority of respondents (89%) agreed with this statement. This is in slight contrast to the 62% of respondents who previously indicated that they do not subscribe to the BER/MFA report.
- When asked whether there is room for a new TPI, based on current building trends, for the South African building industry, there was a mixed response with the majority response (40%) unsure, 38% answered "yes" while 22% answered "no".
- In another question, 64% of respondents agreed with the statement that a TPI should preferably be compiled by an academic institution with the necessary expertise regarding the building industry.
- Respondents were also asked whether their practices would contribute information for the compilation of a TPI if it can be done electronically. The aim of this question was to explore whether the previously identified problem regarding the contributing of information for compiling a TPI could be overcome. The majority of respondents (121 or 85%) responded positively.
- It was interesting to see that a large number of respondents (63%) were of the opinion that they would be willing to pay a subscription fee to obtain a new TPI that is published on a regular basis.

- Although respondents indicated their willingness in the previous question to pay a subscription fee, 69% of respondents indicated in a follow-up question their preference that a TPI should be funded by external funds so that they can receive the publication free of charge. Maybe it is just a natural occurrence among quantity surveyors, who are known for their ability to "look after money", to prefer to get something free of charge rather than paying for it!
- When asked whether the ASAQS should play an active role in the publication of a TPI, the overwhelming majority (86%) agreed with this statement
- Respondents were also asked what other information, apart from a new TPI, such as a TPI published per geographical region; a TPI for different building types as well as separate indices for electrical and mechanical work would be useful to their practices. "Yes" responses of 92%, 87% and 89% respectively were received for the above examples.
- Lastly respondents were asked whether, in their opinion, there was a need for a body similar to that of the Royal Institution of Chartered Surveyors' Building Cost Information Services (BCIS) in the United Kingdom. According to the BCIS, some of the services that they provide include measuring price movement, benchmarking, market research, providing statistical analysis, forecasting and impact studies (Building Cost Information Services, 2013). From the response (79% "yes"), most of South African practices will welcome the establishment of a similar body to the BCIS for the local building industry.

Mention must also be made of a study by Hitch (2014) that took place after survey one was conducted, where an investigation on the accuracy of the BER index was conducted. This survey formed part of a BSc (honours) degree treatise. The objective of this study was a survey questionnaire (hereinafter referred to as survey two), to quantity surveyors in South Africa in order to gauge their perception towards the BER index. Similarly to survey one, the reason for using South African quantity surveyors as the survey population was because they use the BER on a regular basis. This questionnaire was posted on the website of the ASAQS to which quantity surveyors could respond. The total number of respondents came to 49 (Hitch, 2014). The following is a summary of the results of some of the questions in survey two. Since not all the questions in this survey relate to the topic of this paper, only a selection of relevant questions will be discussed.

- The first question was asked to determine how well known the BER index is amongst quantity surveyors in South Africa. The response of 80% correlates with the result of a similar question asked in survey one.
- When asked how often practices use the BER index, 67% of respondents claimed that it is used on each project, while 27% indicated that it is used only on particular projects. This is another indication that quantity surveyors consider a TPI as an important tool in their practices.
- Respondents were asked to indicate whether they think that the BER index should be updated. This is seen in light of the fact that the index has not been updated for approximately 40 years. In response 55% of the respondents believed that the index needs updating. This can be compared to survey one where 38% of respondents indicated that there is room for a new TPI in the South African building industry.
- Lastly an open-ended question was posted where the respondents were requested to put forward potential improvements to the BER index.

One of the items that were raised by a number of respondents was the issue that more data need to be submitted by quantity surveyors in order to create more accurate indices. This correlates with the response in survey one where it was indicated that a large number of respondents do not contribute information on a regular basis.

4. DISCUSSION OF THE RESULTS

A number of inferences can be drawn from the responses received from the two surveys that were conducted. The first of these is that most quantity surveyors in South Africa seem to be familiar with TPI's (or at least with the BER index). Most quantity surveyors also deem a TPI to be an important tool for use in their practices, but, as indicated in survey two, the majority of respondents indicated their perception that the BER index needs updating because of its age. This is in some way supported by survey one, where almost 40% of respondents do not subscribe to the quarterly BER/MFA report, although there can be additional reasons for this, such as the cost of the report.

One of the big issues that have an influence on the accuracy of a TPI in general and the BER index in particular, is the lack of information to base it on. Akintoye (1991) stated in this regard that it is important to ensure that there will be enough data in the right format available on a continual basis to construct an index. If not, it may distort the reliability of the index (Akintoye, 1991).. In the case of the BER index, the information referred to above are priced bills of quantities, and one of the perceived problems with the validity of the index is the quantity surveying practices do not submit enough information. This was supported by Martin (as cited by Brümmer, 2003) who stated that the index has become unstable because "insufficient questionnaires are completed to yield statistically reliable results". The above is also mentioned in the literature by Flemming and Tysoe (1991) whose opinion it was that construction-price indices require a reasonably large number of representative bills of quantities because the rates used by different contractors can vary considerably This observation is also supported by 64% of the respondents in survey one who either "seldom" or "never" contribute information to the index.

A possible remedy for the above problem is to make it easier for quantity surveying practices to submit information electronically in lieu of the completion of a standard form (this suggestion was supported by respondents in survey one). This can also solve one of the issues discussed in survey one, viz. the involvement of the ASAQS with the publication of indices. If quantity surveying practices can submit their priced bills of quantities electronically to the ASAQS, they, in turn, can make this information available to interested bodies, such as the BER, for different purposes.

The last item that needs discussion is the compiling of a new, alternative TPI for the South African building industry. In both surveys this was mentioned as a possibility and can also be combined with one of the questions asked in survey one, whether a TPI should be compiled by an academic institution with knowledge of the building industry. This issue can be solved by a South African academic institution doing research on the methodology of compiling a new TPI and, if found feasible, this TPI can be published as an alternative index to serve as a checking mechanism.

5. CONCLUSION

Although a limitation of the study (especially survey two) was the relatively small sample of the survey (49 respondents compared to the 148 in survey one), the results of the surveys can be considered to be comprehensive. In conclusion, therefore, it can be stated that, although the two surveys that were discussed above were conducted with different purposes in mind, the implication of the study is that the results from said surveys can be used to the advantage of not only the South African quantity surveying fraternity, but the building industry at large. A concerted effort should be made by the ASAQS to assist quantity surveying practices to submit information (e.g. priced bills of quantities) without having to complete unnecessary forms. This information can then be used by both the BER and another body, such as an academic institution, to construct a TPI, based on recent information, as an alternative index for the South African building industry.

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CONTEXTUALISING URBAN ENGINEERING EDUCATION FOR FUTURE CITIES

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ABSTRACT

While rapidity in service activities have strengthened the role of urban areas as engines of economic growth, high population density and increased industrialization, has brought needless social and environmental complaints in cities. This phenomenon necessitates a change in societal attitude in favor of the creation of responsible living conditions, which demands requisite skills and knowledge that would shape the cities. Thus, this paper explores the adequacy of current urban engineering education in terms of the knowledge, skills and competencies required to plan and develop future cities. The paper examines how "wicked problems" that marginalize effective sustainable city planning can be addressed through astute understanding of social and environmental challenges, urban governance systems and stakeholder involvement. Based on current education system, initial findings suggest that competencies in urban planning will not necessarily enable students to address challenges related to the development of smart and sustainable cities. Rather, engineering, science and social knowledge, which would engender the ability to predict future social dynamics, should enable graduates to become active drivers of sustainable and livable cities.

Keywords: Education and Training, Environment, Infrastructure planning, Urban regeneration

1. INTRODUCTION

Although advances in sustainable construction practice can be made within existing principles and pacts, du Plessis and Cole (2011) argue that needed substantial gains may not be achieved without a consistent, all-embracing shift in the

way that things are currently framed. There is increasing evidence, for example, that crime and other social problems can be designed 'out' of a housing development project (Burrage, 2011). While the idea of the need for a new paradigm is not new and has been emphasized in many disciplines, its consequences for stakeholders in Architectural, Engineering, and Construction (AEC) sector have been fairly unexplored. Major shifts in thinking that influence the model of sustainability in a whole systems paradigm were identified by du Plessis and Cole (2011), who argue for a view of sustainability that moves beyond a simplistic model of achieving balance between economy, society and environment to a model based on resilience and adaptive capacity and regeneration of social–ecological system.

Urbanization is a complex process that has been on the upward trajectory. For instance, the United Nations (UN) estimates that about 1.7 billion dwellers will be added to the urban population in Asia from 2009 to 2050 (UN, 2009). This translates into major increases in dwellings, roads and additional infrastructure to convey potable water and all forms of wastes. This expected growth could leave cities with intense strains on infrastructure and dwellers. As an illustration, roads that were designed for limited cars would be choked with traffic, and the concerns would manifest as increased pollution, reduced economic efficiency and increased global warming. Drainage and sewage systems would also form major sources of worry for municipal workers and urban dwellers because of continuous overloading.

The relevance of this argument to the civil engineer, who is focused on meeting the developmental needs of society without compromising the needs of future generations (Corker, 2011), cannot be over emphasized as civil engineers have to tackle "wicked problems", apart from "tame problems". Tame problems are definable, understandable, consensual challenges that are subject to the general idea of efficiency. The general idea of efficiency is a guiding concept in civil engineering, the natural sciences and operation research (Rittel and Webber, 1973; Hardin, 1998). Tame problems have clear missions, exhaustive formulation and are always aligned with the classical paradigm of science and engineering. The work of Hardin (1968) illustrated the features of a tame problem. In response to "how do we allocate natural resources in an equitable way", Hardin (1968) was able to suggest two solutions: either privatize the commons or change human nature. In essence, a tame problem has a relatively well-defined and stable problem statement; has a definite stopping point; has a solution that can be objectively evaluated; belongs to a class of similar problems that can be solved in the same way; and has solutions that can be tried and abandoned (Ritchey, 2013).

However, wicked problems are 'human problems' that require solutions derivable from politics, environmental studies, economics, ecology, demography, professional ethics and philosophy, to mention a few (Rittel and Webber, 1973). Wicked problems are ill-defined, ambiguous and associated with strong moral, political and professional issues, apart from the view that they are strongly stakeholder dependent (Ritchey, 2013). In addition, Ritchey (2013) noted that wicked problems do not keep still: they are sets of complex, interacting issues evolving in a

dynamic social context. In other words, most wicked problems are often without easy technical solutions as they can become malignant, vicious and tricky to solve. Such problems are exemplified in the range of challenges that are faced by cities (Rittel and Webber, 1973). Increasingly, cities in the developed world experience signs of environmental stress in the form of heat waves, poor air quality, excessive noise, and traffic congestion (Schetke and Haase, 2008). Cities with concerns of environmental pressures and the quality of urban life are driven by a common goal. The goal is about asking for clarification of purposes, redefinition of problems, matching priorities with purposes, and reorientation of professional activities (Rittel and Webber, 1973). As an illustration, most Indian cities are characterized by high densities, intensely mixed land use patterns, short trip distances, and a high share of walking and non-motorized transport that lead to persistent environmental decay, congestion, and poor health conditions (Tiwari, 2002). This situation in India cannot be solved through a technical approach alone. Rather solutions lie with ideas that include long-term social and organizational planning issues.

To begin, a succinct analysis of the related literature indicates current education and its contents as it relate to urban planning and development in terms of providing living cities. The differences between "tame problems" and "wicked problems" were highlighted and used to raise concerns about current urban planning related education. To conclude, the implications of this changed understanding – from tame to wicked problems – were used to compliment knowledge areas in urban engineering education.

2. A NEED FOR A PARADIGM SHIFT IN URBAN ENGINEERING EDUCATION

According to Laws and Loeber (2011), practicing sustainability now amount to managing and participating in a process of learning and negotiation within a network of stakeholders whose risks and relations are dramatized and brought into focus by a particular project or need for action. With the use of a water management scheme in The Netherlands, Laws and Loeber (2011) argue that overcoming common infrastructure development dilemmas in terms of sustainability requires engineers to approach technical projects as arenas for learning and problem-oriented negotiation. Such soft skills are advocated in the engineering education literature as a measure to improve project lifecycle performance. In 'future skill sets for the municipal engineer', Cooper and Ashurst (2011), contend that in order for the municipal engineer to thrive in the future, such individual should:

- Have the ability to absorb and accept change willingly;
- Constantly update the traditional technical skills;
- Match new technical skills sets to new work areas in a timely manner;
- Develop non-technical skill sets that must be nurtured by management, and
- Enhance interpersonal skills to meet new and increased job related demands.

Furthermore, Cooper and Ashurst (2011) observe that as most young engineers enter the profession through a university, there is a critical case to ask universities to look at their curricula and determine how the desirable skills could be included in program modules. The inclusion of this skill sets in the civil engineering education could be enhanced when better links are developed between the industry and the academia for the long term benefit of the profession (Barr, 2008). The importance of competency-based training (CBT) that combine skills, abilities and knowledge needed to perform a specific task in the AEC sector has yet again resonate with this discussion because professional competence is always benchmarked against a particular set of specific competencies (Newton, 2008). When these skill sets are available, green hubs that have been proposed in the literature can become a reality. Burrage (2011) suggests that green hubs as a tool in regeneration, and other forms of sustainability would transform a passive green space to a proactive space. The proactive spaces can be places to nurture and develop social and cultural harmony in a community. The literatures cited by Burrage (2011) show that the topology of urban green space involves cultural, ecological, developmental, agricultural and recreational value. All these can be combined to produce parks and gardens; natural and semi-natural urban green spaces; corridors; and outdoor sports facilities.

The ability to engage project stakeholders and engender the indicators shown in Table 1 evidently requires a pedagogy that is progressive. The sustainable development process for a major infrastructure project discussed by Gilmour et al. (2011) provide a mechanism for assessing sustainability through social, economic and environmental prism. See Gilmour el al. (2011) for the definitions and other attributes of these indicators. It is notable that these indicators should not be viewed as exclusive to major projects as the development of effective local infrastructure now requires a complex blend of different expertise in technical aspects of engineering and management that can modify behaviors of stakeholders (Rogers et al., 2012).

Table 1: Sustainable development indicators

Economic	**Environment**	**Social**
Demography	Biodiversity	Housing provision
Skills base retention	Green space / public space	Health and wellbeing
Knowledge-based employment	Waste	Community
Investment stimulation capacity	Air	Social inclusion
Tourism	Water	Participation and responsibility
Regeneration	Noise	Active community participation
Job creation	Energy	Confidence
Economic output	travel	Amenity value

Adapted from Gilmour et al. (2011: 21-23)

2.1 Emergent Urban Engineering Education Propositions

An argument in the literature has continued to encourage people to move to places with better governance. The issue is not whether a development will urbanize or not. It is about "where and under what rules", should locations urbanize (Beck et al., 2011). The changes, which are expected or experienced, are with varied challenges. The question is whether the challenges can be addressed by policy making, governance, and the use of technology. These questions point to the fact the recognition of urban problems are wicked, as opposed to tamed problems, raises major concerns about the way urban planning is currently taught in higher institutions. This changed understanding has implications for competencies that urban engineering education appears to address.

The population growth rates, the dynamics of the economy, information technology, climate change and fluidity in social behaviors show that city planning and development problems will be enormous and the conventional urban related education will fail to solve these challenges adequately. Challenges such as "how should we avoid congestion in urban areas" and "what is the ideal environmental policy for a rapidly expanding city", inevitably demonstrate the need to address wicked planning problems. Planning challenges include all public issues. Concerns about the location of a motorway, tax rate adjustment, modification of school curricula, and the elimination of crime, constitute some of the issues that must be addressed. The planning problems may have features that are not limited to (Rittel and Webber, 1973):

- Lack of a definitive formulation for the problem: the process of solving the problem is identical to the process of understanding its nature.
- Lack of a stopping rule: the planner terminates work for considerations that are external to the problem, for example, time and money.
- Solutions to the problems are not true-or-false; rather they are framed along good-or-bad format.
- There is no immediate and ultimate solution test.
- There is no opportunity to learn by trial-and-error as every solution attempts is vital.
- Every planning problem is unique and can be considered to be a symptom of another problem.

In response to the wicked nature of planning problems (Rittel and Webber, 1973; Ritchey, 2013), urban planning related education has evolved to a highly specialized field of study with varying degree of success. While there is no disagreement on the role of urban development education in the urban development process, there is always confusion over the contextualization of the education provided by institutions of higher learning. Suffice to say, it is not certain that the current urban development related education are geared up to face the challenges that cities are facing or are expected to face in the future. The main question is: are urban planners, urban engineers, urban managers and urban development professionals adequately knowledgeable and skilled to make the cities adaptable to the current and future

challenges? In other words, there is a need to ascertain if these professionals would be able to address wick planning problems. The intent of the urban planning program should include how to resolve wicked problems. According to Rosenhead (1996), certain criteria for dealing with complex social planning problems include:

- Accommodate multiple alternative perspectives rather than prescribe single solutions.
- Function through group interaction and iteration rather than back office calculations.
- Generate ownership of the problem formulation through transparency.
- Facilitate a graphical (visual) representation for the systematic, group exploration of a solution space.
- Focus on relationships between discrete alternatives rather than continuous variables.
- Concentrate on possibility rather than probability.

These criteria invariably suggest a change from the dominant engineering and science paradigm of planning problem solving to a pragmatic approach. For example, group facilitated and computer aided general morphological analysis (GMA) is attuned to these criteria and offers a way to address wicked problems (Ritchey, 2013).

3. A CONCEPTUAL DESCRIPTION FOR FUTURE CITIES

The authors look at the future cities in terms of cities where people would desire to live, instead of a city in which people would be forced to live. May be this sounds utopian; however, this is what the future challenges for city development process would entail. If the notion that cities are engines of economic growth is accepted, cities need to adapt to changes in technology, governance, and the environment. Such adaptations should be economically efficient, socially beneficial, and environmentally benign (Marcotullio and Solecki, 2013). To make the adaptations function properly, it demands robust theoretical understanding of the urban forms and processes concerning how to address identified challenges. The theoretical understanding and application would require appropriate knowledge and skills among the persons involved in the urban development process.

In recent times, a movement is taking shape for the development of sustainable future cities through a smart combination as indicated Figure 1. The smart cities recognize six major parameters. These include the economy (related to competitiveness), mobility (related to accessibility and connectivity), environment (related to natural resources), human capital (related to people), living (related to the quality of life) and governance (related to participation) (Giffinger et al., 2007; Komminos, 2002; Lombardi 2011; Shapiro, 2008; Van Soom, 2009). Smart economy refers to parameters around economic competitiveness related to innovation, entrepreneurship, trademarks, productivity and flexibility of the labor market as well as integration in the national and international market. Smart people are essentially described by the level of qualification or education as well as by the quality of social interactions and integration, participation in public life and the receptive attitude, and

openness towards the outer world. Smart governance encompasses facets of political participation, services for citizens and the functioning of the administration. Local and international accessibility in the form of sustainable physical transportation system, and, Information and Communication Technologies (ICT) is referred to as smart mobility. Smart environment is expressed by attractive natural conditions in terms of the climate, green open space, level of pollution, resource management and efforts towards environmental protection. Smart living includes various indicators of quality of life in the form of culture, health, safety, housing, and tourism, among others (Giffinger et al., 2007).

Thus, a future city will essentially be a relatively complex combination of these smart elements and should be sustainable if it will demonstrate forward-looking development in these six important characteristics on the basis of their coordinated interactions. The interactions are dependent on local circumstances and activities carried out by the inhabitants of a place through politics and business (Lombardi, 2011; Komminos, 2002; Giffinger et al., 2007; Shapiro, 2008; Van Soom, 2009). In brief, the ability to see planning problems as wicked problems that should be addressed with a methodology that is different from the approach that is applied to tame problems would significant affect the dynamics and nature of future cities, especially if the cities have to be smart and sustainable.

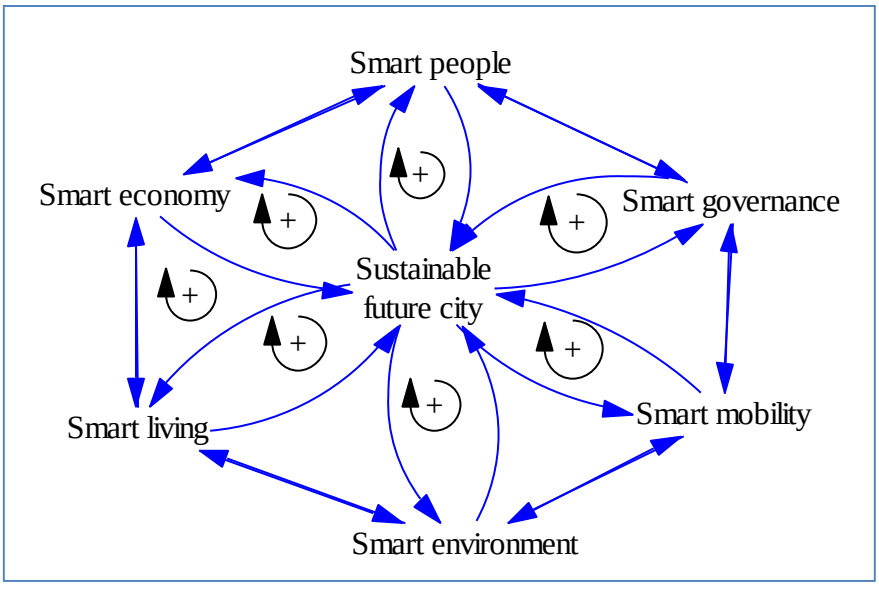

Figure 1: An illustration of a sustainable future city

4. CURRENT URBAN DEVELOPMENT EDUCATIONAL APPROACH

If the approach of urban development education is analyzed, it can be observed that it varies from highly diversified field to highly narrow and specialized ones (see the Association of Collegiate of Schools of Planning (ACSP) 2011/2012 guide).

To mention a few fields, it involves Geography, Economics, Sociology, Civil Engineering, Architecture, and Urban Design.

At present, there are several broad disciplines that are related to urban development. These disciplines include Urban / City / Town Planning with or without Regional / Rural planning, Urban design, Urban Management, Urban Engineering and in some places, it is known simply as Civil and Urban Engineering. The programs vary from social sciences to highly technical designs of built forms and structures. The idea behind urban planning related courses is the development of appropriate strategies for sustainable urban development, which cover aesthetic and psychological concerns. Furthermore, the courses aim to create environmentally sustainable, socially inclusive, economically prosperous, architecturally pleasing, and culturally vibrant cities.

However, despite the evolution of several courses relating to urban development over the years, the challenges in tackling the aspects of urban development remain. The argument here is that urban development education has not evolved the way it should have when compared with other structured applied field of sciences. A debate still remains whether it is an applied science and highly technological or it belong to social sciences. The key question that comes from this argument is that if urban development challenges need technological solutions, why does the status quo remains, despite recent advancements in technology.

4.1 Enhancing Capacity to Overcome Challenges Envisaged for Future Cities

With the contention that the current urban development education could be inadequate to meet present and future challenges, the next question is: what should the education be? Before what urban development education should encompass is discussed, there is a need to understand what the challenges are at present and what could be the scenario in the future. Using rapid urbanization as an example, there is a tendency for increased social pressures in cities and urban area. The increased infrastructure requirements, dwindling natural resources, and worrisome sanitation issues, leads to interventions that is broad-based in terms of knowledge and skills. Similarly, the demographic, economic, sociological and political aspects of city development are becoming more complex. The assimilation of different cultures, races, and generations make the city development process complex. Thus, while technological aspects can be considered as ingenuity to the development process, the socio-economic and environmental aspects cannot be undermined. There is therefore a need for structural union between subject areas important to urban development so as to engender a contextualized education in urban planning and engineering.

What should a contextualized education in urban planning and design entail? The response to the question should bring about new ideas in developing new courses and new curricula or may reconfigure the existing ones. The point is that current education in the related fields of urban development needs revision. Figure 2 is an illustration of the current state and the desirable state of urban planning and engineering education. The illustrated states were derived based on the review of several courses at different level of higher learning.

In particular, Figure 2 suggests that forecasting competency through a scientific process, should be enhanced with appropriate learning courses. Further, while technology related competencies may form the core of urban development education; imbibing soft skills in the area of governance, and policy formulation and management decision making is also vital. The urban development education in a sense is now highly diversified. However, does it need to be? Is different level of urban education and different specializations at various levels, which sometimes look mutually exclusive despite being aimed at the same goal needed? For example, environmental planning looks for providing knowledge and skill for development of a healthy environment in a city; however, they work separately from the people related to transportation planning, who in a sense play the role that provides efficient transportation facilities for people and goods. This is despite the widely held view that transportation or more specifically, vehicles are the main source of pollution in the cities. Similarly, several programs feature the same modules at both undergraduate and post graduate levels, thus creating repetition. This trend marginalize the inclusion of modules that are essential for developing tools for forecasting, space management, environmental impact mitigation, and optimal land use. Desirable modules are not limited to mathematical simulation and modeling, systems analysis, geographic information system (GIS), governance and conflict resolutions, to name a few.

Thus, it is herein argued that urban development related education, in whatever form, should be streamlined and structured as a specific applied science discipline with the incorporation of relevant social science modules. The modules should be offered in a hierarchical way that is relevant and contextualized to both local and global needs. The illustration in Figure 2 is indicative of the areas of knowledge and the skill sets that would be needed. Figure 2 also show how the modules can complement the current curricula. In particular, when governance and conflict resolution related modules are taught in urban planning programs, it should deepen the political, psychological and sociological knowledge and capacity of students and graduates alike. The augmentation of the current environmental impact assessment modules with mathematical modeling and simulation content should also be considered. In a nutshell, increased prioritization of the modules in role 2 as indicated in Figure 2 should assist urban planners to address wick problems.

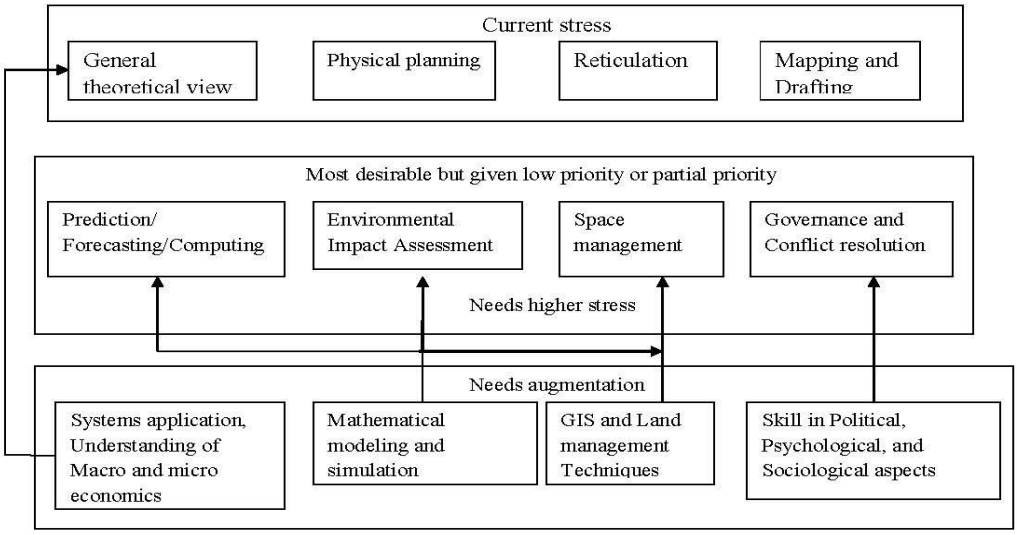

Figure 2: Current and desirable state of courses in urban engineering education

5. CONCLUSION AND RECOMMENDATION

The literature reviewed explored the adequacy of current urban engineering education in relation to the provision of future cities that should uplift the living conditions of urban dwellers. The discourse noted that pedagogy that pertains to urbanization should be revisited. The revision should recognize and address the dynamics of wicked problems that urban planners must solve in order to plan and develop cities.

The authors have argued that urban planning, as currently taught in higher institutions, assumes that the challenges that are to be addressed are “tame problems” instead of “wicked problems”. Evidences in the literature have shown that urban planning problems are societal problems that are inherently different from problems, which are definable and separable and could have solutions that are identifiable. In other words, planning problems tend to be ill-defined and always rely on political judgments for resolution; hence these problems can be malignant, vicious, tricky and aggressive. Thus, the education and training of urban engineers need to take cognizance of the features of “wicked problems”, for it to have meaningful impact on city development.

The paper contends that knowledge and skills required for handling complexities have implications for how to address challenges pertaining to society, environment, and urban governance. Although the key learning outcomes within civil engineering programs that address urban planning do not have to be repudiated, the modules have to be complemented and modified to reflect the knowledge areas that are not currently inside the curricula.

City planners and engineer should therefore endeavor to go beyond technical competencies if they are to remain relevant in a future city context. Civil engineers that are tasked with urban development related projects need to jettison the out-dated outlook of problem resolution in order to produce development that support the 'living cities' concept.

The urban development process constitutes and demands a variety of specializations and skills. Among the specialists, there is a need for a leader that would move the team towards the common goal. The team leader should ideally be an urban engineer with essential knowledge and competencies to understand the inherent nature of urban planning problems. The requirement for a competent urban engineer brings to the fore the need for the reinvigoration of related educational programs.

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SIGNIFICANT WASTE FACTORS INFLUENCING DELIVERY COST PERFORMANCE OF DESIGN AND BUILD LOW-COST HOUSING PROJECTS IN IMO STATE NIGERIA

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ABSTRACT

Effective performances particularly on Low-cost housing projects has been a major problem in many developing countries. In Nigeria, public sector clients have adopted the design and build (DB) procurement strategy as one of the strategies to deliver Low-cost housing (LcH) projects following potential benefits to facilitate improved performances particularly as it pertains to project cost. Yet, many design and build low-cost housing (DBLcH) projects are not delivered within expected target cost performances resulting from the influences of waste factors amongst several others identified. This paper aim to identify the waste factors that significantly influence poor cost performances of DBLcH projects based on the investigation of the LcH sector in Imo State Nigeria. A mixed method design, using literature review and survey questionnaire, was adopted in this study, to identify and validate contextual waste factors influencing DBLcH project cost performances. Findings revealed the significant waste factors influencing poor cost performances of DBLcH projects. This study's findings is expected to increase the awareness of the project team on the significant waste factors that will need to be mitigated towards improving the cost performances of DBLcH projects in Imo State Nigeria.

Keywords: Cost performance, Design and build, Low-cost housing project, Waste factors

1. INTRODUCTION

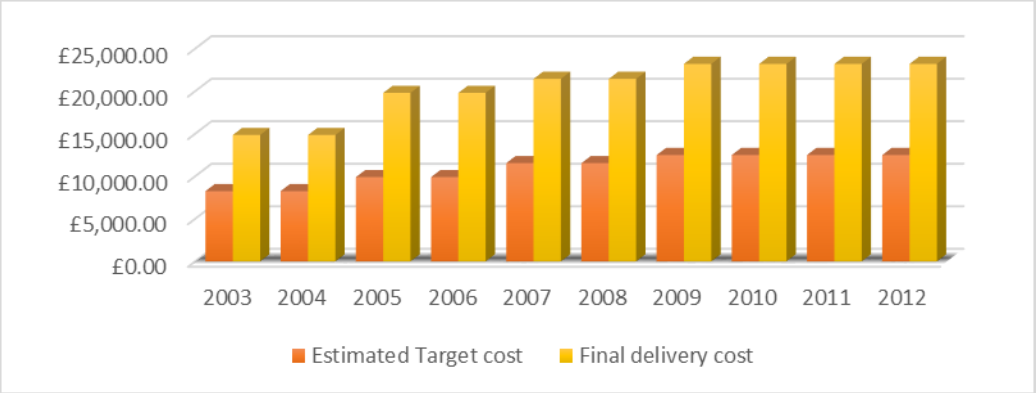
Housing is described as a universally accepted second most important human need for survival and a significant factor in the productivity and worth of every individual which no government can ignore (Sheng and Mehta, 2008 cited in Lin, 2011; Un-Habitat, 2011).The rationale for consistent and adequate housing supply in many countries like Nigeria is to provide for those without homes, shelter for an ever increasing population and for the purpose of healthy and productive living amongst others (Anyanwu 1997). Low-cost housing (LcH) evolved in many countries as one of the intervention strategies by various governments to address the housing needs of the portion of the population who without assistance cannot afford adequate housing at prevailing market rates(Davis, 1997; Assaf et al., 2010). In china, LcH are classified as non-commercial housing initiated, funded and organized by state or local governments (Jingchun, 2011). Nigeria as a developing country also adopts a similar pattern but with the federal and state government responsible for the initiation, funding and organization.

LcH supply in many developing countries like Nigeria, over the years, appear to have recorded minimal success, with supply yet to meet demand and houses supplied unaffordable for target beneficiaries (Makinde 2014; Akinde, 2012; Un-Habitat, 2012). The poor LcH supply is one of the factors identified as a driver to the country's housing deficit estimated at 17 million unit (Federal Ministry of Land Housing and Urban Development (FMLHUD), 2012). This is also corroborated in the report by the coordinating Minister for the Economy of Nigeria, stating that the low production output of the housing sector currently about 100,000 units, instead of 700,000 units per year has accumulated housing deficit of about 17 million units in the country (Okonjo-Iweala 2014). Consequently, seeking viable initiatives that can improve LcH supply have become a necessity by governments at different levels to deal with the existing housing crisis in across the country.

Bridging the gap between LcH supply and demand have spurred collaborations between government housing agencies and private sector organizations in LcH project delivery. This is one of the initiative underway expected to boost LcH production and supply. The initiative has engendered the adoption of the design and build procurement strategy for LcH project delivery (FMLHUD, 2012; Gemade, 2012). The choice of adopting this procurement strategy is due to its well voiced benefits to enhance effective LcH project cost performances.

But judging by documented records from previous studies (Akinde, 2012; Olotuah & Taiwo, 2013) it is obvious that DBLcH projects most often experience poor delivery cost performances as shown in Figure 1 which have apparently impacted on market price, supply and affordability.

From Figure. 1, the trend of poor cost performances and supply can be grasped. As seen in Figure 1, the trend of poor cost performances of many DBLcH projects have been on the increase since 2003. Akinde, (2012) elucidated that the project cost performance is a significant variable impacting on both LcH production and supply. This corroborates findings by Okoroafor (2007), who argues that the performance of the project delivery costs will impact on the market prices and go a long way to determine affordability because of the relationships between project cost performances, price, and supply and demand. From these views, it suggests that the poor cost performances experienced on DBLcH projects can be regarded as a challenge apparently impacting on prevailing housing crisis situations across the country and particularly in the case of the Imo state Nigeria (Amade et al., 2015; Obi & Arif, 2015; Ubani et al., 2013).



where £1= ₦303.00 at April, 2015 exchange rate

Figure 1. Trend cost performances of Design and Build LCH project
Source: Adapted from Akinde 2012

Imo state is one of the states in the South-East zone of Nigeria where DBLcH projects have been flagged (Gemade, 2012). Available information from the NBS, (2014) online published records show that up to 90 percent of the population in the state are below the upper middle income group. This imply pressured demand for LcH by a vast majority of populace. However, the housing situation in the state is said to be characterized by makeshift accommodations following many unsuccessful LcH supply schemes and unaffordability of available housing by many low and low-middle income groups (Duru and Anyanwu, 2014; Ozurumba, 2011; Ukiwo & Chukwuma, 2012). One would expect that this should not be the case given that Imo state was a flagship state for the pilot of the World Bank Assisted Nigerian States Urban Development Programme (NSUDP) with the major objective of setting in motion a National Low Cost Housing Programme (FMLHUD, 2012).

Investigations reveals that the housing and construction sector in Imo state is characterized by poor project cost performances which affects the effective outcome of building and housing projects in the state (Ubani et al., 2013; Obi & Arif, 2015). The ripple effects of the outcomes have apparently constrained effective LcH project delivery and impacted on supply and gone a long way to undermine affordability. Therefore, strategies towards addressing this root-cause apparently impacting on DBLcH projects likewise, can be seen as a viable step to improve future project outcomes in the state.

Several studies such as Josephson and Saukkuriipi, (2007) and Leong and Tilley (2008) investigating causes of poor cost performances on building and construction projects have identified waste as one significant factor. Withana-Gamage, (2011) attributed the occurrence of waste particularly on DBLcH projects to the influences of actions emanating from various stages of the delivery process. This view was corroborated by Akinde (2012) on a study of DBLcH project delivery in South West zone Nigeria. These actions have been identified as waste factors. Adewuyi & Odesola, (2015) argues that there are very few local studies on construction waste in Nigeria, to provide useful information for the benefit of the project team (Dania et al. 2007) towards effective project delivery. The paucity of information on the waste factors could be one of reasons constraining the project team from delivering effective project cost performances in the context of DBLcH projects in the LcH sector of Imo state Nigeria. To bridge this gap, this paper aim to identify the waste factors that significantly influence poor cost performances of DBLcH projects based on the investigation of LcH sector in Imo State Nigeria. It is expected that this study findings will contribute to existing body of knowledge on waste factor identification and increase the awareness of the project team on the significant waste factors that need to be mitigated towards improving the cost performances of DBLcH projects in Imo State Nigeria

This paper is based on findings from literature review and expert opinions and the following sections of the paper reviews extant literature on waste factors, explains the methodology adopted and discussion of findings from data analysed. Finally the paper concluded with recommendations.

2. LITERATURE REVIEW

2.1 Low Cost Housing

Low-cost housing (LcH) has been defined as housing developed within adequate standard and specifications and affordable to the poor and low income group (The United Nations Human Settlements Program (UN- HABITAT), 2011; World Bank, 1975).

However, the concept of income group classification is not presumed to have a universal definition, as meaning may differ within a country, between countries and continents reflect differing national economies (Oladapo, 2001; Ogbu and Adindu, 2012). In the Nigerian context, LcH as defined in the National Housing policy document published by the Federal Ministry of Land Housing and Urban Development (FMLHUD), (2012) is housing adequately built to regulated standard and specifications and at affordable price to the low and middle incomes. It is a non-commercial housing initiated, funded and organized through federal and state governments (FMLHUD, 2012). The above definitions, suggests that specifications, standards, initiators, affordability and target beneficiaries are key terms in defining LcH. Therefore in this context LcH is defined as housing initiated, funded and organized through federal and state governments and built to regulated standard and specifications at prices deem affordable to the low and middle incomes.

The considerations in LcH supply is confined within the context of production and demand based on housing need and requirements(McNelis, 2014; Fordham et al., 1998; Tiwari, 2001;). In developing countries like china and Malaysia, LcH supply is not a profit driven venture but a vehicle and social service for meeting the shelter needs of the low and middle income population (Bakhtyar, 2013; Jingchun, 2011). Essentially, LCH supply involves series of processes by which resources such as land, labour, finance and materials are combined to produce new-build or upgrade existing housing and distribute to target beneficiaries (Agbola and Alabi 2000; Hecht, 2006). Generically, frameworks for LcH supply (See Ball 1986 cited in McNelis 2014; Ambrose, 1991; Mostafa et al., 2006) clearly characterize the supply process into main phases which includes initiation, investment, construction, allocation and maintenance. In the Nigerian context the LcH supply emphasizes new build developments and the process as accentuated starts from the initiation through federal and state housing polices and plans, to funding and land acquisition, followed by project implementation and ends with the allocation/ marketing phase. The implementation phase involves the design and construction of the LcH project which can also be referred to as project delivery phase.

LcH projects have been described as valued, special massing housing projects aimed at constructing adequate housing within defined performance objectives of cost, time and quality for the benefit of target beneficiaries. Drawing from Kwofie et al., (2014) definition on mass housing project, LcH can be defined in this context as projects whose design and construction are standardized and constructed usually in the same or several geographical locations, executed within the same project scheme and under the same management and contract. One of the characterizing features of this LcH project delivery is the highly prioritized criterion of effective cost performances demanded by many public sector clients in like Nigeria (Oladapo, 2001; Adinyira et

al., 2012). This draws from the perceived relationship between project cost performances supply prices and demand (Okoroafor, 2007).This view has necessitated the optimization of various appropriate procurement strategies such as DB procurement strategy in the delivery of LcH projects in Nigeria.

2.2 Design and Build Procurement Strategy

Design and Build (DB) procurement strategy according to Masterman (2002) is described as an integrated system whereby a client contracts a DB organization for a lump sum, to develop full working design, obtain statutory approvals and finally construction, all as a single point of contract. This is as opposed to a traditional Design-Bid Build procurement strategy where the client appoints consultants to design and then a contractor to construct the works. The DB organization can either be appointed at the predesign stage or after the conceptual design has been undertaken (design stage) in which case, the client emphasizes to have greater influence over the initial design and specification. The DB strategy is mainly adopted in simple projects, where design quality is not critically considered as main criteria for effective delivery performance (Turner, 1990). There are variants of the DB strategy; however, they are not discussed within the scope of this paper (see Oladirin et al., 2013; Withana-Gamage, 2012). Several studies both from developed and developing country perspectives have investigated DB use in various construction projects, for example studies by Withana-Gamage, (2012), Shafik & Martin (2006) in the Scottish LcH sector, Chan, (2000); Moore and Dainty, (2001), Hale, et al., (2009) espousing potential cost benefits., and also highlight few constraints

Within the Nigerian context Idiake et al., (2015); Dada (2012) and Babatunde et al, (2010), amongst others have investigated the use of procurement strategies in Nigeria. In some cases, the cost managers, designers and construction manager form a consortium to provide integrated services corroborating similar views by Memon et al., (2014). They identified the DB strategy as one of the main strategies being employed across several building projects including LcH projects. The process on public building projects involves the DB organization engaged by the project sponsor on many occasion after the conceptual designs have been partly or completely developed by the in-house construction professionals. This is also the case in DBLcH projects as documented by Akinde, (2012). It would appear that one of the reason for this is that the housing authorities (project sponsors) want to have greater influence over the conceptual design and specification towards achieving affordable costs. Idiake, et al., (2015) and Babatunde et al., (2010) highlighted that some of the benefits of adopting the DB procurement strategy in building projects is its potential for cost and time reduction. However, they also acknowledged that effective cost performances of many DB building projects are undermined by the influences of waste factors.

This has been corroborated by Akinde, (2012) in his study of improving DBLcH project delivery in South-west Nigeria. Therefore, it has become expedient to examine and understand the concept of waste and identify the waste factors influencing the poor cost performances experienced on DBLcH project delivery process. This is further discussed in the next section of this paper.

2.3 Waste Factors

Waste has been identified as one of the factors affecting construction project performance (Sibiya, et al., 2014a) and in more specific terms a significant factor impacting on a project's cost performances (Leong & Tilley, 2008; Josephson and Saukkuriipi, 2007). Koskela, (1992) and Aziz & Hafek, (2013) described waste as any inefficiency that results in the use of equipment, materials, labour, or capital in larger quantities than those considered necessary in the production of a building without creating value to the product from the point of view of the client. According to Tersine (2004) waste to include undesirable time, money and/or resources consumed in the production of the product without adding value from the perspective of the client. It can therefore be deduced and used in this context that waste is any inefficiency within the project delivery process that results in additional cost above the minimum that would have been required to deliver a housing project.

Earlier works by Ohno (1988 in Likert 2004) on the Toyota production system elucidates that waste on construction projects could be classified under two headings:

- **Process waste**: this relates to waste generated from the flow of materials. It includes defects in products, overproduction of goods not needed; inventories of goods, awaiting further processing or consumption; unnecessary processing; and unnecessary transport of goods.

- **Operations waste**: this is a labour generated waste from the by-product of unnecessary movement of people, waste of human energy and waiting by employees for process equipment to finish work.

Similarly, the works of Likert, (2004) simplified these categories into eight (8 Nr) main waste areas as shown in Figure 2.

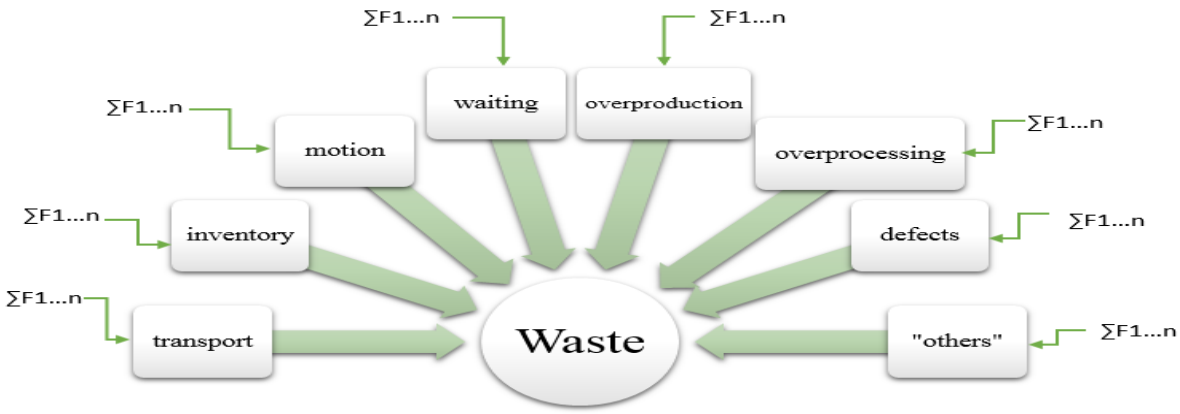


Figure 2: Waste factors and source areas
Source: Adapted from Likert (2004)

In Figure 2, ∑ F1…n represent a summation of various actions that generates and contribute to each type of waste. These actions are referred to as waste factors (Wahab & Lawal, 2011).

Waste factors therefore are the direct or indirect actions undertaken within the project delivery process that generate and contribute to waste influencing project cost performances (Akinde, 2012; Withana-Gamage,2012; Wahab & Lawal, 2011). Machelete (1997) categorized waste factors according to structure that is into design and construction related waste factors. This view has also been corroborated in studies by Withana-Gamage, (2011) in a study of DB building projects in United Kingdom, Wahab &lawal (2011) and Akinde, (2012) both in a study of waste on construction projects and DBLcH project delivery respectively, in south west zone of Nigeria. In their views, design related waste factors refer to waste factors originating from the design stage while the construction related waste factors refer to the waste factors originating from the construction stage.

Consequently, Koskela (1992) argues that in meeting the primary objectives of effective project performances within the construction environment could be very challenging without identifying and addressing the factors that contribute to waste on the project from a lean thinking perspective. The application of lean thinking to the design and construction process to improve project performances in conformity to client needs and expectations is referred to as Lean construction (Koskela, 1992; Lean construction institute United Kingdom, 2015). Waste elimination is probably the single most important term in Lean Construction (Akdeniz, 2014) and the in many countries (Rahman et al., 2012; Hanna et al., 2010).

There are a variety of tools, strategies and technologies used in Lean construction such as value stream mapping (VSM), Toyota practical problem solving process and Pareto diagram to mention a few and their potential benefits to identify and map waste factors affecting building project performances are well documented across studies (Aziz & Hafez, 2013; Rahman et al., 2012; Sacks, et al., 2010).

Several studies have identified various waste factors influencing poor project cost performances across varying construction projects. For example, Osmani et al., (2008) on building and housing projects and Withana-Gamage, (2012) in the DB building projects both in the United Kingdom in developed countries. Similarly, some waste factors have been identified in studies by Nagapan, et al., (2012) in malaysia; Muhwezi, et al., (2012) in Uganda, Polat & Ballard (2004) in Turkey, Alwi et al., (2002) in Indonesia and Ekanayake and Ofori (2000) in Singapore; Machete (1997) and Sibiya, et al., (2014b) in South Africa amongst many others have also identified contextual waste factors on building and LcH housing projects from the developing countries perspective. Many of these studies have also identified the waste factors using observational method, statistical methods and lean construction tools.

In the Nigerian building and housing sector, Adewuyi & Odesola, (2015) argues that there are very few local studies on construction waste. However, a few documented studies such as Adewuyi & Odesola (2015), Adewuyi & Otali, (2013), Akinde (2012) and Wahab &Lawal, (2011) have investigated waste factors across in building and housing projects in the south-south and south-west zone of Nigeria. Akinde (2012) specifically investigated waste factors in the context of DBLcH projects using Toyota production system practical problem-solving technique. Though the above listed studies have examined waste factors in housing projects including DBLcH projects they are not within the geographical context of the Imo state LcH sector. Therefore, this study is needful and is expected to be benefiting the project team towards improving cost performances on DBLcH projects in Imo state LcH sector. The waste factors identified from existing literature provide a platform to aid validation of the factors within this study context by expert construction professionals. The Pareto Diagram is further utilized to validate the findings.

3. RESEARCH METHODOLOGY

To achieve the stated aim of the study, both primary and secondary data sourced. An exploratory sequential mixed method design was employed which allows for data collection and analysis to be carried out sequentially with the findings from the first phase informing the procedure in the second phase (Creswell 2014). In the first phase, secondary data was collected based on a review of relevant literature on waste factors and questionnaire survey allowed for the collection of primary data in the second phase.

This was designed to obtain contextual waste factors in relation to DBLcH project cost performance in Imo state Nigeria.

In the qualitative phase, exploration of relevant literature enabled proper identification of various waste factors associated with the project delivery of projects from a generic context. A search in abstracts of articles using primary key words comprising of waste, construction, building, housing and projects across Scopus and Google Scholar electronic data bases, dated between January, 2010 and December, 2014 was conducted. Ten (10 Nr) publications were purposively selected based on the comprehensiveness of the waste factors listed in the studies. Content analysis was employed which allowed for the identification of forty-three (43) waste factors from the selected publications. The findings informed the development of a 5-point Likert scale questionnaire (Tourangeau, et al., 2000).

In the quantitative phase, the sample population for the study was 36 organisations purposively drawn from a list of fully registered consultancy and contracting organisations with the State ministry and Housing Corporation based on their active involvement in DBLCH projects delivery in Imo state Nigeria. Four (4Nr) questionnaires each were distributed to the thirty six (36) organisations targeting the project managers, quantity surveyors and designers presumed to possess the requisite knowledge as it pertains to delivery cost performance of DBLcH projects based on their professional background and experience. The respondents were requested to identify the waste factors influencing poor cost performances within the context of DBLcH projects in Imo state Nigeria, categorized the waste factors based on their relationship to design and construction and rate their level of influence on the project cost performances. They were also requested to provide other waste factors relevant that were not captured in the questionnaire.

The quantitative data gathered from the questionnaires were analyzed using percentages and Weighted Average Mean Score (WMS) and presented in tables and bar charts. The decision rule adopted was that WMS between 4.5- 5 represent very high influence and 4.0- 4 represent high influence on the project cost performances. Therefore any factor with WMS within the 4.5- 5 ranges is regarded and used for further analysis employing the Pareto diagram. The Kruskal Wallis test was also conducted to determine if there were any significant differences in the perception of the different groups of respondents on the waste factors influencing poor project cost performances on DBLcH projects in Imo state Nigeria. This is to support interpretation of the findings. The data analysis and findings are presented in the following section of the paper.

4. FINDINGS AND DISCUSSION

A total of 144 questionnaires were distributed to the selected 36 organisations and 85 questionnaires completed and returned were used for the analysis. A response rate of 59.03 percent was attained and the Cronbach alpha reliability test conducted on the responses yielded an acceptable co-efficient of 0.782 and therefore suitable for further analysis. The results obtained from the analysis of gathered data are presented in this section.

4.1 Identification of waste factors influencing DBLcH project poor cost performances

Table 1 and 2 shows the identified waste factors influencing DBLcH project poor cost performances by the respondents who participated in survey. The respondent based on their experiences categorized the identified factors under design and construction related waste factors corroborating classifications in earlier studies by Wahab & Lawal, (2011) and Withana-Gamage, , (2012).

Table 1. Design stage related Contextualised Waste factors

Waste factors	WMS	Group rank	Overall rank
Poor communication and coordination during design	4.85	1	1
Insufficient information during construction	4.75	2	3
Design changes	4.65	3	4
Inadequate project planning	4.26	4	7
Errors in quantity estimates	4.09	5	10
Unclear client brief	3.77	6	13
Poor site investigation	3.76	7	14
Poor detailing	3.63	8	15
Selection of Low quality materials	3.62	9	16
Construction technology adopted	2.10	10	31

Source: Researcher's field survey, 2014

Table 2. Construction related waste factors

Waste factors	WMS	Group rank	Overall rank
Poor supervision	4.80	1	2
Inappropriate material storage facilities	4.50	2	5
Poor workmanship	4.38	3	6
Delay in material delivery	4.25	4	8
Mistakes during construction	4.20	5	9
Incompetent site workers	4.05	6	11
"Opening up" for inspections	3.94	7	12
Poor communication and coordination amongst contractors work team	3.58	8	17
Inclement weather	3.53	9	18
Frequent Interference of client in house supervisory team	3.40	10	19
Inappropriate construction methods	3.23	11	20
Delay in funding	3.03	12	21
Incompetent subcontractors	2.90	13	22
Over allowances of materials	2.81	14	23
Government bureaucracy delays in statutory approvals	2.70	15	24
Poor access roads	2.64	16	25
Excess material overproduction	2.60	17	26
Community restiveness	2.57	18	27
unforeseen ground conditions	2.54	19	28
Inappropriate material delivery methods	2.50	20	29
Burglary	2.41	21	30

Source: Researcher's field survey, 2014

It is observed from Table 1 that ten waste design related waste factors were identified by the respondents contextual to DBLcH project cost performances. based on the perceptions of the respondents, Poor communication and coordination of design team ranks 1st with a weighted average mean score of 4.85 followed by Insufficient information during construction, Design changes, Inadequate project planning and errors in quantity estimates ranking, 2nd, 3rd, 4th and 5th with average mean scores of with a score of 4.75,4.65,4.26 and 4.09. The table also reveals that the least occurring waste factor is construction technology adopted with a score of 2.10.

From Table 2 it is also observed that twenty-one construction related waste factors were identified influential on DBLcH project cost performances by the respondents. Analysis based on the respondents ratings show that poor supervision ranks 1st with a weighted average mean score of 4.80, followed by inappropriate material storage facilities, Poor workmanship, Delay in material delivery, Mistakes during construction, incompetent site workers ranking 2nd, 3rd, 4th 5th 6th within the group with average mean scores of 4.50, 4.38, 4.25, 4.20 and 4.05 respectively. The table also reveals that the least waste factors occurring on the projects are unforeseen ground conditions, inappropriate material delivery methods and burglary with mean scores 2.54, 2.50 and 2.41 respectively. The identified construction related waste factors from literature are also inherent in DBLcH project delivery. However, it is observed that community restiveness were peculiar within the Nigerian based literature (Adewuyi & Odesola, 2015; Adewuyi & Otali, 2013; Akinde, 2012).

From Table 1 and 2 it is observed that five (5Nr) waste factors had WMS ratings above 4.5 and are regarded to be used for further analysis using the Pareto diagram.

4.2 Prioritizing Waste Factors influencing DBLcH project cost performances using Pareto Diagram Tool

Based on the Pareto Diagram analysis as shown in Figure 3, five (5Nr) waste factors were highly prioritized.

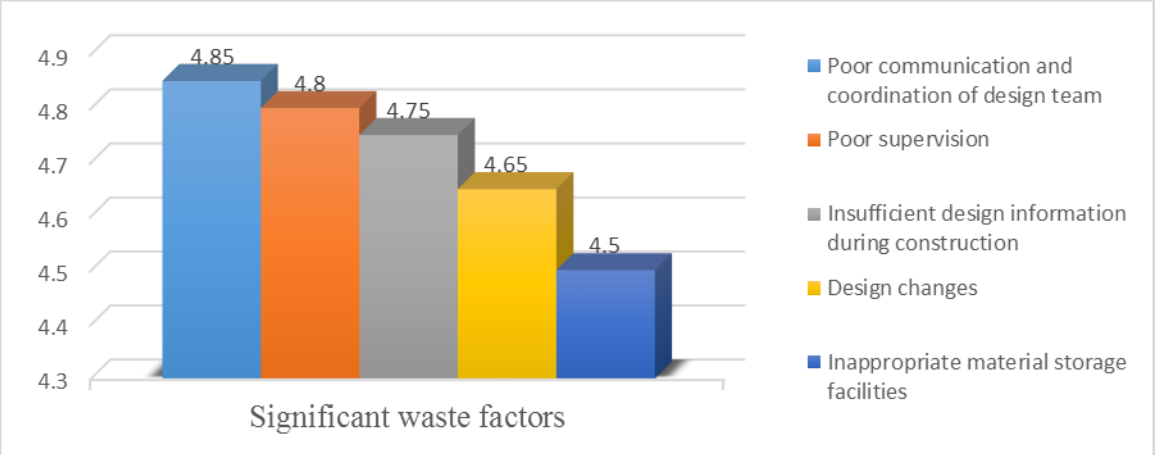


Figure3. Prioritized significant waste factors
Source: Researcher's field survey, 2014

These factors include: poor communication and coordination of design team, poor supervision, design changes and inappropriate material storage facilities and insufficient information during construction with ratings 4.85, 4.80, 4.75, 4.65 and 4.50 respectively. Three (3Nr) of the waste factors were design related whereas the other two (2Nr) were construction related.

Further analysis based on the Pareto diagram was used to further validate the findings based on their contribution to waste generation on DBLcH projects. The results are as shown in Figure 4.

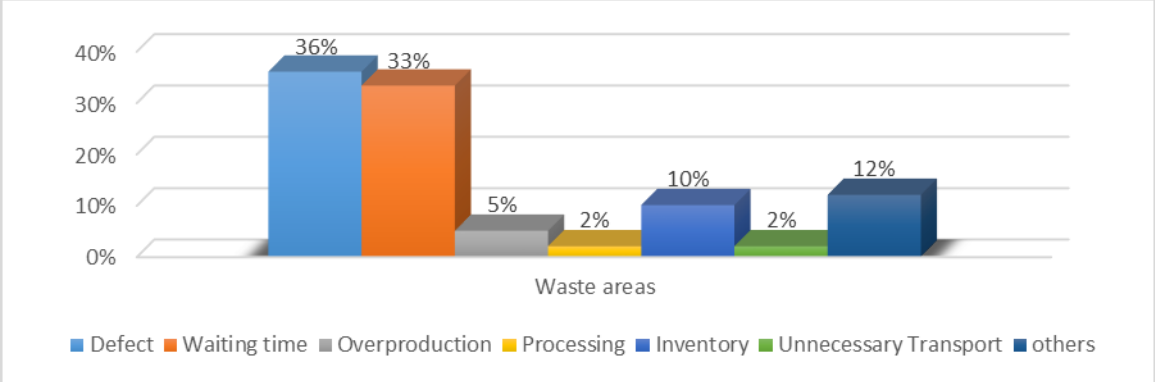


Figure.4. Distribution of Waste factors in relation to waste areas
Source: Researcher's field survey, 2014

Based on Figure 4, respondents affirmed that the prioritized waste factors significantly contribute to seven waste areas affecting cost performances on DBLcH projects. From the analysis 36 % of the respondents confirmed that the prioritized waste factors contributed to Defects waste, 33% confirmed that the prioritized waste factors significantly to waiting time waste, 12% confirmed that the prioritized waste factors contributed to "other type of waste" 10% confirmed that the identified waste factors contributed to inventory waste, 5% confirmed that the prioritized waste factors contributed overproduction waste and 2% confirmed that the prioritized waste factors contributed to both processing and unnecessary transport.

4.3 Kruskal Wallis Test of Significant Difference between Group Respondents

This test was employed to identify if there were significant differences in the perceptions of group respondents, on the ratings of the identified waste factors influence cost performances of DBLcH projects in the Imo state LcH sector. The result from the Kruskal Wallis test carried out as shown in Table 3.

Table 3. Kruskal Wallis Test Statistics[a,b]

	Total for Waste factors
Chi-Square	2.000
df	2
Asymp. Sig.	.368

Source: Researcher's field survey, 2014

The result of the Kruskal Wallis Test Statistics as presented in Table 3 shows that the p-value is 0.368. This value is greater than 0.05 significant level set for the test. This implies that there is no significant difference in the overall perception of the respondents on the waste factors identified influencing DBLcH projects cost performance in Imo state Nigeria. The responses show that the project team comprised of Contractor, consultants and contractor teams who are presumed to have managerial influence on the project cost management they have same view on the various factors identified. Therefore, the study findings can be generalized for the benefit of the project team involved in DBLcH projects in the Imo state LcH sector in Nigeria.

Discussing further on the results in Tables 1 -3 and Figures 3, 4 and 5 it clearly indicate that respondents are in agreement that waste occurs on DBLcH projects and waste factors influences poor cost performances of DBLcH projects in Imo state. The findings also revealed that design related factors are highly influential waste factors on the projects. These findings corroborates previous findings by Osmani, Glass and Price (2008), Nagpan et al. (2012) Muhwezi, et al., (2012) and Adewuyi & Otali (2013) on various construction projects. The results from The results in Tables 1 -3 and Figures 3, 4 and 5 also indicated that poor communication and coordination of team during design, poor supervision, design changes, inappropriate material storage facilities and insufficient information during construction, were highly ranked and prioritized waste factors with the most significant influence on DBLcH projects poor cost performances. These waste factors are further discussed.

- Poor communication and coordination during design. Effective communication means that the information is provided in the right format, at the right time, and with the right impact. Therefore the efficient and effective coordination of the design process will depend on the quality of communication. In a case where these is lacking implies poor communication and coordination. This waste factor has been identified to lead to design errors, time loss and eventual construction failure amongst other adverse effects (Tipli, et al., 2014). According to Akinde, (2012) this waste factor is the most common cause of various types of waste in DBLcH projects and he affirms corroborations to earlier studies by Bertelsen (2004).

Therefore, various professionals in the design phase must effectively disseminate information and the project manager should effectively coordinate the team to facilitated necessary information to develop detailed drawings, specifications and elucidate construction methods (Aishawi & Underwood, 1999 cited in Olaniran, 2015). This could be achieved using appropriate formal, informal and semi-formal mediums at the design phase of DBLcH projects.

- Poor supervision is the inability of the contractor onsite supervisors to plan and direct site activities, as well as communicate adequately with site workers. This can result in waste increasing amount and cost of rework. This factor is identified to have significant influence on poor cost performances of DBLcH projects and contribute to all the seven areas of waste on the project. Whereas Alwi et al., (2002) and Akinde, (2012) did not rate it as significant, in a more recent study by Adewuyi and Odesola, (2015), it was identified significant. This could result from the contextual and contemporary changes in practice. Therefore can be viewed as an emerging finding contextual to DBLcH projects in Imo state Nigeria. To mitigate the effects of poor supervision on poor cost performance, engaging the right professionals as site supervisors is very important. Also upgrade training on contemporary skills for effective site supervisions such be encouraged by the contractor. This will assist in mitigating poor site supervision.
- Design changes is defined as variations or any change to the scope of the work as defined by the contract documents following the creation of legal relations between the principal and contractor (Choy & Sidwell 1991 cited in Alwi et al., 2002). This waste factor is also prioritized as a significant waste factor that could lead to loss of time, demolitions and other actions that leads to cost increase on the DBLcH projects. For example waiting for variation orders could lead to delay which may have cost implications. Also, if a structure has already been constructed, a change in design may result in demolition. This finding is seen to corroborate previous findings by Ekanayake and Ofori (2000), Muzhewi et al., (2012) and Akinde, 2012) who affirm that this waste factor is a very significant source of construction waste with high cost implications. As a result, effective collaboration among project team during design stage to grasp all necessary information needed for effective design is essential. During construction, a design change control evaluation approach should be established. These will help mitigate the barrier of Design changes.
- Inappropriate material storage facilities expose materials to possible damage from inclement weather conditions or from other site activities resulting in material waste amongst others. This finding corroborates previous works by Muhwezi et al.,(2012) and Enshassi, (1996) who also identified this waste factor as one of the major waste factors facing building projects in the Gaza Strip and Uganda respectively.

Therefore there is need for making appropriate site planning and provision for material storage and relevant training for handling sites facilities by provided for the site storage staff provided by the contractor. This will help mitigate the barrier of inappropriate material storage facilities on site.

- Insufficient information for and during construction: This could have an adverse effect on the level of work done on site. It would slow down project completion and lead to extra cost. Unclear Information makes it difficult for the contractor to develop well detailed work breakdown structure which impacts adversely on work process. According to Tipili et al., (2014) this factor ranked second most significant factor affecting the level of work done on project sites in Nigeria. Therefore, adequate information should be provided in well detailed contract documents as well as when requested during construction in a timely and effective manner. This will serve as a mitigating measure.

5. CONCLUSION AND RECOMMENDATION

Waste has been identified as a contributing factor to poor cost performances challenging the effective supply of LcH in Nigeria and particularly in Imo state. The occurrences of waste have been attributed to actions within the project delivery process. The aim of this paper is to identify the waste factors influencing DBLcH project cost performances in Imo state Nigeria. Literature revealed several waste factors related to both design and construction that generate waste on building and housing projects. The findings from the literature provided a platform for the development of the questionnaire. The results from the analysis of questionnaire survey obtained from the project teams on DBLcH projects operating in Imo State Nigeria revealed 31 waste factors influencing poor DBLcH project cost performances. 21 waste factors were construction related, while 10 were design related.

Findings reveal that Five (5Nr) prioritized waste factors with very high significance influence on DBLcH project cost performances. These include, insufficient design information needed for construction, poor communication and coordination of the design team members, design changes, poor site supervision and inappropriate material storage facilities.

Based on these findings, it is possible to deduce that the prioritized five waste factors possess high significant influence on poor cost performances of DBLcH project in Imo state Nigeria. Therefore are problem areas which require very important attention of the project team towards eliminating waste and improving delivery cost performance of DBLcH projects in the state. It is recommended that the project team adopt the mitigation measures proffered in this paper towards improved cost performances.

The findings from this paper supports work conducted by previous researchers that there waste factors affect the performance of construction projects. It also contributes to the body of existing knowledge of waste factor identification in Nigeria particularly beneficial to the project team. This is because the findings are expected to increase their awareness on the significant factors influencing poor cost performances of DBLcH projects and how the factors can be mitigated based on the recommended measures proffered towards improved project cost performances in Imo state Nigeria.

Finally, this paper has made some significant contributions by identifying waste factors from a generic view point and contextualizing such in DBLcH project delivery in Imo state Nigeria. However, the study findings are limited only to DBLcH project in the LcH sector in Imo state. Therefore, further studies across LcH projects delivered through other procurement strategies are encouraged to identify waste factors that could be influencing their cost performances. This will facilitate exhaustive findings on waste factor identification towards improve project cost performances in the LcH sector of Imo state.

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AN EMPIRICAL ASSESSMENT OF INEFFECTIVE COMMUNICATION INHERENT IN THE ATTRIBUTES OF MASS HOUSING PROJECTS

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ABSTRACT

Mass housing projects (MHPs) continue to experience significant communication difficulties among the project teams in their delivery which is largely perceived to be due to the influence of its unique characteristics. However, what is less known is the extent and nature of the communication problems caused by the unique features of MHPs. Through a structured questionnaire survey, empirical data were drawn from mass housing project team leaders of real estate organizations who have been actively involved in the execution of mass housing projects in Ghana. The crux of the survey was to identify the communication ineffectiveness among the project team that are inherent in the unique features of MHPs. Through the use of factors analysis as the analytical approach, three underlying clusters named in order of their significance as component 1: Access to information challenges, component 2: Challenges in flow of information and component 3: Import of information challenges were identified as the main communication ineffectiveness inherent in the unique features of MHPs experienced among the project team. These findings provide the necessary foundation towards planning and formulating communication strategies as well as developing behavioural skills needed to engender communication effectiveness in mass housing delivery. The findings 'misunderstanding' and lack of defined roles' emerging as communication ineffectiveness peculiar to MHPs also reinforce the uniqueness of mass housing projects compared to traditional construction building projects and thus useful for practitioners to gain insight into the project attributes and management intuition on MHPs.

Keywords: ineffective communication, mass housing projects, project team communication

1. INTRODUCTION

Effectiveness of project team communication for the design and management of construction projects are becoming increasingly important due to the growing technical

and organizational complexities of construction projects. Communication effectiveness on mass housing project is deemed to be influenced by its unique nature and characteristics which additionally presents unique managerial challenges (Enshassi, 1997; Zairul and Rahinah, 2011; Ahadzie et al., 2014). According to Ahadzie et al. (2007), mass housing projects are unique and this imposes significant challenges in its management intuition and delivery. However, it has been emphasized that the ultimate step towards communication improvement is by identifying the challenges and problems that confront the teams' communication performance (Thomas et al., 1998; Xie, 2002). Unfortunately, there has not, as yet, been any work that empirically examines and explicitly establishes communication problems among mass housing project team inherent from its unique particularities and features especially in developing countries. Effective communication is continually identified as very crucial towards project success and team effectiveness especially in multi-disciplinary, interdependent, multi-cultural and collaborative task functional project teams on building projects (Liu, 2009; Reeta and Neerja, 2012; Remidez and Jones, 2012). Mass housing project teams exhibit unique composition and participants that require effective communication to effectively perform to engender the needed success on mass housing delivery. Studies have indicated that MHPs exhibit unique attributes which have huge implication for its management compared to traditional 'one-off' construction building projects (Zairul and Rahinah, 2011; Ogunsanmi, 2012; Ahadzie et al., 2014). The communication ineffectiveness inherent in the unique characteristics of mass housing could be said to be exhibited in the communication task performance and the communication information flow process.

In recent times, the adoption of mass housing delivery as a veritable approach coupled with the role of communication towards managerial efficiency make the need for an empirical assessment towards improvement in mass housing delivery the more significant. Unfortunately, despite the acknowledgement of the uniqueness of MHPs, and its perceived contribution to communication problems among the project team, to date, studies fail to empirically specify the exact communication ineffectiveness on mass housing projects (see Enshassi, 1997; Zairul and Rahinah, 2011; Ibem et al., 2011; Ahadzie et al., 2014). Additionally, notable studies on communication ineffectiveness measures have tended to focus on traditional one-off projects which differ significantly from other project of unique attributes. Hence there is significant limitation in the application and generalization of such studies across all project typologies (see Thomas et al., 1998; Murray et al., 2000; Xie et al., 2010). However, emerging studies continue to suggest improvement in communication performance among the team as very critical (Murray et al., 2000; Xie, 2002; Xie et al., 2010). Hence identifying the communication problems among the project team remains a viable step towards devising strategies tailored towards communication improvement.

The primary objective of this study is to identify the communication ineffectiveness among mass housing project teams inherent in the unique features. The findings from this paper is thus considered very important for engendering managerial efficiencies and communication effectiveness towards success on current and future mass housing projects.

2. DEFINITION AND UNIQUE FEATURES OF MASS HOUSING PROJECTS

The term Mass housing projects (MHPs) have been perceived from various perspectives which consequently have contributed to lack of consensus in its definition. The dominant definition of the term is purely focused on the large scale production of housing

development projects as hinted by Mahdi (2004). Unfortunately, several definitions fail to account for certain unique features of mass housing projects such as project environment, contractual arrangement, physical, organizational and operational attributes, design, procurement, construction and management intuition. In the context of this paper, mass housing has been defined as:

The design, construction and management of standardized single or multiple domestic house-units usually in the same or multiple sites and geographical locations executed within the same project scheme and under the same management and contract (Adinyira et al., 2013; Kwofie et al., 2014).

The unique physical features of mass housing projects are depicted by multiple sites for various units, multiple standardized design-units in scheme, and multiple geographical locations for schemes (Blismas et al., 1999; Khalid, 2005; Zairul and Rahinah, 2011; Ahadzie et al., 2014). The organizational unique features are evidenced in its complex network of team relationship, multiple interdependent sub-contracting under scheme and complex network of procurement systems (Oladapo, 2002; Ogunsami, 2012; Adinyira et al., 2013). The operational task functions that characterize the management of MHPs define its unique operational features. These are defined by duration schedules and planning on housing units, organization of preliminary activities and contract packaging and management concept for labour contracting and subcontracting.

Mass Housing project environment involves interdependent, collaborative and multi-disciplinary team participants. This attribute makes project participants who communicate by adapting to the project's characteristics and organizational context are more likely to be successful and promote team effectiveness. To this effect, a clear understanding of the critical communication problems inherent from the mass housing project environment and features will assist project teams to appropriately develop and adopt plans and strategies towards effective communication.

2.1 Conceptual Framework: Attributions to Communication Ineffectiveness on Mass Housing Projects

The theoretical underpinning of communication effectiveness measure is that communication is contextual and lies within behavioural domain and that internal and external factors are the main attributions of communication performance outcome (Weiner, 2006; Salleh, 2008). The internal factors relate to the communicator's ability and effort in the communication tasks whereas the external factors relate to the communication environment, task difficulty and the communication context. By drawing on the attribution theory and the practical mass housing project environment, communication competencies and the unique features of mass housing were perceived as the main attributions of communication effectiveness among mass housing project teams. The unique features of mass housing inherent from it physical, organizational and operational attributes are accounted as the external factors that significantly influence the

communication information flow outcome among the mass housing project teams (Enshassi, 1997; Kwofie et al., 2014a).

Continuously, the significance of attaining communication effectiveness has been highlighted by several studies. Likewise, it is well noted that, the theoretical positions these studies have traditionally adopted measuring communication ineffectiveness as the valid approach to assessing communication performance (see Guevera and Boyer, 1981; CII, 1997; Thomas et al., 1998; Xie, 2002, Liu, 2009). Additionally, the performance indicator approach has remained the dominant method for communication effectiveness measures in the construction industry through a quantitative inquiry (see Guevera and Boyer, 1981; CII, 1997; Thomas et al., 1998; Xie, 2002; Liu, 2009). Additionally, the CII (1997) study has remained the most extensively adopted in several recent studies on communication performance assessment and thus considered to be very effective (see Thomas et al., 1998; Mead, 1999; Murray et al., 2000; Xie et al., 2010; Liu, 2009). Hence, in ensuring triangulation and theoretically validity, this study adopted the same approach from the studies above mainly being founded on a quantitative paradigm, research design and the choice of survey in the collection of the empirical data.

The emergence and acceptance of the Construction Industry Institute (CII) indicator approach is underpinned by the fact that CII's model incorporates communication variables from a humanistic viewpoint and social network for communication analysis which reflect the global construction project environment of social behavioural interactants. These indicators relate to the accuracy, completeness, understanding, gate keeping, timeliness, barriers and procedures of the communication on the construction project (CII, 1997). Against this, the measure of the communication problems in this paper has been perceived as the quality of the communication composition and flow among the project team due to the influence of the unique features of mass housing. Hence, it is theorized that, the communication effectiveness outcome on mass housing projects due to the influence of the unique features of mass housing projects can be conceptualized in Figure 1.0.

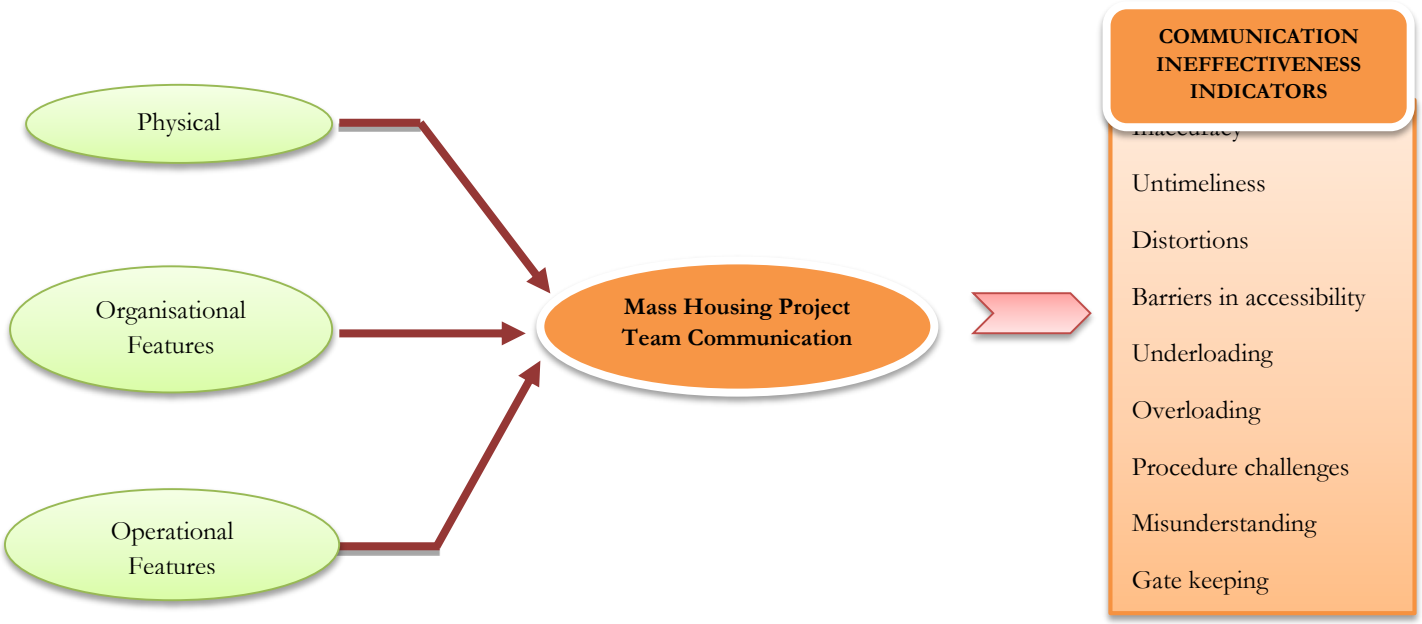

Figure 1.0: Conceptual Model for the influence of Mass Housing Project Features on Team Communication Effectiveness

By drawing on the practical and theoretical perspective of the mass housing project environment and the traditional construction industry in Ghana, the communication effectiveness indicators in the conceptual model were operationalized as indicated in Table 1.0 below.

Table 1.0: Explanation of the Communication Ineffectiveness/Problem Variables

Indicators	**Explanatory Variables**
Inaccuracies	Receiving conflicting information from team participants. Lack of consistency in communicated information leading to lack of coordination among project team. Lack of conciseness in communicated information among the project team.
Untimeliness	Late delivery of needed communicated information
Distortions	Persistent change in meaning of communicated information. Persistent change in content of communicated information. Lack of clarity in communicated information resulting in different interpretations. Lack of coherency in communicated information resulting in different interpretations.
Barriers	Difficulty in accessing communicated information from channels
Underloading	Receiving less information than expected from team participants for tasks
Overloading	Receiving more information than necessary for the tasks
Misunderstanding	Misunderstanding of communicated information
Gate keeping	Withholding of part of the information by the one who controls communication Withholding of whole of the information by the one who controls communication
Procedure	Difficulty in disseminating information among project team Lack of defined roles and responsibilities among members of the team leading to communication failure

Source: CII, (1997); Thomas et al., (1998); Liu, (2009)

3. STUDY METHODOLOGY

The empirical data to meet the main objective of this paper were collected through structured questionnaires administered in a survey. This was conducted on the project team leaders at various mass housing project construction sites of active members of the Ghana Real Estate Development Association (GREDA). Practically in Ghana, GREDA remains the umbrella body of real estate mass housing developers, hence their choice as the sampling frame. The focus on the project team leaders was also motivated by the fact that in mainstream management practice and project management, the overall performance assessment is undertaken by team leaders or managers (Edgar and Lockwood, 2008). Hence, in the survey, the project team leaders at the various project sites were chosen as the unit of analysis to assess the frequency of the various communication ineffectiveness that occurs on their mass housing projects.

The targeted respondents for this study were drawn using purposive sampling technique of active members from the registered list of members of GREDA. The project team leaders managing various projects sites of the sampled active members of GREDA were invited to indicate the frequency of communication ineffectiveness occurring in their project communication based on a five-point Likert rating scale interpreted as: very frequent = 5, frequent = 4, occasionally = 3, rarely = 2 and never = 1).

Out of the total number of 402 registered GREDA members on the standing register, 369 were identified to have complete particulars in address, location and contact numbers and were active in operation. A total of 109 were reached with most of them having more than one project sites. Consequently, a total of 158 questionnaires were retrieved from the total 202 questionnaires distributed to various construction sites of 109 active GREDA members reached representing a response rate of 78%. Similar studies by Ahadzie et al., (2007 & 2014) yielded 37% and 55% response rate respectively. Hence, it can be said that this response rate recorded can be perceived as high and adequate for the statistical analysis. It could be noted that this response rate was borne from the continuous follow up through phone calls, e-mails and personal visits to the respondents. The questionnaire was divided into two sections: A and B. Section A encompasses background information of respondents which included their profession, and years of experience in mass housing delivery. The Section B relates to the main objective of this paper which is to examine the communication ineffectiveness among mass housing project teams. Factor analysis was used to analyze the data collected using statistical package for social sciences (SPSS) version 17. Descriptive statistics were conducted on the background information. The application of the factor analysis was to evaluate which of the variables could be assessing aspects of the same underlying constructs related to communication problems being experienced among the mass housing project team. The potential of factor analysis to identify cluster of related variables as well as reducing large number of variables into a more condensed and easily understood framework justifies its suitability (Motulsky, 2005; Field, 2009). By adopting a Principal Component Analysis (PCA) approach in tandem with similar studies (see Ahadzie et al., 2007; Liu, 2009), the results and discussion of the main ineffective communication among the project team on mass housing projects are presented in the following section.

4. DATA ANALYSIS, FINDINGS AND DISCUSSIONS.

4.1 Analysis of Background Information

The descriptive statistics showing the professions and years of experience of the various respondents acting as leaders of the project team is presented in Table 2.0.

Table 2.0: Background Information on Respondents (Project Team Leaders)

Profession	**Frequency**
Project Manager	26 (*17%*)
Architect	43 (*27%*)
Quantity Surveyor	63 (*39%*)
Civil/Structural Engineer	26 (*17%*)
TOTAL	**158 (100%)**

Years of Experience in industry	**Frequency**
0-5 Years	18 (*11%*)
6-10 Years	82 (*52%*)
11-15 Years	32 (*20%*)

16 Years and Above	26 (*17%*)
TOTAL	**158 (100%)**

Field Data

There were a total of 158 project team leaders at various mass housing construction sites who responded to the survey. The respondents' professional background as mass housing project team leaders were: Project manager (17%), Architect (27%), Quantity Surveyor (39%) and Civil/Structural Engineer (17%). This suggests that, Quantity surveyors are the dominant professionals acting as project team leaders on mass housing projects in Ghana. From Table 2.0, it is obvious to state that over 85% of the respondents have had over 5years of experience on mass housing project delivery in the Ghanaian housing industry. From the above statistics on the respondents' demographic information as project team leaders on mass housing, there is enough evidence that the experience and expertise of the respondents can be considered as highly adequate, respectable and are more likely to give accurate response on the subject under study. The responses offered can thus be regarded as important and reliable, and thus results drawn from their responses is more likely to reflect a sound and credible representation of the communication ineffectiveness among mass housing project teams in the mass housing delivery in Ghana.

4.2 Factor Analysis- Communication Performance Ineffectiveness (Problems) among the Project Team on MHPs.

The factor analysis test proceeded a Kaizer–Meyer–Olkin (KMO) and Bartlett test of sphericity to determine the sampling adequacy and the identity of the population matrix. These are conventional requirements for determining the trustworthiness and reliability of factor analysis results (Field, 2009).

Table 3.0: KMO and Bartlett's Test[a]

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.672
Bartlett's Test of Sphericity	Approx. Chi-Square	412.828
	df	120
	Sig.	.000

a. Based on correlations b. Cronbach's Alpha = 0.786

From Table 3.0, the KMO test yielded 0.672. According to Hair et al. (2014), the Kaizer–Meyer–Olkin (KMO) measure of sampling adequacy of 0.600 is considered very adequate and thus affirm the adequacy of the sample size for the factor analysis in this paper. Ideally, a KMO value of 0.5 is recommended in literature for sample size adequacy to merit factor analysis (Field, 2009). Additionally, the result of the Bartlett test of sphericity recorded 412.828 with an associated significance of 0.000 (see Table 3.0). The import of this is that, there are potential correlations among the variables and thus indicative of a reasonable potential cluster forming factors from the variables (Field, 2009; Hair et al., 2014). Likewise, the significance of the sphericity value suggests that, the population matrix realized was not an identity matrix. Also a Cronbach's alpha of 0.786 was realized suggesting an acceptable level of internal consistency and reliability in the measures and the scale (Field, 2009; Hair et al., 2014). Conventionally, a Cronbach's alpha of 0.70 is considered reasonably good for scale reliability and internal consistency of the instrument (Field, 2009).

Prior to conducting the PCA, communalities extracted on each variable were assessed and presented (see Table 4.0). The communalities are critical and useful in deciding the variables that have to be finally extracted (Field, 2009). This is because by connotation, the communalities typify the total amount an original variable shares with all other variables included in the factor analysis (Field, 2009; Hair et al., 2014).

Table 4.0: Communalities Extracted

	Initial	Extraction
Receiving conflicting information from team participants	1.000	.678
Lack of consistency in communicated information leading to lack of coordination among project team	1.000	.651
Lack of conciseness in communicated information among the project team	1.000	.313*
Misunderstanding of communicated information	1.000	.681
Receiving less information than expected from team participants for tasks	1.000	.758
Receiving more information than necessary for the tasks	1.000	.422*
Late delivery of needed communicated information	1.000	.638
Persistent distortion in meaning of communicated information	1.000	.651
Persistent change in content of communicated information	1.000	.451*
Lack of clarity in communicated information resulting in different interpretations	1.000	.585
Lack of coherency in communicated information resulting in different interpretations	1.000	.430*
Withholding of part of the information by the one who controls communication	1.000	.275*
Withholding of whole of the information by the one who controls communication	1.000	.466*
Difficulty in accessing communicated information from channels	1.000	.717
Difficulty in disseminating information among project team	1.000	.582
Lack of defined roles and responsibilities among members of the team leading to communication failure	1.000	.733

Extraction Method: Principal Component Analysis. * extractions less than 0.50

From Table 4.0, the average communality of the variables after extraction was 0.67. According to Field (2009), an average communality of the variables after extraction should be above 0.60 to support reliable results and interpretations in factor analysis. Hence, the communalities extracted support the use of factor analysis on the variables. Also, the conventional rule about communality values in factor analysis suggests that, a potential significant variable must yield an extraction values (eigenvalues) greater than 0.50 at the initial iteration (Field, 2009; Hair et al. 2014). This criterion determines the inclusion or removal of the variable for further detailed analysis. From the results presented in Table 4.0, six (6) variables had their extracted enginevalues less than the 0.50 cut-off point, suggesting that they do not explain much variance and thus were subsequently dropped from the analysis (Field, 2009; Hair et al., 2014). The remaining ten (10) variables with communalities above 0.50 were carried to the factor analysis extractions.

Following the appraisal and the conclusion of all necessary and mandatory pre-checks and preliminary tests of sampling adequacy, population matrix identity and scale reliability, the data yielded from the questionnaire survey on the communication ineffectiveness among mass housing project team was tested. The test was conducted using the PCA approach by adopting conventional varimax rotation for robust results in factor analysis (Field, 2009). By following this approach, the eigenvalue and factor loading were set at conventional high values of 1.0 and 0.5 respectively as suggested by Field (2009), Liu (2009) and Hair et al. (2014). Likewise, by adopting the latent root criterion on the number of principal components to be extracted, the total variance explained by the variables as contained in Table 5.0 indicate that, three components should be extracted from the data as their respective eigenvalues were greater than 1.00. Similarly, the Rotated Component Matrix[a] in Table 6.0 also affirmed three distinct component factors as each variable dominantly belonged to a unique factor (component). From this, it could be suggested that, these components that emerged could be perceived as the dominant underlining communication ineffectiveness experienced among mass housing project teams.

Table 5.0:Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	3.561	35.611	35.611	3.561	35.611	35.611	2.995	29.955	29.955
2	1.942	19.417	55.028	1.942	19.417	55.028	2.238	22.238	52.193
3	1.328	13.283	68.312	1.328	13.283	68.312	1.597	15.970	68.312
4	.726	7.265	75.577						
5	.645	6.446	82.022						
6	.565	5.652	87.675						
7	.451	4.508	92.183						
8	.411	4.109	96.292						
9	.313	3.129	99.421						
10	.058	0.579	100.000						

Extraction Method: Principal Component Analysis.
Source: Field Data

From the results presented in Table 5.0, the total variance explained by each of the three extracted component is stated as: the principal component one (1) accounted for 35.611% of the total variance whereas the second principal component accounted for 19.417% of the total variance. The third and final principal component extracted on the other hand accounted for 13.283% of the total variance in the measure of communication ineffectiveness experienced among the project team on mass housing projects. From this, it could be seen that, the total three components extracted cumulatively accounted for 68.312% of the total variance which is above the recommended minimum of 50% (Ahadzie et al., 2007; Field, 2009). The Rotated Component Matrix in Table 6.0 reveals all the variables contained in the various components extracted.

Table 6.0: Rotated Component Matrix[a]

	Component		
	1	**2**	**3**
Late delivery of needed communicated information	.896		
Lack of consistency in communicated information leading to lack of coordination among project team	.868		
Difficulty in accessing communicated information from channels	.859		
Difficulty in disseminating information among project team	.703		
Lack of defined roles and responsibilities among members of the team leading to communication failure		.834	
Persistent distortion in meaning of communicated information		.724	
Lack of clarity in communicated information resulting in different interpretations		.681	
Receiving less information than expected from team participants for tasks		.599	
Receiving conflicting information from team participants			.907
Misunderstanding of communicated information			.682

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

The adoption of the rotated component matrix over the ordinary unrotated matrix was influenced by the ability to yield and achieve simple robust structure aiding easy identification and interpretation of results (Field, 2009). Beside, all the components extracted had more than one variable on it, suggesting that the results yielded are reasonable and devoid of complex structures (Field, 2009). Following a critical appraisal of the likely interrelations among the variables contained in each component and the factor loadings, a more suitable name that encapsulates the ineffective communication explained by the components was derived. By drawing on the relationship among the variables in each of the components, *Component 1* was labeled 'Access to information challenges'. *Component 2* on the other hand was labeled 'Challenges in flow of information' whereas *Component 3* was named 'Import of information challenges'. In the following section, the discussion on the various components is presented.

4.3 Discussion: Component 1: Access to Information challenges

From Table 6.0, four communication ineffectiveness indicators were extracted for this component. The variables in this component and their respective factor loadings in brackets were *late delivery of needed communicated information (89.6%), Lack of consistency in communicated information leading to lack of coordination among project team (86.8%), Difficulty in accessing communicated information from channels (85.9%) and Difficulty in disseminating information among project team (70.3%).* From Table, 5.0, the cluster of variables in this factor accounted for about 35.611% of the total variance in communication ineffectiveness among the mass housing projects team. It could be deduced that the variables in the component explains communication ineffectiveness related to untimeliness, information inaccessibility and inconsistencies.

According to Dainty et al. (2006), timely delivery of project related information being communicated is considered very crucial to the smooth progress and success of construction projects in the construction industry. Hence untimely communication can be of adverse effect to project performance. From the results, 'late delivery of needed project related communicated information has been identified as very significant communication issues among mass housing project teams. Studies by (2009) and Xie et al. (2010) revealed that, late delivery of communicated project related information required by project participants was common on traditional construction projects in Hong Kong. This finding suggests that the experience of late delivery of communicated information is common to both traditional 'one-off' projects and mass housing projects. It is emphasized that timely delivery of project related information is crucial towards building trust and improving team productivity (Henderson, 2008), communication satisfaction among work groups, teams and employees (Madlock et al., 2009) and team cohesion at the design and construction stage (Gorse and Emmitt, 2007).

Dainty et al. (2006) and Gorse and Emmitt (2007) also established that, the communication medium adopted on construction projects significantly influence the timeliness of shared communication. However, Azu (2014) revealed that, face-to-face meeting, telephone conversation and personally delivering project related information remains the dominant medium used on mass housing projects. It can be said that these media are perceived as traditional ones which unfortunately contribute to delays in information delivery (Liu, 2009). Practically, from the result, it can be suggested that, late delivery of communicated information indeed provide evidence to the degree of potential influence of mass housing unique features especially multiple project sites for housing units, different geographical location and nature of communication infrastructure on sites. Similarly, mass housing projects exhibit seemingly complex project relationships inherent from their procurement styles adopted (Oladapo, 2002; Ogunsanmi, 2012). Traditionally, mass housing project delivery in the Ghanaian context involves the packaging of housing units under different construction contractors in different geographical locations and multiple sites management under the control of same project teams. This means that sharing of communication is done across different sites and locations. Indeed, Blismas et al. (1999) and Ahadzie et al. (2014) affirmed that the multiple construction site nature of construction projects especially mass housing presents unique communication challenges often leading to delays in receiving information. Hence, these could be plausible attributions for the untimeliness in communication among the project team.

Also, other variables which together account for significance variance in communication ineffectiveness relate to lack of coordination and barriers to accessing communicated information on mass housing projects. Studies by Xie (2002) revealed that lack of coordination in project communication was the most dominant communication problem among project participants at the design phase. The development was primarily attributed to the lack of role and team co-ordination, conflicting information and poor communication skills (Xie, 2002). Liu (2009) on the other hand, affirmed that, project document management and arrangement of organizational structures are the main contributors to communication barriers on construction projects in Hong Kong and China. The emergence of barriers here is an indication that, communication dissemination and information accessibility problems are prevalent on both traditional projects and mass housing projects. On the contrary, Xie et al. (2010) revealed that, communication problems relating to barriers to information was not common at the construction stage among the design team in traditional construction building projects. Drawing on the practical and theoretical perspective of the construction industry in Ghana, project related information have traditionally been distributed by post or at meetings which are predominantly organised monthly. In recent times, communicating project information among the project team by the use of the internet has become an emerging channel and trend in project delivery in Ghana. However, practically at most mass housing construction sites, there are no accesses to reliable internet service as compared to the main offices of the mass housing developing organisation. Hence, plausibly, this is likely to account for the occurrence of this communication problem among the team on mass housing projects. This is because, lack of reliable internet access hinders the easy and timely access to shared information on mass housing projects at the construction sites.

Given that, in Ghana, untimely communication of project related information has been identified as the dominant factor contributing significantly to project delays and failures across various project typologies (Fugar and Agyakwah-Baah, 2010). It is thus of prime importance for mass housing stakeholders to be interested in developing and adapting emerging media capable of improving timely delivery of communicated information among project teams.

4.4 Discussion: Component 2: Challenges in flow of information

Component 2 which accounted for 19.42% of the variance had its respective loading factors as: Lack of defined roles and responsibilities among members of the team leading to communication failure (83.4%), Persistent distortion in meaning of communicated information (72.3%), Lack of clarity in communicated information resulting in different interpretations (68.1%) and Receiving less information than expected from team participants for tasks (59.9%). This component was subsequently named Lack of defined Protocols and Distorted Communication. Dainty et al. (2006) hinted that established protocols and defined roles are necessary for effective communication on construction projects.

Procedure in communication as used here refers to the existence, use, and effectiveness of formally defined procedures and protocols that facilitate the sharing of project related information among the team. From the results, ‘lack of defined roles and responsibilities among members of the team leading to communication therefore emerged as the significant and most critical factor in this grouping.

This finding is contrary to the report in several studies (see Dawood et al., 2002; Xie, 2002; Liu, 2009; Xie et al., 2010). The results indicate that, lack of defined roles among the project team is a dominant procedural communication problem in mass housing delivery than on traditional projects. Consequently, the emergence of communication problems relating to procedure dominant on mass housing projects demands deeper insight. It can be argued that, the emergence of this is more likely to be the influence of the multi-cultural nature of project teams and strong attachment of teams to their discipline and organizations. This according to Javidan and House (2001) and Ochieng and Price (2010) leads to lack of collectivism and eventually lack of team integration. This development makes adopted procedures and protocols for team function very difficult to operate due to strong attachment to traditional organizational culture and multi-culturalism among the team. This supports the assertion that, strong cultural diversity among project team leads to poor communication and task break down (Javidan and House, 2001; Diallo and Thuillier, 2005; Ochieng and Price, 2010).

Additionally, the results revealed that distorted and incomplete communication were also experienced in mass housing delivery among the project team. Xie et al. (2000) and Xie et al. (2010) revealed that distorted communications are common on construction projects and this is often due to the influence of varying background and technical language of the professional team. However, the result here in respect of completeness of communicated information is contrary to the account from Liu (2009) and Xie et al. (2010). This indicates that, whereas communication underload is a major communication problem among mass housing project team, it rarely happens on traditional construction project (Xie et al., 2000; Liu, 2009). However, Gluch and Raisanen (2009) indicated that overcoming communication distortions and incomplete communication is very crucial in the performance of tasks and the progress of the overall project. Given that distorted communication has been arguably identified as very significant communication problem in this factor, it is thus no denying the fact that, stakeholders must not overlook this revelation. Given the significant role clear undistorted communicated project related information plays in project delivery, it is thus considered very crucial for mass housing project teams and stakeholders to make appropriate choice of communication planning and strategies towards ensuring effective communication.

4.5 Discussion: Component 3: Import of information challenges

The third and final component 3 accounted for 13.28% of the variance with the factors and their loadings in bracket as: Receiving conflicting information from team participants (90.7%) and Misunderstanding of communicated information (68.2%). This component was named conflicting communication and misunderstanding. Conflicting information has to do with the accuracy of the communicated information (Xie et al., 2010; Dainty et al., 2006). From this factor component, *'receiving conflicting information from team participants'* emerged as the most dominant communication problem among mass housing project teams contributing about 91% of the factor. Issues of inaccurate communication emanating from conflicting information shared among construction project teams have well been acknowledged and reported in literature (see Dawood et al., 2002; Liu, 2009; Xie et al., 2010). The dominance of this problem suggests that, it is a common problem experience among teams across various project typologies in the construction industry.

Similarly, the results indicated that, misunderstanding communicated information was a problem among the team contributing to about 68% of the communication problems in the factor. This finding however, contradicts studies by Liu (2009) and Xie et al. (2010) where misunderstanding was among the least problems among the project team at the construction stage. Additionally, Bowen and Edwards (1996) previously indicated that, misunderstanding is not common in construction organizations and project teams especially at the construction stage. However, with the revelation of misunderstanding communicated project information among mass housing project team provides empirical evidence to the unique project environment compared to traditional building projects. Indeed just like accuracy of project information, the core significant of attaining clear understanding of shared information is towards performing tasks and actions to achieve zero variance in outcome (Dainty et al., 2006). Against this, Liu (2009) and Xie et al. (2010) indicated that, construction design and management is a typical interaction process which involves multi-disciplinary team participants from different domains (specialists), disciplines, organizations and cultures. This undoubtedly has been identified to significantly influence the ease of understanding of related communication shared among this multi-disciplinary team (Xie et al., 2010). However, from the practical and theoretical perspective of training of the core professionals (architects, Quantity Surveyors, engineers etc.) of the built environment in Ghana and other countries, it can be said that there are lines of technical, cultural and work language diversities. Significantly, Xie et al. (2000) established organizational and cultural diversities, poorly defined information requisition and different discipline background as the major barriers to understanding communicated project information among construction teams.

Invariably, the occurrence of distortions and misunderstanding in communication among the project team can likely be traditionally be traced to the fact that mass housing projects delivery involves a multi-disciplinary team approach with varying professional cultural, professional, technical, social and organizational background as well as variations in technical languages (Khanzadi et al., 2008; Zairul and Rahinah, 2011; Ogunsanmi, 2012). Similarly, these participants tend to lack the clear understanding of the unique attributes and challenging project environment of mass housing projects and their implications for management. Given the significance of understanding of project information among the project team, it is thus crucial for project teams to gain pre-existing patterns of work activities, specialized work language, overcome technical constraints and reduce organizational diversities. Without this, it is more likely for the multi-disciplinary team to persistently encounter misunderstanding of each other and related communication. Against this, gaining and developing common communication skills across all professional disciplines could be a valuable asset to mitigating distortions and misunderstanding of communicated information among construction project teams especially on mass housing projects.

5. CONCLUSION AND RECOMMENDATION

Against the background of limited or no empirical studies on identifying the communication problems among mass housing project team inherent from the unique attributes of mass housing projects, this paper has sought to fill the knowledge gap. By adopting quantitative survey design, the paper has empirically identified the communication problems among mass housing projects teams.

By using factor analysis, the significant communication ineffectiveness experienced among mass housing project teams have been determined to be three main clusters, named as: component 1: Access to information challenges, component 2: Challenges in flow of information and component 3: Import of information challenges. Consequently, the findings recorded in this study indicate that though some of the results seem obvious, it also further brought to light some important findings which have not so far been empirically examined in the field of construction project management practice especially on projects of unique particularities. More specifically, the results have also highlighted some communication problems which are peculiar to the mass housing project environment. It is clearly evident from the findings that communication problems inherent in the unique features and particularities of mass housing projects among the project team are evident and cannot be underestimated or ignored.

Given the empirical evidence that effective communication across all project typologies is critical and significantly influence project outcome, team effectiveness and management intuition (Dainty et al., 2006; Dawood et al., 2002; Gluch and Raisanen, 2009), the insights given by this study could be useful and offer practical and theoretical implications for planning, managing and improving the communication and strategies on mass housing project delivery. Considering that, there is the need for enhancing managerial efficiencies and communication effectiveness on mass housing projects, the findings generated can therefore help mass housing project professionals and practitioners to develop the core task and behavioural knowledge and skills related to communication to engender effective communication outcome on MHPs. This can be achieved both by training and continuous professional development. Additionally, the findings and its congruence with literature have cemented the unique attributes of mass housing in respect of repetitive tasks and housing units and its resultant potential towards standardization and uniformity in communication aided by ICT. Against this, the findings presented can be extremely significant for stakeholders to develop bespoke communication technology backbone necessary to standardize the communication tasks and functions on MHPs towards inducing effective communication among project teams and participants.

Identifying the limitations of any research helps improve its acceptance and the general applications of the findings. There are some potential limitations that should be borne in mind in the interpretation and generalization of the findings of this research. The focus of the empirical aspects of this study was entirely based on the experiences of Ghanaian construction industry. Given that practical and professional experiences may differ across countries, geographical region or continent, it is entirely conceivable that there may be significant differences and variations in the findings if this study is replicated in other countries or geographical regions. However, theoretically, it can be said that the construction industry in many developing countries especially in sub-Saharan Africa are deemed to exhibit similar practical and professional characteristics. Hence, this limitation noted here does not undermine the validity of the research undertaken and potential application of its main findings in these developing countries.

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ELIMINATING ENFORCED IDLENESS OF RESOURCES AND JOB WAITING TIME IN TIME-CONSTRAINED CONSTRUCTION ACTIVITIES USING WAITING LINE THEORY

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ABSTRACT

Waiting of labour on construction site is a waste of energy and has been described as a shortcoming and production waste that can affect work performance and profitability of contractors. Labours are expected to be flowing through the construction site and not to be stationary; but when activities are not well-designed, their capacities are withheld and are forced to be idle. Also, conventional job-design techniques focus on planning of operations and required operatives without considering the elimination of waste related to operatives. Hence, this study explored the application of waiting line theory to eliminating the cost of waiting time of resources using the construction of a hypothetical upper floor slab. The practical application of waiting line theory was demonstrated and conclusions were drawn from the findings of the study. The findings revealed that waiting line theory can be applied in the design of time-constrained construction activities so as to eliminate enforced idleness on construction sites through reduction in the waiting time of resources.

Keywords: Enforced idleness, waiting line theory, idleness of resources, job waiting time, queue discipline.

1. INTRODUCTION

Enforced idleness is a form of waste that exists when specialized resources have been driven out of productive employment (Hutt, 2011). Russel & Wong (1993) observed that labours are forced to wait for the space vacated by others in order to carry out their tasks on construction sites. Devi & Ananthanarayanan (2007) concluded that resource idle time and job waiting time can result in higher costs and possible delay.

Activities with long waiting time are wasting productive time and capacity. According to the United State Environmental Protection Agency (2007), waiting of labour on construction site is a waste of energy. It can also be described as a shortcoming and production waste that can affect work performance and profitability of contractors. Song *et al*. (2010) inferred that waiting of labour is an unnecessary movement of labourers on construction site; together with inefficient sequencing of work procedures, waiting can contribute to schedule delay. Waiting of any resources, especially labour can cause gap and delay between activities and lead to production waste (Ohno, 1998 cited in Belayutham and Gonzalez, 2003; Womack & Jones, 2003). Fagbenle *et al*. (2011) concluded that labour is the major and the most important resource in the construction industry which need to be properly managed if performance is to improve. Hutt (2011) described enforced idleness of resources as the withholding of capacity of resources. He pointed out that when resources are left in a state of 'valuelessness' in respect of any alternative employments, those resources are forced to be idle and their capacities wasted. Sridhar (2000) observed that idleness of resources has a strong negative effect on resource utilization.

It is not part of the construction plan for resources to be idle on site. Many authors have studied the causes of enforced idleness of resources on construction sites. Hutt (2011) noted that the monopolization of a cooperant stage of production may force labours into enforced idleness. Koskela (2000) identified long distance between facilities as a cause of waiting and delay between activities. For example, long distance between concrete batching plant and working area. Devi & Ananthanarayanan (2007) argued that idleness and waiting of resources on construction sites are due to unbalanced production rates and variation during execution. Belayutham & Gonzalez (2003) claimed that defective output, overproduction of other activities and shortage of material may cause waiting of labour on construction sites. Enforced idleness has been observed on construction sites when labours and equipment's are waiting and being idle because the activities were not well-designed (Javkhedkar, 2006). Most of the construction projects result in huge time and cost overruns because of the inability of the construction projects managers to make use of the right management technique or failure to apply the same (Wideman, 2001). Managing construction activities and demands to achieve the maximum efficiency from the available resources is difficult and typically not well done. Time, money and resources are wasted when projects are poorly managed, causing workers to have to wait around (Modular Building Institute, 2010).

Jobs wait in line to be executed and resources wait in line to be utilized. The time spent by works in the line waiting to carry out their respective tasks could otherwise be spent in productive activities (Waiting Line Management, 2003). Belayutham & Gonzalez (2003) and Koskela (2000) opined that a smooth process flow can increase value to clients by minimizing or eliminating idleness of resources. Production waste could be reduced by analysing and designing the process flow. Song *et al.* (2010) observed that productivity study has been mainly focused on observing and improving construction operation, whereas emphasizes ought to be placed on the eliminating of waste related to construction operatives.

Labours are expected to be flowing through the construction site and not to be stationary and to achieve this a schedule technique for smooth movement of resources is needed for minimizing idle time on construction sites. A pending job and waiting labour can be avoided by proper resource planning. Optimization of resources starts with the determination of the right number of labour for a specific task or activity to obtain minimum project duration with maximum labour utilization (Devi & Ananthanarayanan, 2007). It is imperative that specific time bound tasks are spelled out clearly and allotted to specific labour for execution within that time frame in order to achieve results within a pre-decided time-frame (Wideman, 2001). Sridhar (2000) noted that one of the important of service quality is ease of access, which includes not only location of service facility and its opening hours but also minimum waiting time to receive service.

Contractors are under enormous pressure for continuous improvement to enhance their productivity and competitiveness locally and internationally (Javkhedkar, 2006). The conventional techniques may not be able to smooth the process flow that may create waiting between activities (Belayutham & Gonzalez, 2013). Understanding waiting lines or queues is basic to creating schedules and job design and learning how to manage waiting lines is one of the most important areas in operations management (Waiting Line Management, 2003).

The objective of this study is to balance the cost of waiting time of resources with the cost of adding more resources to a waiting job by applying waiting line theory to resource scheduling for the construction of a hypothetical upper floor slab.

2. LITERATURE REVIEW

The central problem in virtually every waiting line situation is a trade-off decision. The manager must weigh the added cost of providing more resources against the inherent cost of waiting time (Waiting Line Management, 2003). Sridhar (2000) pointed out that waiting line theory is being ignored in the planning of service delivery process. He carried out a study to examine the concepts of service quality and customer satisfaction in waiting line theory and applied it to a typical library situations. In his conclusion, he stressed the need for appropriate studies on the application of waiting line theory. Cernea *et al*. (2010) applied waiting line theory to waiting situations in a fast-food restaurant to highlight the characteristics of a waiting system and concluded that waiting line theory plays a key role in highlighting the operations effectiveness and the need to improve their characteristics. Yang & Ioannon (2001) conducted a research to investigate the existence and influence of idleness on construction sites and proposed the pull-system scheduling system to eliminate idleness. Hutt (2011) maintained that 'withheld capacity' arises when the output of a resources is cut down. Withholding the capacity of resources reduces the degree of utilization of those resources. Javkhedkar (2006) studied the application of lean construction in concrete construction projects at both operation and project levels.

He proposed the use of Linear Scheduling Method to identify and eliminate waste of resources on construction sites. Song *et al*. (2010) studied lean construction and its application in concrete construction projects at both the operation and project levels. An actual concrete construction project was observed and problems areas contributing to production wastes were identified. The study recommended the use of 3D animation to train workers and eliminate production wastes. Hutt (2011) argued that the absence of idleness does not imply the absence of waste. According to him, waste of capacity exists when movement of labours does not contribute to productive output of the employed resources. Koskela (2000) concluded that waiting of labour and idleness in the construction processes can be caused by wrong choice of construction method, improper allocation of resources that creates lag between works and improper planning and sequence of work that creates gap between activities. Waiting times may happen due to the delay of a previous activity, inefficient space allocation, low productivity of a crew, deficient or insufficient equipment, delay in information flow, unavailability of material and external situations such as heavy downpour (Belayutham & Gonzalez, 2013). Devi & Ananthanarayanan (2007) attempted the development of an automatic resource-driven construction schedule with which resources can optimally be allocated to the activities. Modular Building Institute (2010) reported the documentation of 25 to 50 percent waste in coordinating labour by studies focusing on construction efficiency. Waiting Line Management (2003) critically pointed out that waiting lines are not a fixed condition of a productive system but are to a very large extent within the control of the system management and design. Modular Building Institute (2010) expressed a belief that an improvement in the efficiency of labour will also improve overall productivity and help individually construction firms become more competitive. Studies on the application of waiting line theory are few and no specific study has applied waiting line theory to time-constrained activities like the construction of upper floor slabs.

2.1 Waiting Line Theory

Waiting line theory is the study of waiting (Wang, 2009). Waiting lines are a part of everyday life and exist wherever the current demand for a service exceeds the current capacity to provide that service, and their adequacy has strong effect on quality of service and productivity (Wang, 2009; Sridhar, 2000). The theory deals with one of the most unpleasant experiences of life – waiting, and its application is about determination of the main performance measures of the system which are the probabilistic properties of the number of customers in the system, number of waiting customers, utilization of the server(s), response time of a customer, waiting time of a customer, idle time of the server, and busy time of a server (Sztrik, 2012). According to Cernea *et al.* (2010), waiting line theory can be applied to determine the most economical strategy to reduce the time spent in waiting systems. Wang (2009) developed a waiting line model (figure 1.0) which shows the waiting line characteristics and observed that the provision of too much service units involves excessive costs and non-provision of enough service units causes the waiting line to

become excessively long. The ultimate strategy to achieve an economic balance between the cost of service and the cost associated with the waiting for that service.

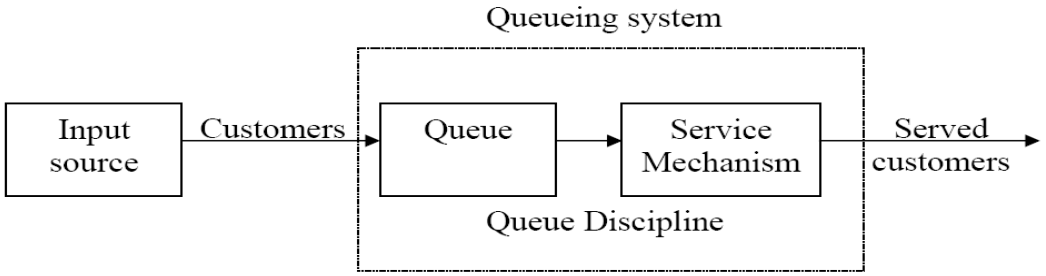

Figure 1.0: Basic structure of waiting line model (Source: Wang, 2009).

2.2 Waiting line characteristics

2.2.1 Queue

The queue is where those in need of service wait before being served. A queue may be infinite or finite based on the maximum permissible number of customers it can contain and it is formed when customers arrive faster than they get served and usually has length and number (Wang, 2009; Waiting Line Management, 2003).

2.2.2 Queue discipline

This refers to the order in which members of the queue are selected for service (Wang, 2009). It can also be referred to as a priority rule or set of rules for determining the order of service to customers in a waiting line (Waiting Line Management, 2003). According to Waiting Line Management (2003), examples of priority rules in queue discipline include: chronological arrival (first come, first served), shortest service first, reservations first, emergencies first, highest-profit customer first, largest orders first, best customers first, longest waiting time in line first, and soonest promised date first.

2.2.3 Service mechanism

This consists of one or more service facilities, each of which contains one or more parallel service channels, called servers (Wang, 2009). It represents the structure of the flow that customers may go through for service; examples include: single channel-single phase, single channel-multiphase, multichannel-single phase, multichannel-multiphase and mixed structures (Waiting Line Management, 2003).

2.2.4 Service time

Usually defined by a probability distribution, it is the time the customer spends with the server once the service has started (Waiting Line Management, 2003).

2.2.5 Arrival/input source

This generates customers for a service system. It has population sizes which are considered unlimited (infinite) or limited (finite) and patterns which are considered random (variable) or constant (periodic) (Wang, 2009; Waiting Line Management, 2003).

3. RESEARCH METHODOLOGY

The objective of this study is to balance the cost of waiting time of resources with the cost of adding more resources to a waiting job. In order to achieve the objective, a hypothetical 200mm thick upper floor slab of 298 cubic metre in volume with allocated time of one day (8 working hours) which cannot be exceeded was used to illustrate the application of waiting line theory to resource scheduling. Four various types of concrete mixers were considered for hiring with their respective service rates according to their capacities as shown in table 1.0 and profit losses due to waiting time of resources as shown in table 3.0 were calculated according to waiting time of resources as shown in table 2.0 in order to determine the concrete mixer type to be hired which will balance the cost of waiting of resources with the cost of adding more resources to the work.

Table 1.0: Service time of concrete mixers types (See appendix A)

Type of concrete mixer	Service Time (T)
Type 1	One wheelbarrow every 3.5 minutes
Type 2	One wheelbarrow every 2.3 minutes
Type 3	One wheelbarrow every 1.75 minutes
Type 4	One wheelbarrow every 1.4 minutes

(Source: Olugboyega, 2015)

Table 2.0: Waiting time of resources (See Appendix B)

Type of con-crete mixer	No. reqd	Service rate (μ)(labour per 7minutes)	Average no. of workers waiting in line (Lq)	Average waiting time in line by labour (Wq) (min.)	No. of idle labour based on service rate	Time waiting in line if max. time waiting line	No. of Idle labour based on time waiting in line

					(μ - λ)	allowed is 2minutes ($Wq_{max} - Wq$)	($\lambda_n - \lambda$) n=1,2,3,4
1	27	54	5.79	0.12	4	1.88	3
2	19	58	2.70	0.05	8	1.95	7
3	15	60	2.08	0.04	10	1.96	9
4	14	70	0.89	0.02	20	1.98	19

(Source: Olugboyega, 2015)

Table 3.0: Profit loss due to waiting time of resources (See Appendix A)

Type of concrete mixer	Cost of hire of plant (per minute)	Profit loss per minute due to idle time of plant using the values of $Wq_{max} - Wq$	Profit loss per minute due to idle time of labour using the values of $\lambda_n - \lambda$	Total profit loss per minute due to idle time of labour and plant
1	\$0.09	\$0.17	\$0.03	\$0.20
2	\$0.07	\$0.13	\$0.07	\$0.21
3	\$0.01	\$0.13	\$0.10	\$0.22
4	\$0.07	\$0.13	\$0.20	\$0.33

(Source: Olugboyega, 2015)

Table 4.0: Waiting time parameters for concrete mixer type 2 (See Appendix C)

Waiting time parameters	values
Lq	5.39 labours
Ls	6.25 labours
Wq	0.11 minutes
Ws	0.13 minutes

ρ	86%

(Source: Olugboyega, 2015)

Table 5.0: Optimal utilization of skilled labour and concrete mixer (See Appendix D)

Available optimal utilization options	**No. Of skilled labour required**
Equating the output of skilled labours to the output of the concrete mixer	100
Equating the output of skilled labours to the quantity of work	100

(Source: Olugboyega, 2015)

4. FINDINGS AND DISCUSSION

Table 2.0 shows the number of concrete mixers required for the work based on their service rates, number of labours required, average number of labour waiting in line, average waiting time in line by labours, number of idle labour based on service rate and time waiting in line. The number of concrete mixer type 1 required, if it is to be considered for hiring is 27 with service rate of 54 labours per 7 minutes, 5.79 labours waiting in line, waiting time of 0.12 minutes, 4 and 3 idle workers based on service rate and time waiting in line respectively, waiting time of 1.88 minutes at maximum time waiting in line of 2 minutes. Concrete mixer type 1 gives the highest number of concrete mixer required for the work, closely followed by concrete mixer type 2 which gives 19, and the least is 14 by concrete mixer type 3. Concrete mixer type 3 has the highest service rate of 70 labours per 7 minutes and the least number of labour waiting in line and average waiting time in line by labours. The profit losses due to waiting time of resources as shown in table 3.0 shows that concrete mixer type 1 will cost \$0.09 to hire but the profit losses due to idle time of plant and labour are \$0.17 and \$0.03 respectively. Concrete mixer type 4 will cost \$0.07 to hire which is \$0.03 lesser than concrete mixer type 1, but its profit loss due to idle time of labours is \$0.20 which is higher than that of concrete mixer type 1.

Although, both type 1 and 2 concrete mixers give the lowest profit loss and the number of idle labours, but concrete mixer type 1 gives the lowest profit loss and number of idle labours as compared to concrete mixer type 2; however, the required number of concrete mixer type 2 is lesser, its service rate is higher which makes the average number of workers waiting in line and waiting time in line by labour lesser than that of concrete mixer type 1. Also, the cost of hiring concrete mixer type 2 is lesser than that of concrete mixer type 1 and its total profit loss per minute due to idle time of labour and plant is the 2nd lowest after that of concrete mixer type 1.

As shown in tables 4.0 and 5.0, using the waiting time as criterion for selection because of time-constraint, concrete mixer type 2 is selected to be hired for the work because its cost of hire is lesser than that of concrete mixer type 1, its average time waiting in line is lesser than the maximum time waiting in line, offers the 2nd least total profit loss and optimally utilizes the skilled labour, thereby eliminating enforced idleness of resources and job waiting time. The results in this study are consistent with the earlier studies by Koskela (2000), Javkhedkar (2006) & Hutt (2011) which pointed out that waiting of labour and idleness of resources can be eliminated by proper allocation of resources and that optimizing the movements of labours based on the capacities of employed resources can help to eliminate waste of resources.

5. CONCLUSION AND RECOMMENDATION

Meeting of target rates of construction projects as drawn up in construction programmes and delivering on projects' objectives as required by clients can aid avoidance of cost overruns, reduce profit losses and give values to clients on their investments in the construction industry. Although the method employed for the study is largely based on the construction methods obtained in the Nigerian construction industry; but Waiting Line Theory is a management technique which when applied in designing of construction activities in any construction industry can help in reducing wastage of resources on construction sites. It takes time and money to bring plant and human resources to construction sites; but if these resources are forced to be idle by not utilizing them optimally, more time and money would be lost. It has been established that conventional job schedule techniques may not be adequate in eliminating enforced idleness on construction sites; but the application of waiting line theory to job planning, especially time-constraint activities can help to achieve optimal utilization of resources and meeting of targets as drawn up in the construction programmes by eliminating enforced idleness on construction sites through reduction in the waiting time of resources.

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APPENDIXES

Appendix A: Assumption of requirements

- Concrete mixer type, outputs and costs

Concrete mixer type	Output/ capacity		Cost of hire
	M^3 per hour	M^3 per minutes	Per hour
Type 1	1.4	0.02	$0.20
Type 2	2.0	0.03	$0.22
Type 3	2.5	0.04	$0.26
Type 4	2.8	0.05	$0.28

- Output for placing concrete in upper floor slab = $3m^3$/man day

Therefore, number of skilled labour to complete the work in a day = $\frac{298}{3}$ = 100 skilled labours.

Output for placing concrete per hour = $\frac{3}{8}$ = $0.38m^3$/hour (using 8working hours per day)

Output for placing concrete per day = $\frac{0.38}{60}$ = $0.0063m^3$/minute.

- Output for transporting concrete within 100m haulage cycle = $6m^3$/man day

Therefore, number of unskilled labour to complete the work in a day = $\frac{298}{6}$ = 50 unskilled labour

Output for transporting concrete per hour = $\frac{6}{8}$ = $0.75m^3$/hour (using 8working hours per day)

- Ratio of skilled labour to unskilled labour = 1:2 (i.e., two skilled labour attending to one unskilled labour).
- Assume Poisson arrival rate and exponential service rate.
- Equipment for transporting concrete is wheelbarrow with $0.07m^3$ capacity.
- Allocated time for the is 1 working day
- Distance from the concrete mixing plant to the work station is 20m.

- Cost of skilled labour per day = $12.76
- Cost of unskilled labour per day = $5.10 ($0.67 per hour and $0.01 per minute)
- Estimated arrival rate (λ) for unskilled labour to the mixing plant to load their wheelbarrows.

Assuming the travelling time to the mixing plant as 20 seconds (0.3 minute),
Assuming the travelling time from the mixing plant as 25 seconds
(0.4 minute),
Assuming that one unskilled labour will supply one wheelbarrow full of concrete to two skilled labour,

The time taken for one unskilled labour to be attended to = $\frac{0.07}{2(0.0063)}$ = 5.4minutes

Allow waste time of 0.9 minutes,

Therefore, total arrival time (λ) for unskilled labour = 0.9 + 0.3 + 0.4 + 5.4 = 7minutes (50 labours per 7 minutes).

- Estimated time taken (T) for the mixers to serve the unskilled labourers (Service time).

  Mixer type 1 = $\frac{0.07m^3}{0.02m^3/minute}$ = 3.5 minutes

  Mixer type 2 = $\frac{0.07m^3}{0.03m^3/minute}$ = 2.3 minutes

  Mixer type 3 = $\frac{0.07m^3}{0.04m^3/minute}$ = 1.75 minutes

  Mixer type 4 = $\frac{0.07m^3}{0.05m^3/minute}$ = 1.4 minutes

Appendix B: The type of concrete mixer to be hired

- Mixer type 1:

  Number of mixer type 1 required for the work, N = $\frac{298m^3}{8hrs\ per\ day \times 1.4m^3\ per\ hour}$ = 27

  Service rate of mixer type 1 in terms of number of labourers,

  $$\mu = \frac{\lambda}{T} \times N \quad (1)$$

  $\mu = \frac{7}{3.5} \times 27 =$ 54 labourers per 7 minutes.

  Average number of labourers waiting in line,

$$Lq = \frac{\lambda^2}{2\mu(\mu-\lambda)}$$ (Waiting Line Management, 2003) (2)

$$Lq = \frac{50^2}{2(54)(54-50)} = 5.79$$

Average waiting time in line,

$$Wq = \frac{Lq}{\lambda}$$ (Waiting Line Management, 2003) (3)

$$Wq = \frac{5.79}{50} = 0.12 \text{ minutes}$$

- Mixer type 2:

$$N = \frac{298}{8(2.0)} = 19$$

$$\mu = \frac{7}{2.3} \times 19 = 58 \text{ labourers per 7 minutes}$$

$$Lq = \frac{50^2}{2(58)(58-50)} = 2.70$$

$$Wq = \frac{2.70}{50} = 0.05 \text{ minutes}$$

- Mixer type 3:

$$N = \frac{298}{8(2.5)} = 15$$

$$\mu = \frac{7}{1.75} \times 15 = 60 \text{ labourers per 7 minutes}$$

$$Lq = \frac{50^2}{2(60)(60-50)} = 2.70$$

$$Wq = \frac{2.08}{50} = 0.04 \text{ minutes}$$

- Mixer type 4:

$$N = \frac{298}{8(2.8)} = 14$$

$$\mu = \frac{7}{1.4} \times 14 = 70 \text{ labourers per 7 minutes}$$

$$Lq = \frac{50^2}{2(70)(70-50)} = 0.89$$

Wq = $\frac{0.89}{50}$ = 0.02 minutes

- Using maximum waiting time in lines (Wq_{max}) of 2minutes due to unforeseen circumstances.

  Wq = $\frac{Lq}{\lambda}$ = $\frac{\lambda}{2\mu(\mu-\lambda)}$; $\lambda = \frac{2Wq\mu^2}{1+2Wq\mu}$ (Waiting Line Management, 2003) (4)

  When μ = 54; $\lambda_1 = \frac{2\times2\times54^2}{1+(2\times2\times54)}$ = 53 per 7minutes

  When μ = 58; $\lambda_2 = \frac{2\times2\times58^2}{1+(2\times2\times58)}$ = 57 per 7minutes

  When μ = 60; $\lambda_3 = \frac{2\times2\times60^2}{1+(2\times2\times60)}$ = 59 per 7minutes

  When μ = 70; $\lambda_4 = \frac{2\times2\times70^2}{1+(2\times2\times70)}$ = 69 per 7minutes

Appendix C: Waiting time for loading

(Using the parameters of concrete mixer type 2 to determine the number of labourers waiting to load their wheelbarrows and how long they have to wait to load their wheelbarrows)

- Average number in the waiting line, Lq = $\frac{\lambda^2}{\mu(\mu-\lambda)} = \frac{50^2}{58(58-50)}$ = 5.39 labourers
- Average number in the system, Ls = $\frac{\lambda}{\mu-\lambda} = \frac{50}{58-50}$ = 6.25 labourers
- Average waiting time in line, Wq = $\frac{Lq}{\lambda} = \frac{5.39}{50}$ = 0.11minutes
- Average waiting time in the system, Ws = $\frac{Ls}{\lambda} = \frac{6.25}{50}$ = 0.13 minutes
- Average utilization of the mixer, ρ = $\frac{\lambda}{\mu} = \frac{50}{58}$ = 0.86 = 86%

Appendix D: Balancing the outputs of plants and skilled labours in order to ensure that the selection of concrete mixer type 2 would eliminate idleness of resources

- Option 1: equating the output of skilled labours to the output of the concrete mixer

  Nr. Of mixer required = 19

  Output of mixer per hour = 2.0m^3

  Quantity of concrete available per hour = 19×2.0m^3/hour = 38m^3/hour

Output of skilled labour for placing concrete in upper floor slab= $3m^3$/man day =$0.38m^3$/hour

Nr. Of skilled labour required = $\frac{38m3/hour}{0.38m3/hour}$ = 100

- Option 2: equating the output of skilled labour to the quantity of the work

Nr. Of skilled labour required for the work = $\frac{298m3}{3m3/manday}$ = 100

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PREDICTING THE FUTURE OF QUANTITY SURVEYING PROFESSION IN THE CONSTRUCTION INDUSTRY

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ABSTRACT

Quantity surveying profession has changed over time to adapt to the changing and increasing requirements of project owners. In the year 2007 to 2011, the construction industry experienced economic downturn causing uncertainty in the profession. This study examined the developmental trend of the quantity surveying profession in the construction industry to determine its future. The independent variable was the current level of satisfaction of quantity surveyors while the dependent variable was the future growth of the profession. The working hypothesis was that the profession would experience future growth. A survey questionnaire via Qualtrics online survey software was administered to quantity surveyors to determine their opinion of the profession. Data collected were analyzed using SAS v9.4 statistical analysis software. The results showed a greater level of satisfaction of quantity surveyors with the current developments in the profession. Further, the current level of satisfaction with the profession strongly correlated with the chances of growth of the profession, implying a greater likelihood of future growth in the roles of quantity surveyors in the next 10-15 years. Areas such as information technology and sustainable construction would favor the growth. Thus, the hypothesis was supported. Another finding was that females tended to be fewer in the profession. Thus, it was recommended that further research be conducted focusing on gender equality and propose ways to encourage women to join the quantity surveying profession. Overall, the study concluded that quantity surveyors should improve and diversify their roles more to provide greater value to project owners as the profession seemed promising.

Keywords: Construction Industry, Predicting, Profession, Quantity Surveying

1. INTRODUCTION

The profession of quantity surveying has faced uncountable challenges in its development considering when it first came into existence.

It has grown and survived the storms to an extent that today it is a notable profession in the construction industry. In providing the best value to project owners, quantity surveyors (QS) determine cost estimates of projects and ensure that construction activities are executed in a manner that satisfy the project owner's needs. Their name emanates from their role of quantifying the amount of construction resources such as materials, labor, and equipment. They have different names in different countries. For example, United States of America (USA) sometimes call them project engineers, cost engineers/planners or estimators while other countries may call them building economists. Such titles are characteristic of some of their professional roles in construction such as planning or cost estimating of building and engineering works. Their roles may differ or get advanced in some countries such as in the Africa, Asia, and United Kingdom (UK) where they may undertake core roles in construction such as arbitration and overall construction project management.

In completing projects, quantity surveyors usually work with other construction professionals such as architects, engineers and in conjunction with project owners, governments, insurance companies, and contractors. However, the QS roles have significantly changed over the times to adapt to the changing nature of the construction industry, especially considering when it first came up in the 1820s. Part of the reason for this change was to meet the ever-changing needs of the clients and to beat the competition from other construction professionals such as architects or engineers. Similar to other professions in the construction industry, the effects of the recent economic meltdown was also evident in the quantity surveying profession in terms of job orders and development.

Some predictive studies have tried to bring hope to the construction industry. Research by the U.S. Department of Labor concluded that they expected employment of construction managers to grow by 17% from the year 2010 to 2020. As pointed out from their large-scale research, the percentage implied that about 86, 600 new jobs were expected for construction managers during this duration (Berry, 2013). This notion was reinforced by the August 2013 Jobs News Update that marked construction manager job as the third most meaningful jobs in the world (Newman, 2013). Research conducted by On Center Software (2015) concluded that construction management is turning to profitable best practices and technology to stay lean. They identified automated take-off, estimating, and project management in a cloud based format as avenues to improve productivity in construction. The outcome aligned with the research by RS Means (2015) which concluded that construction boom required better planning and estimating and that a 9.3% compound annual growth rate was expected until 2019. In addition, it aligned with Schneider (2015) that concluded on an increased employment of skilled crews and a strong demand for technological skills in the construction industry. It also stated that the Bureau of Labor Statistics projected a 2.6% compound rate in growth of construction jobs through 2022, making it the fastest growing industry in the decade (Schneider, 2015). These developments have a positive bearing on the QS profession.

From the recent research conducted up to the year 2015, it is apparent that the quantity surveying profession has not been extensively investigated to determine its present and future standing in the construction industry. Such a gap elicited and motivated an investigation of its developments in the construction industry. Specifically, the aim of this research was to examine the developmental trend of the quantity surveying profession to determine its future. The objectives were to determine the current level of satisfaction of quantity surveyors and to predict the future growth of the profession in the construction industry. The *current level of satisfaction with the profession* was the independent variable while the *future growth of the profession* was the dependent variable. Data was collected using survey questionnaire via Qualtrics survey tool while SAS v9.4 facilitated the data analysis.

The outcome of the study would be beneficial to quantity surveyors and project owners or clients as they would be able to know the current and future status of the profession in the construction industry. If the outcome is unfavorable, the quantity surveyors may find ways to keep up and/or diversify to other core areas requiring advanced skills in construction that would eventually benefit them and their clients.

2. LITERATURE REVIEW

2.1 History of Quantity Surveying Profession

The Royal Institution of Chartered Surveyors (RICS) documentation (2014) defined quantity surveying as a client led profession where the QS respond to the client needs and that they must continue with their own skill development depending on the ever changing project owners' requirements. The quantity surveyor adheres to the Continuing Professional Development (CPD) to keep up to date with the continuous changes that occur in the construction field. The dynamics in the construction industry has made the profession to change severally along the timeline.

The profession has been in existence since 1820s and has gained international recognition through construction professional organizations such as RICS and Quantity Surveyors International (QSI). RICS and QSI are construction professional organizations for those specializing in the financial as well managerial aspects of construction and engineering works. These organizations support and protect the character, status, and interests of quantity surveyors in addition to promoting high level of good practice of its members. QSI is an international construction professional body that is specific only to quantity surveyors while RICS covers all other construction professionals and an array of other skill areas such as real estate and construction business improvement. Overall, these construction professional organizations lay down the competency requirements for quantity surveyors for the assessment of their professional competencies. These competency requirements have so far assured the survival of the profession considering when it was first conceived (Said *et al*., 2010).

During the early years of quantity surveying, the roles involved quantifying construction works that entailed measurement and valuation of building works.

Over time, these roles have become narrow scoped, starting with preparation of bills of quantities (BoQ) and ended up with settlements of final accounts at the end of construction ventures (Oke *et al*., 2010; Moss, 2012). These roles have made some construction professionals to believe that QS roles could be replaced by anything capable of conducting arithmetic solutions. They have asserted that quantity surveying is of no use. Anon showed this doubt in 1889 by stating that '*the QS is not a necessity in the order of things. Any convenient and cheap method of multiplying drawings and specifications and placing copies in the hands of each estimator would answer the same purpose and get rid of the QS for good*' (Menaha *et al.*, 2011).

Despite this stance by Anon and others in the construction industry, the quantity surveying profession has been developing strategically to meet the owners' requirements of greater value in projects. Research has shown that the profession has undergone significant changes due to changing industrial and owner demands, advancements in information technology, and higher levels of competitions in the industry especially in the international construction arena that is characterized by large construction projects and diverse professionals (Smith, 2004).

2.2 Characteristics of the Quantity Surveying Profession

The developments in the quantity surveying profession have made it to develop a defined set of skills (Thayaparan *et al*., 2011). Quantity surveyors contribute at all stages of construction projects (Mackie & Cooper, 2012; Thayaparan *et al*. 2011). Their roles include ascertaining that the budgets are reasonable, identifying areas of possible cost risks and laying out avenues for mitigation, coordinating and making final cost reports at important stages of projects, identifying potential areas for value engineering, procurement of works of contractors, negotiating project activities, and assist in agreement on terms and conditions of construction works. In addition, they help in drawing up of construction contracts and handling change orders, including settling final project accounts.

As provided by RICS, they have been expanding their roles under the optional competency requirements. The RICS's optional competencies provide areas for future career expansion as well as providing avenues for improvement when meeting the needs of clients. In essence, the competencies enhance the professional quality of quantity surveyors through intra and inter-professional reflection (Nkado & Meyer, 2001). Overall, they must adhere to the construction ethical standards as they advance professionally (Aje & Awodele, 2006). This will create more appeal to project owners as providers of value in construction projects.

Advancing quantity surveying depends on its ability to respond to the changes or adjustments in the international construction business environment. Maintaining global relevance and significant improvement require the quantity surveyors to review their work operating landscapes to capture and adjust to imminent changes in areas such as their professional ethics, practices, and overall level of expertise (Frei & Mbachu, 2010). They need to understand their own objectives and the dynamic requirements of project owners in order to explore appropriate and innovative ways to deliver the needed value diligently and effectively.

In essence, they must evaluate their Strengths, Weaknesses, Opportunities and Threats (SWOT) to thrive in the wider construction industry market that is laden with high competitions from other professionals such as architects and engineers (Frei & Mbachu, 2010).

The opportunities and threats are the micro-environmental factors that can hinder or boost their abilities to execute or meet their project goals (Langford & Male, 2008). Political, Economical, Social, and Technological (PEST) model define and facilitate the identification of the many factors that operate in the construction's wider or macro-environment. Political factors such as unavailability of published rates of fees for professionals and levels of fee competitions in the construction industry have brought about greater opportunities to compete favorably with each one offering their own prices (Frei & Mbachu, 2010). Economic and market conditions including factors such as economic downturn in the construction markets are possible avenues or opportunities for future roles of quantity surveyors. Social factors such as relative uncertainty in the profession can pose a significant threat (Frei & Mbachu, 2009). Technological factors such as Information Technology (IT) advancements and value engineering or analysis are to reshape quantity surveying business environment. These offer great opportunities for quantity surveyors to develop to higher levels both technologically and in popularity.

IT advancements in areas such as Building Information Modeling (BIM), Building Energy Modeling (BEM) and estimating software could provide quantity surveyors with ways to fortify their standing in the construction industry. This is augmented by the belief that quantity surveyors are the professionals who are better placed to handle major information in construction projects because most of the pieces of information in construction tend to revolve around construction quantities, quality improvement and cost reduction which they usually take control of in projects. However, the current opportunities may be taken over by other professionals like architects or engineers if the quantity surveyors adopt a complacent approach in construction ventures that is characterized by little or no motivation to further develop or diversify their roles (Smith, 2004). Quantity surveyors currently have adequate strengths as they have ability for strong international ties, good network of clients, and a wide range of knowledge in construction processes (Frei & Mbachu, 2010). Their roles and strength in construction give them a greater level of satisfaction with their jobs, especially before the economic recession. However, females tend to be unsatisfied because they believe that the profession is gender biased (Bowen *et al.*, 2008).

Despite the profession being dominated by males, Bowen *et al*. (2008) found quantity surveyors to be generally satisfied with their jobs from a survey conducted on quantity surveyors in the South African construction industry. The factors influencing their job satisfaction included low supervision level, participation in creativity and decision-making, personal satisfaction in work, and recognition for achievement.

3. RESEARCH METHODOLOGY

3.1 Aim, Objectives, Variables, and Working Hypothesis

The aim of this research was to examine the developmental trend of the quantity surveying profession to determine its future. The objectives were to determine the current level of satisfaction of quantity surveyors and to predict the future growth of the profession in the construction industry. The independent variable was the *current level of satisfaction with the profession* while the dependent variable was the *growth of the profession in the next 10-15 years*. The duration was considered adequate forecast period to determine the future of the profession. The working hypothesis was that the quantity surveying profession would experience future growth.

3.2 Survey Questionnaire Design and Administration

In order to meet the aim and objectives of the research, an online survey questionnaire was administered to the quantity surveyors via Qualtrics survey software. Before its administration, five people (n = 5) agreed to take part in a pilot study to test the validity and reliability of the survey items. Cronbach's alpha statistic tested the reliability. The result of the pilot survey showed a Cronbach's alpha value of 0.85 implying that the questionnaire was reliable and that the items were well understood. Consent to conduct the research with human subjects was sought and granted by the Institution Review Board (IRB).

The questionnaire consisted of open ended and multiple-choice questions. One part of the questionnaire focused on the respondents' demographic data such as work title, number of years in construction field, project owner representative, and roles in projects. The other part required the respondents to rate their current level of satisfaction with their profession on a five (5) point Likert scale (1 = not rewarding, 2 = neutral, 3 = somewhat rewarding, 4 = rewarding, 5 = very rewarding). In addition, they were asked their opinion about the overall growth of their profession in the next 10-15 years on a similar scale (1 = not improve, 2 = neutral, 3 = somewhat improve, 4 = improve, 5 = improve highly). Finally, they were to give reasons for the growth.

The survey was sent to the membership email list-serve of QSI, an international quantity surveying professional organization that promotes the aims, objectives, and ideals of quantity surveyors worldwide. The QSI was chosen for this research since it was believed it would give a global representation of quantity surveyors. The respondents were assured of confidentiality and anonymity in their feedback. In order to improve the response rate, respondents were informed that the results would be reported in the next publication of QSI members' newsletter.

3.3 Sample Size and Data Analysis

The study employed 239 quantity surveyors who completed the survey. This sample size (n = 239) was considered adequate as required by parametric or univariate statistical analyses and tests that achieve adequate statistical power.

The quantitative data analysis utilized SAS v9.4 statistical analysis software (SAS, 2015) for both descriptive and inferential statistics. The descriptive statistical analysis results utilized the measures of central tendency and dispersion that comprised of the mean, median, mode, kurtosis, and skewness values while inferential statistics employed correlation and regression analysis as predictive indices in addition to pooled *t*-test statistics that tested for the equality of variance. The main purpose of these analyses was to determine the level of satisfaction with the current state of the profession and to provide an index of growth of the profession in future. Qualitative data themes were also identified and analyzed.

4. FINDINGS AND DISCUSSION

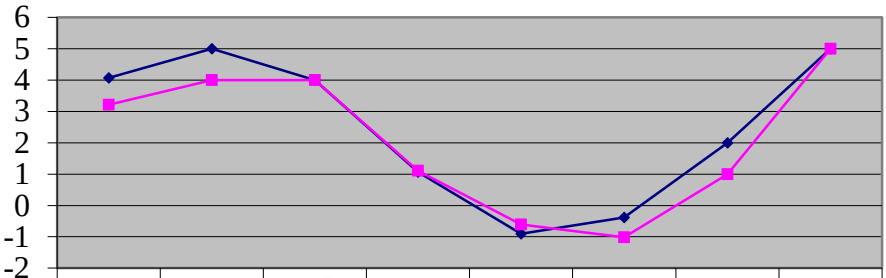
4.1 Demographics

The power of Qualtrics survey software is that it can detect and report the geographical location where a survey is taken. Thus, the results showed those who were working in construction ventures in Australia, Brazil, Colombia, Egypt, Ghana, Haiti, Japan, Kenya, London, Malaysia, Nigeria, Scotland, Seychelles, South Africa, Thailand, and USA. These countries provided a modest representation of the worldwide construction sector and market. Majority of the respondents were managing directors, presidents, chief quantity surveyors, consultants in quantity surveying, and professors in institutions of higher learning. This shows that the sample was from diverse international construction community who mostly held leadership and managerial roles in projects.

Out of those who took the survey, about 95% were males and 5% were females. This outcome is consistent with the study by Bowen *et al*. (2008) which concluded on the quantity surveying profession being male dominated. The survey results also showed that more than half (56%) of the respondents had over 15 years of experience in the quantity surveying profession and so they would be expected to provide invaluable ideas about the status of the profession. They were mainly involved in commercial construction projects (68%) and residential construction projects (53%). Out of the survey respondents, about 58% had been client/owner's representatives in construction projects. Some of their main duties entailed providing pre-contract services and preparing BoQ for tendering and tender evaluation, employer's agent, project management and scheduling, contract administration, inspection of work in progress, negotiating contracts, and contractual advice. They also engaged in cost aspects such as cost planning, budget estimating, preparing final accounts, post contract cost control, valuation, risk analysis/assessment/control, cash flow projection, financial management, value engineering, and overall advising on joint ventures. In as much as these roles are similar to their core and optional competency requirements as stated by RICS, it is evident that their roles have expanded over time to remove the negative stereotyping shown by Menaha *et al.* (2011) and Oke *et al.* (2010) where the roles would be limited and narrow scoped if not obsolete.

4.2 The Current State and Future of Quantity Surveying Profession

The survey asked the respondents about the level by which their current construction profession was rewarding and how they would rate the level of improvement of their profession in the next 10-15 years. About 35% of the respondents reported that their current profession was rewarding and very rewarding respectively. About 51% of the respondents believed that their profession would significantly improve in the next 10-15 years. Figure 1 summarizes the descriptive statistical results where the trend lines compare the satisfaction and growth variables.



	Mean	Mode	Median	Std	Skew.	Kurt.	Min.	Max.
Satisfaction	4,07	5	4	1,07	-0,9	-0,38	2	5
Growth	3,21	4	4	1,11	-0,61	-1,02	1	5

Figure 1. Descriptive Statistics of the Satisfaction and Growth of the Profession

Using a 5-point Likert scale whereby 1 = not rewarding, 2 = neutral, 3 = somewhat rewarding, 4 = rewarding, and 5 = very rewarding, an average of 4 (Mean = 4.07) was recorded for the current status of the quantity surveying profession. This implied that the professionals tended to derive relatively good level of satisfaction from their work in the construction industry. That is, they tended to get good rewards from their work as shown by their high frequency of reporting very rewarding level (Mode = 5). Using another 5-point Likert scale (1 = not improved, 2 = neutral, 3 = somewhat improved, 4 = improved and 5 = very improved), the professionals expected the profession to experience some level of growth in the next 10-15 years as shown by mode of 4 and average of 3.21, which implied a somewhat improved profession. Both predictor variable (satisfaction) and the predicted variable (growth) showed a negatively skewed distribution implying that most scores clumped up on the upper side of the rating scale. The outcome led to the conclusion that most of the quantity surveyors were satisfied with their profession and that they believed it would sufficiently grow in future.

Pooled *t*-test statistics tested the difference in average responses between the future growth of the profession and the current level of satisfaction with the profession. The *t*-test result was $t\,(28) = 20.54$, $p < .0001$. The interpretation of *p*-value is to reject the null hypothesis (no future growth of the profession) if $p < .05$ implying that there exists a significant difference in the tested statistical statement or

fail to reject the null hypothesis if $p > .05$ implying not enough evidence to reject the null hypothesis. Therefore, $p < .0001$ implied that the averages of the responses for the future growth and the level of satisfaction differed significantly and that the prediction of growth was highly dependent on the satisfaction with the profession.

Correlation and regression analyses determined the relationship and prediction level of growth of the profession from the current level of satisfaction. A correlation coefficient of 0.56 existed between the current level of satisfaction with the profession and the future growth of the profession. This index was statistically significant at $p < .05$ and was interpreted as a relatively strong positive correlation. The strong relationship implied a higher expectation of growth of the quantity surveying profession in future. Regression analysis investigated this outcome further.

Linear regression analysis predicted the future growth of the profession. In predicting the growth, coefficient of determination, R^2, estimated the amount of variance in the growth variable that was accounted for by the predictor variable (current level of satisfaction with the profession). Root Mean Square Error (RMSE) showed how far off the prediction of growth tended to be. Table 1 shows the results of the regression analysis. The y-intercept is 0.833 while the slope/gradient is 0.5833.

Table 1. Predicting the Growth of the Quantity Surveying Profession

Variable	Label	DF	Estimate	Standard Error	*t*-value	Pr > |*t*|
Intercept	Y Intercept	1	0.833	0.7006	1.19	0.2446
Satisfaction	Satisfaction with Current Profession	1	0.583	0.1667	3.50	0.0016

From Table 1, the regression coefficient (slope) for the satisfaction variable was statistically significant, [t (28) = 3.50, p = .0016]. This implies that the predictor variable had significant contribution to the predicted growth variable. In predicting the growth in the next 10-15 years, R^2 value of 0.3119 was recorded. This suggested that 31.19% of the variance in growth variable was accounted for by the current level of satisfaction with the profession variable. This percentage is high enough to warrant higher level of confidence in the predictive ability. RMSE of 0.9412 was recorded implying that the prediction of growth tended to be off by 0.9412. This was in accordance with the expectation that higher R^2 tend to be associated with lower RMSE. Regression equation (1) summarizes the results in Table 1.

$$\text{Growth} = 0.833 + 0.583*(\text{Satisfaction}) \quad (1)$$

Overall, it can be deduced from the statistically significant steep slope and strong correlation coefficient that the profession would improve in future. However, this may not imply a cause-effect relationship because there could be other confounding or extraneous factors in the profession or the construction industry that might affect such strong positive relationship or growth.

For example, tax breaks on new construction ventures or improvement in real estate markets may have significant implications. Such factors can make the professionals to be satisfied with the profession as well as being optimistic for its future growth.

4.3 Reasons for Future Growth of Quantity Surveying Profession

The respondents had different reasons behind their optimism for the future growth of the quantity surveying profession. These included:

- Economic improvement with more openings in areas such as sustainable design and construction.
- New regulations favoring the construction industry, e.g., improved ethical standards.
- Construction professionals preparing for the future as the construction industry is rising from economic downturn.
- Increase in the scope of quantity surveyors services in the challenging and dynamic construction industry environment.
- Wider international acceptance of British style quantity surveyor and even those project owners who put engineers as jack of all trades do realize that quantity surveyors provide far much better services than other construction professionals in meeting owner's needs.
- Current technological trends in IT that have helped in streamlining construction office practices thus reducing wastes and resulting in good use of resources and overall improvement towards profitability.
- Globalization is enabling QS to adopt best international construction practices.

Some of the aforementioned avenues that may favor future growth of the profession such as IT developments are akin to the outcome of the research by Smith (2004) which identified critical areas the QS needs to focus on to meet the dynamic owners' needs. Overall, the expectation of future awakening from the economic recession and new governmental rules that favor construction industry serve as a precursor for the future growth of the quantity surveying profession. In addition, the current level of satisfaction with the profession (Mean = 4.07) that is highly correlated with the growth of the profession ($r = 0.56$), the steep slope of the regression model (0.583) depicting greater level of growth of the profession, and relatively good level of coefficient of determination ($R^2 = 0.3119$) support the greater chance of future growth of the profession. Therefore, the working hypothesis of the expectation of future growth of quantity surveying profession was greatly supported.

5. CONCLUSION AND RECOMMENDATION

The focus of this paper has been to analyze the developmental trend of the quantity surveying profession by determining the satisfaction level of quantity surveyors and predicting the future of the profession in the construction industry.

This is because the profession recently experienced a meltdown and so it would be important to understand its current situation and growth in future. Qualtrics survey tool has been used to collect data from quantity surveyors where the results has shown that more than half of the respondents had over 15 years of experience in projects such as commercial and residential construction projects. The quantity surveyors offer many valuable roles in construction, and are satisfied with the current developments or trends in their profession. They believe that the future of the profession is promising. The future growth of the profession could be attributable to the expectations of future awakening from economic recession that could present avenues for advancements in areas such as IT and sustainable design and construction. This could widen the QS construction roles beyond preparing BoQ, representing employers in projects, and overall project management.

Overall, this study adds to the predictive and trend analysis studies involving quantity surveyors in the construction industry. It offers a rich source of information to construction professionals and project owners about the status and development of quantity surveying profession in future. The outcome of this research could positively affect the rate of recruitment and retention of the quantity surveyors in the construction industry since the profession is expected to grow. Thus, quantity surveyors would become confident in their continued service of providing greater value to their project owners or clients and need to continue expanding, improving, and diversifying their roles. They should maximize their potential in construction ventures in order to be reap greater benefits and improve relevance in construction.

In spite of the future developments, this research has shown quantity surveying profession to be male dominated from the very small percentage of female respondents (5%). This is a major limitation in this study since there is inequality of gender. It is recommended that further research be conducted focusing on gender equality that could propose ways to encourage more females to join the quantity surveying profession since its future growth would be invaluable when both males and females perform and benefit in relatively equal proportion. This study has also focused on the growth of the profession in the next 10-15 years. It would be worthwhile to conduct a stochastic study with a longer forecast period of say over 30 years since this is a typical projection period for most large-scale predictive research. Further research could also focus on differentiating growth among different professionals such as engineers, architects, and quantity surveyors. Each could be compared or expressed as a ratio of the total growth of the construction industry to determine their individual contribution.

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MANAGING QUALITY ON CONSTRUCTION SITES IN SOUTH AFRICA: AN EASTERN CAPE STUDY

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ABSTRACT

In South Africa, construction projects still experience non-conformance to quality requirements as well as cost and schedule overruns to the detriment of clients. For project success to be attained, conformance to these parameters is the minimum expectation in the face of other considerations related to client satisfaction. Thus, through the use of existing literature, and a field study conducted among site management employees working for general contractors (GCs) in the Eastern Cape province of South Africa, the management of quality on construction sites was examined. The study that was descriptive in nature shows that lack of skilled general workers and artisans contribute to poor quality control and management processes; while defects and rework form the main reason for project quality deviations on the sampled sites. The quality deviations in turn influence the level of cost and time overrun experienced on construction projects. The study corroborates the literature reviewed in that there is an interrelationship between cost, quality, and time in South African construction. For example, when the quality of work is below the required threshold, it leads to cost and time overruns due to rework that requires extra effort and expense. The value of this explorative study is that both site management and workers should be hands-on in terms of managing quality on project sites as failure to do so could have a domino effect relative to other project considerations.

Keywords: Contractors, Construction, Production, Quality, South Africa

1. INTRODUCTION

The construction industry contributes immensely to the global economy. As a result, there appears to be a relatively vigorous competition among construction firms for various business reasons. Most firms therefore compete with their prowess in production efficiency. The quality of site production activities are often taken into consideration in order to satisfy internal and external stakeholders while building good reputation for the firm. However, the literature is full of examples of project deviations in the form of non-conformance to quality requirements and other objectives. These deviations constitute a hindrance to the competitiveness of the firm on one hand, and the entire industry on the other hand.

Oakland and Marosszeky (2005) state that organizations compete on reputation for quality, reliability, price and delivery, and as such people now recognize that quality is crucial to the sustenance of a competitive advantage. As an illustration, when firms become known for poor quality product, it could take a long time to recover that reputation. Hence, quality is a key competitive weapon in the construction industry (Oakland and Marosszeky, 2005).

In particular, the industry in South Africa is currently facing problems related to the standard of construction quality expected by clients (Emuze and Smallwood, 2011). It is notable that project delivery that occurs within expected duration, cost, healthy and safe conditions, and to quality standards is a 'difficult' task because least duration and minimal cost tend to conflict with quality and health and safety (H&S) (Patrick, 2004). According to Ali and Kamaruzzaman (2010), scope, cost, time, and quality are the four fundamental constraints needed to be considered when managing construction projects, regardless of location. This quality focused paper discuss the relationships between these parameters from the production perspective in sections that explain the research problem and objectives, the synthesis of the literature, and the methodology that show how the field work was conducted. The findings and related discussions provide insights that were closed-out in the concluding remarks.

Research Problem and Objectives:

Based on the reviewed related literature, it was observed that projects experience non-conformances related to quality, which exacerbate cost and time overruns in the construction sector (Sommerville, 2007; Love, Irani and Edwards, 2004). The immediate effects of these problems are exemplified in dissatisfied clients and end-users of construction products. This research thus investigated the reasons for poor quality in construction production processes so as to evolve ways to improve it in the South African context. Also, the research investigated the relationship between cost, quality and time in a production setting. For instance, to ensure that work conforms to requirements, construction managers have to consider the performance of completed work via functionality, appearance, durability and maintenance.

2. DEVIATION FROM QUALITY REQUIREMENTS IN CONSTRUCTION

The quest for optimum reputation by a general contractor (GC) in the construction industry demands project performance considerations that would improve the satisfaction of clients. General contractors (GCs) gain reputation through fulfilling the needs of clients and the gain of reputation is the major requirement for a GC to be more competitive in the sector (Ashworth, 2004). The interdependence between the business and project aspects of construction management has been argued to be crucial in the quest for improved profitability in the sector (Smallwood, 2006).

The interdependence can be gleaned from various construction management related researched findings from South Africa. Ncwadi and Dangalazana (2006) report that South African construction is faced with productivity and quality problems. The authors contend that productivity and quality in South Africa has dropped, while H&S have only marginal improved. As a result, the industry is continuously experiencing confrontations with regard to dissatisfaction of clients (Ncwadi and Dangalana, 2006). This may suggest that contractors have realized the importance of H&S in the construction industry, and then started to focus on H&S, at the expense of other project considerations such as quality. The lack of quality is recognized through non-conformance of work to the established requirements that is evident when constructed project does not meet client's needs and specifications (Battikha, 2002).

2.1 Implications of Quality Deviations in Construction

Concealed quality related problems such as rework during construction process can be projected to other phases of the process (Ford and Sterman, 2003). The quality of work is one of the factors that reduces the incidences of rework and then, determine clients' satisfaction levels. Client dissatisfactions conversely could lead to a drop in the market share and profit of the construction firm that is responsible for a project through its implications for productivity (Rivas, Borcherding, Gonzalez and Alarcon, 2011). Quality deviations affect clients and other members of the supply chain, especially contractors. This means non-conformances affect the contractor because it yields penalties in the form of rework, which can significantly reduce productivity (Rivas et al., 2011). Furthermore, this demonstrates that quality; time, cost, and productivity are always linked together in construction (Battikha, 2002).

According to Joubert, Cruywargen and Basson (2005), who cited Grobbelaar (2001) and Ngowi (2001), top management in construction firms, both in South Africa and Botswana; do not show enough commitment to quality because of a skewed focus on profit maximization and construction time reduction. In some cases, it might happen that management's commitment is not clearly communicated to the workforce of a project in terms of access to the quality policy and goals of a firm and / or workers are not motivated to deliver work that conforms to requirements (Joubert et al., 2005).

The non-conformance of work to requirement could also arise when top management involved in a project is focusing too much on minimizing cost and reducing schedule. In order to cut time and cost in construction industry, management tend to ignore quality (Love, Holt, Shen, Li and Irani, 2002; Eden, Williams, Ackermann and Howick, 2000).

This illustrated scenario contradicts the needs of clients nowadays as they require quality more than price, especially in the public sector. The analogy means that clients do not necessarily look towards minimizing cost at the expense quality. To deal with this problem, commitment to quality is the main factor to focus on because management is the one that has a great influence on what is happening within a project (Rahman, Karim, Danuri and Wen, 2007). The extent to which management shows involvement and support to applying a total quality management (TQM) system within the construction project environment is very vital to producing work that conforms to requirements. When the commitment of management is lacking, quality improvement cannot be implemented adequately and if top management clearly shows commitment to quality, the employees would logically follow suit (Pheng and Teo, 2004).

In addition, the literature appears to indicate that employees who are physically involved in construction activities and quality improvements are not well trained to deliver the required results, and this is the major reason for the non-conformances in South African construction (Emuze and Smallwood, 2013). It has been reported (Zietsman 1997 in Joubert et al., 2005) that in South Africa, there is very little, if any, correlation between the performance of workers and their remuneration and this observation contributes to the tendency not to strive to produce a quality product. For example, a poorly remunerated qualified artisan has leverage in terms of changing jobs due to the scarcity of skilled tradespeople in the country. In contrast, unskilled or non-qualified artisans that stay in a firm with limited morale would continue to produce poor workmanship that manifest in rework, which affect the quality of delivered projects (Cooper, Lyneis and Bryant, 2002). Therefore, a balancing strategy is needed when deliberating remuneration, morale and performance of construction workers.

Another dimension that has implication for quality is the relative increase in the use of subcontracting by general contractors (GCs). Joubert et al. (2005) suggest that the increased use of subcontractors has led to increased fragmentation of the process, with the results that such subcontractors performs their tasks almost in isolation. This is particularly precarious when the GC and the subcontractor have varying project aims. As an illustration, the subcontractors may aim to complete the work as soon as possible while spending as little as possible by employing cheap labor; and to get remuneration as quickly as possible in a particular project to stay financially afloat. When a project by chance experiences a mismatch of interests among the project team, non-conforming work is a strong likelihood (Joubert et al., 2005). If works does not conform to requirement, this means that quality management and control by the main contractor is inadequate, because when it is planned and managed properly, subcontractors will be properly engaged and supervised.

Supervision in South African construction is however under strain because of reported shortage of experienced supervisory employees (van Wyk, 2008). The reported shortage results in a situation where monitoring and supervision do not take place on a regular basis and therefore defects are not identified at an early stage and continuous rectification of defective work abounds. As the work is not monitored and supervised regularly, and / or when the quality of supervision is below expectations, continuous corrective work occurs on project sites (Joubert et al., 2005).

3. METHODOLOGY

This research was conducted by collecting data relevant to the research problem. The descriptive research method was used to obtain information in the subject area (Leedy and Ormrod, 2010). The literature in turn informs the methodology and the design of the study. The data were collected using a semi-structured questionnaire that aided the interviews that were conducted among site management employees on different project sites in the Eastern Cape Province of South Africa.

The sampling method was therefore purposive as ten project sites were visited for observation and interview purposes within six weeks. The reason for sampling the Eastern Cape is to increase accessibility and get different views due to separation of towns in the province where the researchers were domiciled. Logistics also play a role in the decision to only sample the province. This approach was adopted so as to ensure that contextual and inductive approaches to understand local meanings and rules for behaviour underpin the findings (Tracy, 2013).

The semi-structured questionnaire comprised both close- and open-ended questions. The instrument was design to enable minimal participant response time. The Likert scale was used for eliciting responses to close-ended questions. The study that was conducted at the exploratory level allowed the student researcher to pay visits to project sites within the province. Fifty (50) construction professionals were approached in the course of the study. These respondents were found on the visited project sites. Hard copies of the interview guide were shown to the site personnel and the researcher was able to facilitate the completion process by talking with site management employees that agreed to be interviewed. Despite this hands-on approach, only thirty three (33) responses were validly recorded and analyzed. This equates to a 66% response rate.

4. DATA ANALYSIS AND INTERPRETATION

When the respondents were asked to indicate if dedicated personnel are specifically responsible for quality control in their firms, most (79%) of them responded in the affirmative. The comments from 21% of the participants who said ‘no’ show that the supervisory team is responsible for quality in their firms. The supervisory team is mandated to ensure that work is executed up to the required standard and is done according to requirements of the client. The supervisory team can be foremen, site agents and site engineers.

In particular, all the respondents suggest that site agents, site managers, construction managers, and foremen are individually and collectively responsible for quality during site production activities. Some of the respondents mention that their firms normally have dedicated quality personnel on large projects, while on project that are not large, the architect is responsible for quality control. In contrast, a respondent said that everyone is responsible for quality control, especially quality control of their section of work. Meaning that everyone is conscious about the importance of achieving work standard that conforms to clients' requirements. Furthermore, the interviewee comment that the client and / or promoter of a project appoints the engineer to ensure that the activities of the GC conforms to agreed specifications.

The respondents were also requested to indicate the reason for their diligence in terms of conformance to project specifications. The response which was based on a response percentage of 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree) and 5 (strongly agree), shows that client satisfaction, good reputation, and profitability are the primary motive behind quality related diligence on project sites. The mean score (MS) of all the top three motive is greater than or equal to 4.24, which means that these motives are either 'agree' or 'strongly agree'. In particular, majority of the respondents strongly agreed that the main reason why firms try to provide work that conforms to requirements is to satisfy the client. In addition, more than half of them strongly agreed with the option that firms attend to quality in order to foster and retain good reputation. Similarly, about half of them were also strongly in agreement with the statement that a quality focused firm improves its bottom line and avoid claims.

Table 1: Why provide work that conforms to specified requirements

Motive	**Mean Score**	**Rank**
Satisfy clients	4.73	1
Improve bottom line	4.30	2
Foster and retain a good reputation	4.24	3
Avoid claims	3.79	4

The next question asked the respondents to rate the factors that have an impact on non-conformance to requirements. As indicated in Table 2, these factors are arranged according to their individual rank in terms of the observed MS. These factors are ranked according their extent of impact on non-conformance of work to requirements. In this case, lack of skilled labor is perceived by the respondents as the factor with the most impact.

The responses also show that the respondents were relatively confident while completing this question as no one was unsure of his / her response. The MS of the top three factors are all above 3.0, which represent 'moderate' on the Likert scale. This suggests that the responses proves that it is has an impact, but in certain situations. Furthermore, it is notable that slightly more than half of respondents support the statement that lack of skilled labor has an impact on non-conformance of work to requirements. Some of the respondents equally perceive that inadequate quality control has an impact on the non-conformance of work to requirements.

Table 2: Factors that impact non-conformance to work requirements

Factor	**Mean Score**	**Rank**
Lack of skilled labour	3.36	1
Inadequate quality control	3.30	2
Inadequate quality management	3.18	3
Lack of suitable material	2.76	4

When the respondents were asked if there is a strategy for total quality management (TQM) in their respective firms, majority of them responded in the affirmative. This particular response is interesting as these firms still grapple with quality related problems despite their assertion of the use of TQM in their firms. Out of the minority of the respondents who have no TQM strategy in their firms, three provided reasons for its absence in their firms. Their reasons include:

- "Supervision provides quality control at all levels".
- "Site agent is responsible for the quality management".
- "Conformity to standard specifications such as the SABS 1200".

It is instructive to note that the respondent that made the first comment presume that supervision that provide quality control is part of TQM. This shows a gap in how such employees perceive a TQM strategy. These comments all shows that even when the construction firm has no TQM strategy in place, there is always a way of improving quality of work. Nevertheless, all the respondents were of the opinion that their firms make use of a strategy to assure quality of work. With respect to this assertion, the scale indicates response percentages of Never (1), Rarely (2), Sometimes (3), Often (4), and always (5), that were used to examine the issue. The MSs are all greater than 4.28, which indicates that all the strategies are either 'often' or are 'always' applied to ensure that work conforms to requirements. In particular, almost all the respondents contend that the use of quality material as specified in the contract data is always applicable to ensure that work conforms to clients' requirements. Some of them were of the opinion that regular supervision is always taken into account in order to ensure that quality is achieved.

Similarly, half of the respondents perceive that adequate management and control of quality and training of laborers respectively are the best strategy to apply in order to achieve work that conforms to requirements. Hence, it can be argued that all the strategies are important to ensure that work conforms to requirements.

Table 3: Strategies to ensure that work conforms to specified requirements

Strategy	**Mean Score**	**Rank**
Use of specified materials	4.59	1
Regular supervision	4.48	2
Adequate management and control of quality	4.39	3
Trained general workers	4.28	4

The study further corroborates the literature findings in terms of the relationships between different project parameters. A look at Table 4 indicates the extent to which non-conformance of work requirements impact other project parameters. The rating scale for the question ranged from 1 (strongly disagree) to 5 (strongly agree), and an unsure option. The recorded MSs were greater than 3. This suggests that non-conformance to requirements has impact on the four project parameters that were mentioned in the study. Even though the last ranked parameter is 3.72, it can still be argued that the impact exist to a certain extent. In all, almost all the interviewees strongly agreed that non-conformance of work to requirements has a pronounced impact on client satisfaction; meaning that it is one of the major reasons for client to be dissatisfied with the work done. Moreover, more than half of respondents strongly agreed that non-conformance of work to requirements also impact productivity. The analysis also shows that more than half of them strongly agreed that non-conformance impact cost, meaning that it plays a role in cost overrun that may arise through the agency of rework relative to defects. Therefore, all the top three parameters can be influenced by non-conformance of work to requirements.

Table 4: Impact of quality deviation on other project parameters

Parameter	**Mean Score**	**Rank**
Client satisfaction	4.88	1
Productivity	4.50	2
Cost	4.44	3
Environment	3.72	4

4.1 Discussion

Construction, especially in developing economies, often pulls together employees with different capabilities to complete a given project. When the project is finished, the project parties go their separate ways without further interactions that will lead to improved work practices. Failure to take advantage of 'lessons learned' can have a detrimental effect on the bottom line and reputation of a GC (Frank, 2011). As indicated in the findings of this explorative study, the major reasons for quality related diligence on construction sites have to do with the bottom line and reputation of the GCs as suggested by Frank (2011).

Client satisfaction is however central to the ability to engender profitability in a given construction business. However, a series of construction issues have continued to manifest in the industry to the extent that they have devastated the credibility of many firms, GCs and subcontractors alike (Forbes and Ahmed, 2011). Some of such issues, inter-alia, include (see Frank, 2011):

- Uneducated, unaware and incapable supervision.
- The fallout from poor site supervision.
- Factors that affect job harmony.
- Lack of or insufficient documentation.
- Quality assurance as opposed to quality control.

The aforementioned affect quality of construction products in various forms. For instance, insufficient knowledge of work, inexperience, limited knowledge of quality standards, inability to coordinate work activities, and poor scheduling competency (Frank, 2011) contribute to the manifestation of incapable supervision that often engender poor workmanship and quality in construction. In spite of the call for continuous improvement in construction (Egan, 1998; CIDB, 2004; Lopez, Love, Edwards and Davis, 2010), these issues have persisted unabated. The completion of most construction project within scheduled time has been a problem for a long time as maximizing quality, minimizing cost and meeting scheduled milestone are ever present challenges in construction, especially in large and complex projects (Corsar, 2011). As a result, construction clients are often exposed to poor satisfaction levels because of cost overrun and inferior quality that always accompany project delays (Ali and Rahmat, 2010). According to Love, Edwards, Watson and Davis (2010), project rework is a global plaque of the construction industry that tend to escalate the failure to deliver infrastructure needs on time. The inability of the construction industry to innovate and deliver projects on scheduled time has therefore cause widespread dissatisfaction among clients of the industry (Love, Edwards, Smith and Walker, 2009).

A study that mapped rework related empirical findings in South Africa in order to assess how the industry is addressing this problem that has been said to be pervasive and cyclic in construction was conducted by Emuze and Smallwood (2013). Emuze and Smallwood used various authored conference papers that discussed South African findings as the source of their primary data and conclude that rework is a problem that beget a range of consequences in South African construction.

Such consequences are not limited to cost and time overruns, but they also include reduced quality, productivity and profitability. Though, the knowledge of, and encountered with, rework has percolated in the industry, the phenomenon cannot be said to be adequately tracked and monitored in South Africa (Emuze and Smallwood, 2013). In other words, there appears to be a major scope and motivation for additional effort that is required to address rework as an immediate cause of non-conformance to quality that beget a range of negative consequences in South African construction.

From this particular study, it is evident that signed conventional construction contracts defines what is to be built, and provides the framework of a quality management system that can be said to be less detailed, and partly effective (Rwelamila, 1995). This deduction resonates with the work of Rwelamila (ibid) that examined construction quality in the SADC region. After analyzing results of opinion surveys and interviews that were conducted among construction professionals in the region, Rwelamila (1995) suggests that a gap exists between how standards of quality within established practice of the construction industry are defined, and how standards of quality are established on project sites. He noted that it would appear that site management establishes quality in a situation that is characterized with arbitrary decisions. Experiences and management abilities therefore determine the level of quality that occurs on project sites. This perspective offered by Rwelamila in 1995 persist today as the projects sites that were visited in the course of this specific study equally rely on experiences and management abilities for the achievement of quality on site.

The CIDB report that is entitled "Construction Quality in South Africa; a client perspective" (CIDB, 2011) support the 1995 findings of Rwelamila. The report noted that site management and the supervision of works marginalizes quality in South Africa. The report further mention that it is notable that design and construction processes anomalies often manifest as rework, defects and non-conformances in the works in South Africa. More so, the annual construction industry indicators (CII) by the CIDB have continuously highlighted the need to improved quality. The 2007, 2008 and 2009 CII reports show that more than 18% of clients were either neutral or dissatisfied with the quality of works delivered as recorded defects in the period were more than 12%. Even in the recent CII report, around 8% of the projects surveyed had levels of defects which are regarded as inappropriate (CIDB, 2014). These findings show that quality as excellence relative to site management should be addressed.

5. CONCLUSION AND RECOMMENDATION

This study that was conducted to explore the impact of non-conformance to requirements on construction projects was qualitatively done so as to contextualize rather than general the findings. With a succinct literature review and a field study conducted among site based construction professionals, it can be concluded that there is a major possibility for quality improvement in South African construction.

The analysis of the obtained data show that the firms that took part in the study view the achievement of quality products as a key to their continued business growth through improved bottom line and reputation that is backed-up by optimal satisfaction of clients and other end-users of delivered projects. The research further shows that there is a relationship between quality, and other project parameters in production settings. And so, it can be said that when quality is achieved, there a tendency to attain enhanced construction production performance. For this to occur, it is imperative to avoid pitfalls associated with lack of skills among site management and workers so that adequate quality assurance and control processes can be assured. The study reinforces the view that conventional quality management for assuring client satisfaction and compliance with specification is based on a system, which partially fulfills the requirements for an effective quality system.

Although the use of specified materials and regular proper supervision of works have major impact on the reduction of defects and rework, quality related problems would persist except the tenets of TQM is properly interpreted and embraced by GCs. Quality improvement imply excellence in how the 'works' are carried out on project sites. Thus, 'learning, unlearning and relearning' should form the cornerstone of firms that are keen on the development and sustenance of competitive advantages in an industry that is noted for low barriers to entry. The enhancement of cost, productivity, and time performance of a project should thus be driven by a 'quality focus' approach by GCs. When planning for a project, more focus is needed for how to achieve and improve quality without escalating project cost. When avoiding increased cost, informed decisions should be made because such a decision would affect quality and exacerbate mistakes that increase avoidable rework, morale and other aspects of a project.

To sum up, this study has shown that managing quality on project sites requires additional efforts from site management and workers in the employ of GCs, especially in relation to the firms that took part in the study. Future research should examine the extent that supervision affects the quality of works carried out in a particular site. Even the dynamics between supervision and quality initiatives such as quality assurance (QA), quality control (QC) and TQM, should be examined as QA is preferred to QC. In other words, executed work should meet expected conformance requirements when they are done right 'first time.'

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WINTER CYCLING IN VERY COLD CLIMATE – A CASE STUDY IN CALGARY

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ABSTRACT

A survey was conducted among cyclists in the city of Calgary, Canada, to identify the characteristics of winter cyclists in a metropolitan area with a very cold climate, and to investigate what variables are most likely to affect their cycling behavior. The findings of the survey reveal that even very low temperatures do not appear to be a major concern for most participants. Instead, the majority of cyclists mentioned road surface conditions, rather than the weather itself, to be the major deterrent to winter cycling. In order to analyze the direct and indirect relationships between the different variables affecting winter cycling, a multi-layered model was developed. The model distinguishes between the cyclists' inherent characteristics, cycling behavior variables and motivating factors that could both affect cycling behavior and be affected by inherent characteristics. Since the cyclists' inherent characteristics, such as age and gender, cannot be changed, identifying and addressing the cyclists' motivating factors could be a key to influencing cycling behavior.

Keywords: Cold Climate, Cyclists Characteristics, Cycling Behaviour, Statistical Analysis, Winter Cycling

1. INTRODUCTION

Car-based transportation has a negative impact on the environment, through air pollution, congestion, noise, and extensive land use for roads and parking facilities.

The importance of bringing about an increase in cycling as a method to reduce motor traffic has consequently been widely recognized over the past two decades (Hillman and Maughan, 1992). In addition to its beneficial impact on the environment, cycling also positively affects the health of individuals, and is accessible by all layers of society and economically affordable, hence addressing all three aspects of environmental, social and economical of sustainability (Pucher and Buehler 2008). For the above reasons, cycling is considered as an important and strategic mode of transportation in urban areas (Andrade et al., 2011; Brandenburg et al., 2007).

Past research indicates that the construction of cycling facilities in urban areas (i.e. off-street bike paths and on-street bike lanes) is associated with an increase in cycling (Buehler & Pucher, 2012). The construction of cycling facilities is, however, a major investment for cities. The six largest metropolitan areas in Canada – Toronto, Montreal, Vancouver, Ottawa, Calgary and Edmonton – have all initiated extensive initiatives to facilitate cycling, by providing additional bike paths and lanes and ample bike parking. With the exception of the province of Quebec, these initiatives are almost entirely dependent on municipal funding (Pucher & Buehler, 2006). Similar to other metropolitan areas, the city of Calgary has made major investments in order to support cycling, creating one of the most extensive networks of bike paths and lanes per capita in North America (Pucher & Buehler, 2006). Calgary's initiative is accompanied by policies to encourage the integration of transit and cycling, such as safe and secure bicycle parking at transit stations, allowing bicycles on trains and buses and improvements to bicycle routes and transit station access (CTP, 2009).

From an environmental perspective, it is especially important to reduce the number of car trips in wintertime, when colder ambient temperatures increase the emission rates for some pollutants caused by traffic (Bergström & Magnusson, 2003). However, cycling is generally considered to be constrained by weather conditions such as rain, strong winds and low temperatures (Nankervis, 1999). Therefore the benefit of investments in cycling facilities in cities with a very cold climate, such as Calgary, is uncertain in light of the extreme conditions prevailing during the extended winter season. A very cold climate zone is defined as a region with more than 5,000 heating degree days or greater, on an 180C basis, and less than 7,000 heating degree days (ASHRAE, 2007). Cities with a very cold climate can also be uncertain how to plan their cycling facilities, in light of the requirements of those who do cycle during winter. Questions include: how extended should the bike paths and lanes be, in light of the distances that winter cyclists are likely to cycle? And how should cycling infrastructure be maintained in order to satisfy the needs of those who cycle in winter?

The objective of the present research is to identify the characteristics of winter cyclists in a metropolitan area in North America with a very cold climate classification, and to investigate what variables are most likely to affect their cycling behavior. The results of this study can assist cities with a very cold climate in planning new cycling facilities, and maintaining existing ones, to support winter cycling.

2. LITERATURE REVIEW

A number of variables that can impact cycling in metropolitan areas were identified through an extensive review of cycling research literature. These variables include the gender and age of cyclists; trip distance and urban morphology; cycling safety; cycling facilities and route conditions; weather conditions; trip purpose; and use of intermodal transportation. Following is a summary of the literature on each one of these variables.

1) Gender and Age: Studies conducted in North America show that an individual's age is negatively associated with cycling, and that women are less likely to cycle than men (Kim & Ulfarsson, 2008; Moudon et al., 2005). In North America, cycling is more popular among male, younger adults, who are physically active and in good health. In Europe, on the other hand, men *and* women are equally likely to cycle, and cycling rates vary little across age strata (Winters et al., 2007). This indicates that there might be an opportunity in North America to increase cycling among women and older adults.

2) Trip distance and urban morphology: An increase in the distance between home and work tends to decrease the number of trips by bicycle (Bergström & Magnusson, 2003). This decrease becomes even more significant in winter. Similarly, greater proximity to offices, clinics, and restaurants contributes to the likelihood of cycling (Moudon et al., 2005). Pucher & Buehler (2006) identified higher densities and mixed-use development in Canadian cities, compared with cities in the U.S., as causes for Canada's relatively higher cycling rates. However, the most recent data shows that Canadian commuters spend an average of 25.4 minutes travelling to work, which is almost identical to the average in the United States (25.5 minutes) (Statistics Canada, 2011). Moreover, no correlation was found by the authors between cycling rates and commute times when comparing different Canadian metropolitan areas. Calgary specifically has a higher than average commute time, and a slightly lower than average cycling rate (Statistics Canada, 2011).

3) Cycling Safety: Higher cycling rates have been found to be strongly correlated with lower levels of cycling deaths and injuries.

Higher cycling rates have been considered to create a virtuous cycle that increases safety. In other words, safer cycling encourages more people to cycle, and as more people cycle, more cycling facilities will be provided and more consideration by motorists will be given to cyclists, which in turn make cycling even safer (Pucher & Buehler, 2006).

4) Cycling facilities and route conditions: Cities with more extensive cycling facilities have significantly higher rates of commuting by bikes (Buehler & Pucher, 2012). The road conditions on bike paths and lanes are, however, very important. A survey study in Sweden found that around 40% of the respondents stated that they would cycle more during winter, if the maintenance service level of bike paths were improved (Bergström & Magnusson, 2003). The most recurrent desires they expressed were more frequent snow clearance and de-icing. These findings echo the results of a survey in Vancouver, Canada, in which the top deterrent of cycling was identified as the route being icy or snowy (Winters et al., 2011).

5) Climate and weather conditions: The impact of route conditions during winter on cycling alludes to the importance of weather conditions. Various studies found rain, snow and freezing weather to be associated with lower levels of cycling (Flynn et al. 2012; Miranda-Moreno & Lahti, 2013; Nankervis, 1999; Thomas et al., 2009; Winters et al., 2007). These studies report a decrease of 30%-50% in cycling rates during winter, accompanied by an increase in the number of car trips. One study found low temperatures to be more important to women than to men (Bergström & Magnusson, 2003). It should be noted, that these findings reflect differences between cycling rates in summer and in winter at the same location. When different large cities are compared, annual precipitation and the number of cold and hot days are not found to be statistically significant predictors of the rates of commuting by bikes (Buehler & Pucher, 2012). This is demonstrated by the fact that cycling rates are considerably higher in Canada than in the United States, despite the much colder climate (Pucher & Buehler, 2006).

6) Trip purpose: While studies show that cycling levels do decrease during the winter, cyclists with less obligatory purposes such as recreation, are much more influenced by cold weather than commuting cyclists (Thomas et al., 2009; Nankervis, 1999; Brandenburg et al., 2007).

7) *Intermodal transportation*: Finally, studies have suggested that facilitating intermodal transportation can increase the distances travelled, eventually leading to more cycling (IST, 2010).

While research has shown that the above variables characterize cycling behavior, their impacts on cycling seem more complex, and in some cases, interrelated; e.g.:

- Age and gender are important factors in North America, but not in Europe (Winters et al., 2007).

- Better facilities do encourage cycling (Buehler & Pucher, 2012), but only if good surface conditions are maintained (Winters et al., 2011).
- High cycling rates and safety appear to be interrelated (Pucher & Buehler, 2006).
- Many people tend to cycle less in winter, but this does not necessarily mean that people cycle less in colder cities (Buehler & Pucher, 2012).
- Cold weather seems to affect commuters less, but women more (Bergström & Magnusson, 2003).

It is therefore important to identify not only the variables characterizing cycling behavior, but also their interdependencies. Previous studies on winter cycling have been few in number and mostly carried out in cities with *mildly cold* and *wet* winters in Europe, North America and Australia. One exception is the study carried out by Bergström & Magnusson (2003) that was conducted in the *subarctic* climate of northern Sweden. It dealt, however, with the relatively small, compact town of Lulea, which has an area of 28 km^2 and approximately 75,000 inhabitants. Moreover, most of the previous studies relied either on observing cyclists, or on questionnaires distributed among sampled respondents from the community at large, which were then answered via the web, mail or telephone.

3. THE PROPOSED MODEL

The model developed in this study was motivated by the results of an earlier city-wide public telephone survey conducted in Calgary (City of Calgary, 2011). The results of the study identified that "fearless" or "confident" cyclists were mostly male and middle aged, and cycled frequently. On the other hand, "interested" or "reluctant" cyclists" were more concerned about traffic and tended to cycle less frequently. These results suggested that maybe instead of a traditional model that defines relationship between dependent and independent variables, cycling behavior can be explained as a multi-layer model with relationships between three groups of variable: the *inherent characteristics* such as gender, the *concerns of cyclists*, such as cars on the road, and their actual *cycling behavior*, such as frequency of cycling. A multi-layered model was consequently hypothesized in which *inherent characteristics* of the cyclists (i.e. age, gender and thermal comfort) could have an impact on intermediate variables related to cyclists' *motivating factors* (i.e. safety concerns, infrastructure deficiencies, and trip purpose), which in turn can affect dependent variables related to *cycling behavior* (i.e. duration and distance of trips, the use of intermodal transportation and cycling frequency in summer and winter) (Figure 11). For example, a cyclist's safety concerns might increase or decrease the frequency of cycling, and at the same time be affected by the age of cyclist itself. Since cyclists' inherent characteristics cannot be changed, identifying and taking into account such motivating factors could be a key to influencing cycling behavior.

Thus, in this example, the definition of a strategy to increase the frequency of cycling among a specific age group might benefit from a better understanding of the safety concerns that are more common among cyclists in that age group.

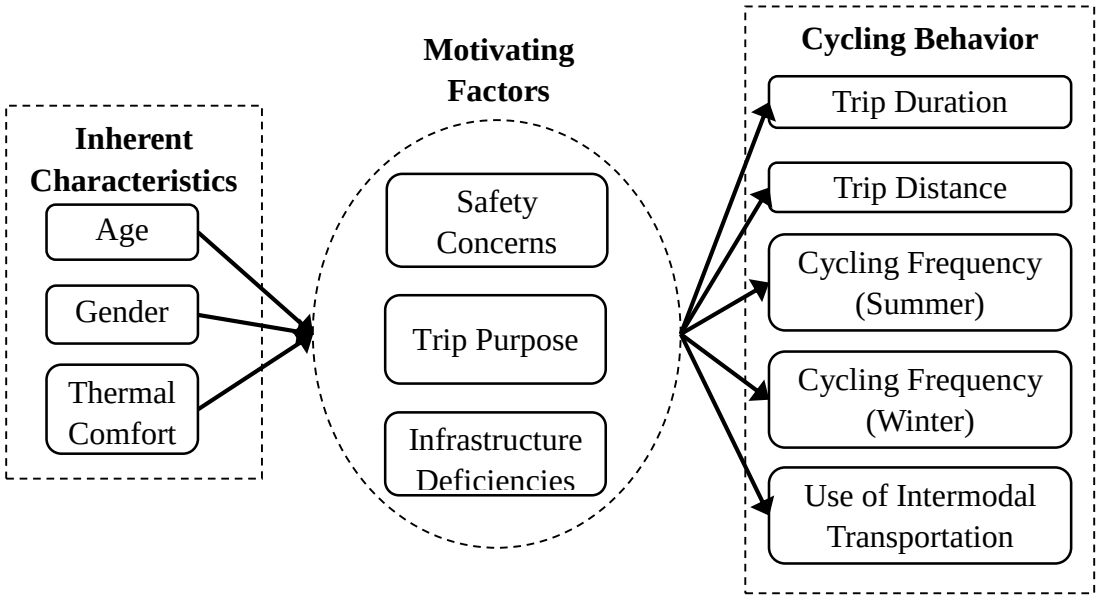

Figure 1: Hypothesized Model.

4. DATA COLLECTION METHODOLOGY

The objective of this study is to identify the variables affecting the cycling patterns in metropolitan areas with a very cold climate and to analyze the interrelationships between those variables. The present study seeks to broaden the existing knowledge on winter cycling by directly interviewing winter cyclists through an intercept survey on cycling routs during winter months. By asking the cyclists to answer questions in-situ, the intercept survey ensured that the respondents are those who actually cycle during winter and in a city categorized to have a very cold climate. The results of this study can be beneficial for planning of cycling infrastructure in cities with very cold climate by providing a better understanding of cycling behavior and concerns of winter cyclists.

4.1. Survey Instrument

Eleven variables, identified in the literature review that was summarized in previous section, were used to study the characteristics of winter cycling in this study. These variables are:

- Age
- Gender
- Safety concerns

- Infrastructure conditions
- Temperature
- Distance traveled
- Purpose of the trip and its duration
- Frequency of cycling (in winter as well as rest of the year)
- Use of intermodal transportation

A questionnaire was designed to collect data on these variables. In most cases, the measurement of the variable was straight forward. For questions regarding the age, thermal comfort, trip duration and trip distance (for the current trip), and the frequency of cycling (in winter and in summer) the respondents were provided options with numerical categories. Regarding the gender of the respondent and the use of intermodal transportation ("are you combining your trip with any other mode of transportation: walk, car, public transit?"), the possible options were also clear.

To develop a list of options for questions regarding the safety concerns of the respondents ("what are your most important safety concerns when cycling in winter?"), the infrastructure conditions ("what are the most important infrastructure deficiencies that you would like to see improved?"), and the trip purpose ("what is the purpose of your trip?"), the results of a previous survey conducted in Calgary regarding cycling in summer months were incorporated (Har 2011). Those options that received the highest number of responses in this survey were included in the questionnaire. For those three questions, the option of "Other" was also included to capture responses that could have been missed in the summer survey. If they selected "Other" as an answer, participants were asked to specify.

A pilot survey was performed using 5 participants who either had expertise in cycling infrastructure planning or were frequent cyclists themselves, to assess its logical consistency, ease of understanding and the sequence of questions. The feedback from these participants led to minor modifications in the wording of the questions and options available for each question. The complete list of options provided for each question can be found in figures presenting the survey summary in Section 4.

4.2. Survey Administration

The survey was conducted on a newly-implemented bike lane as a case study. The bike lane is located on 10th St. NW in the city of Calgary, Canada, which is a street with relatively high traffic, feeding to the downtown core (business district in Calgary). The implementation of this bike lane was a pilot project that had been carried out to investigate the feasibility of a new urban planning strategy to promote cycling as a means of sustainable transportation in Calgary (Pilot, 2013).

In addition to the variables mentioned above, one more question was added to the survey in order to measure the effect of the implementation of the bike lane on the frequency of cycling ("Did you cycle on this route before the implementation of the bike lane?"). The recent date of the implementation of the bike lane was helpful in ensuring that the participants remember their prior travel path and answer the question accurately.

The questionnaire was used to conduct an *intercept* survey. The use of an intercept survey ensured that the study reduces the perception error and targets actual winter cyclists. The ethical aspect of the survey was reviewed and approved by the University of Calgary's Conjoint Faculties Research Ethics Board. Signage indicating "Cycling Survey Ahead" was used few meters ahead of surveyors to give cyclist awareness of the activity. Upon stopping, cyclists were briefly explained the purpose of the survey, and provided with a consent form that summarized the voluntary nature of the survey. Once the cyclists agreed to participate, questions were read to them, and their answers were recorded in-situ by the surveyors.

The survey was conducted over nine days on the abovementioned bike lane in late winter (March) 2012. The timing of the survey was selected during the afternoon rush hour (4:30 to 6:30pm) to take advantage of the increased number of cyclists. Previous summer surveys in Calgary showed that the peak morning hour for cycling was 7:00 to 8:00 a.m. and the afternoon peak hour was 4:45 to 5:45 p.m. (Calgary 2013). During the first days of this survey it was quickly learned that during the morning rush hours cyclists were often not inclined to stop as they were rushed to get to work. However, during afternoon hours they were more willing to participate in the survey. The average temperatures during morning and afternoon rush hours were -1°C and +6.5°C, which is typical for Calgary in this time of year (Table 1). As survey results will demonstrate, the majority of participants were commuters, indicating that they had also cycled earlier in the morning, when the temperatures were as low as -5°C (Table 1). A total of 103 surveys were collected during the nine days of the survey. Of all the cyclists who were reached out to stop at the surveying points, only four did not stop for the survey, bringing the rate of response to 96%. Despite the cold temperatures, the participants were in general very enthusiastic and often offered extra explanations in answering the questions. Table 1 shows the distribution of the collected surveys and the temperatures over the surveying period.

Table 1: Temperature and number of surveys collected over data collection period.

Day #	Date (March 2012)	# of surveys collected	Temperature (°C)	
			8:00 AM	5:00 PM
1	3rd	12	-3.9	4.9
2	7th	6	-4.6	4.6
3	8th	23	3.4	10.8
4	9th	9	3.8	11.6
5	13th	9	4.4	2.0
6	14th	6	-4.8	4.8
7	15th	22	-3.6	12.2
8	20th	2	-3.5	4.9
9	21st	14	0.1	4.0
Average		11.4	-1.0	6.6

5. SURVEY SUMMARY

Following is a summary of the data collected in the survey, concerning each one of the previously identified variables:

5.1. Gender

85% of the participants were male (Figure 2). While previous studies also showed that women are generally less likely to cycle in North America, the gender gap among the winter cyclists in this survey is much wider than that found in previous studies, which reported women to be half as likely to cycle as men (Winters et al., 2007). A possible explanation that comes to mind is that women have been found to be more sensitive to low temperatures than men, feeling comfortable at temperatures that are on average higher by about 2°C (Van Hoof, 2008). However, the present study did not find any correlation between the participants' gender and the temperatures at which they reported feeling comfortable to cycle. Moreover, it is interesting to note that the findings do seem to correspond to those of a city-wide bicycle count that was recently conducted in Calgary during the spring and summer season, and in which 79% of the cyclers were male (Calgary 2013). Thus, the major cause for this gender gap does not seem to be directly related to thermal comfort.

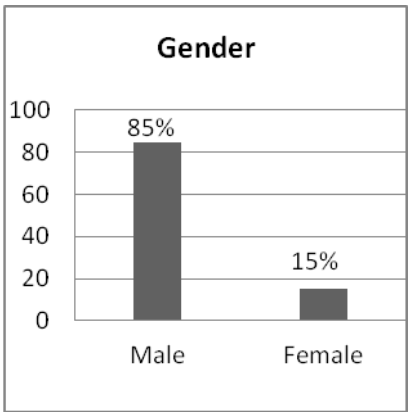

Figure 2. Gender distribution of the participants.

5.2.Age

More than 60% of the participants in this survey were than 35 years or older (Figure 3). It was interesting to observe that one third (33%) of the participants were more than 44 years old, which is only slightly lower than the share of this age group in the general population of Calgary (standing at 36%) (Statistics Canada, 2011). This seems to indicate that unlike what was reported in other studies (Kim & Ulfarsson, 2008; Moudon et al., 2005), in this case study an individual's age is not negatively associated with cycling, and that age does not significantly impede cycling in cold weather. These findings correspond to those in the previously conducted telephone survey, in which 66% of those who cycle regularly *year-round* were more than 35 years old, and 40% were more than 44 years old (Har 2011).

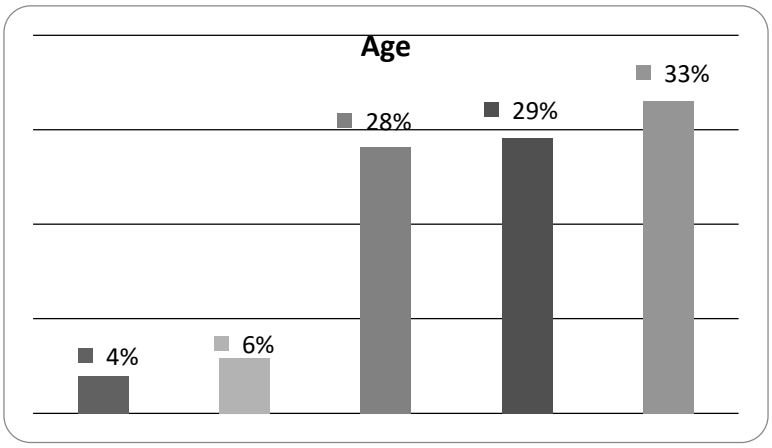

Figure 3. Age distribution of the participants.

5.3. Thermal Comfort

While it was expected that winter cyclists would display a relatively high tolerance for cold weather, the participants' answers, when asked to specify at how low a temperature they felt comfortable to cycle, were striking (Figure 4). Overall, the findings of this survey are in principle in line with results reported in the other study conducted on winter cycling in very cold climate (i.e. Lulea in Northern Sweden), where the majority of frequent cyclists mentioned road surface conditions, rather than the weather itself, to be the major deterrent to winter cycling (Bergström & Magnusson, 2003). However, even very low temperatures do not appear to be a major concern for most participants in this study. 33% indicated that they were comfortable cycling at temperatures down to -20°C, and another 38% said that they felt comfortable cycling at even lower temperatures; i.e. it did not matter to them how cold it is. As the average temperature during the coldest month in Calgary (January) is between -3°C and –15.7°C (Environment Canada, 2014), it appears that the majority of winter cyclists will be comfortable cycling in Calgary through all winter months. While it was expected that the winter cyclists in a city with very cold climate would have some tolerance to cold temperatures, such a high tolerance among more than 70% of the participants was surprising. It should be noted that thermal comfort has been found to depend, to a large degree, on cultural and social contexts, differing from one country to another (Andamon et al., 2006; Knez & Thorsson, 2006; Nikolopoulou & Lykoudis, 2006; Shove & Chappell, 2004; Stoops, 2002). For example, one study found people in different European countries felt comfortable in a variation of over 10°C (Nikolopoulou & Lykoudis, 2006).

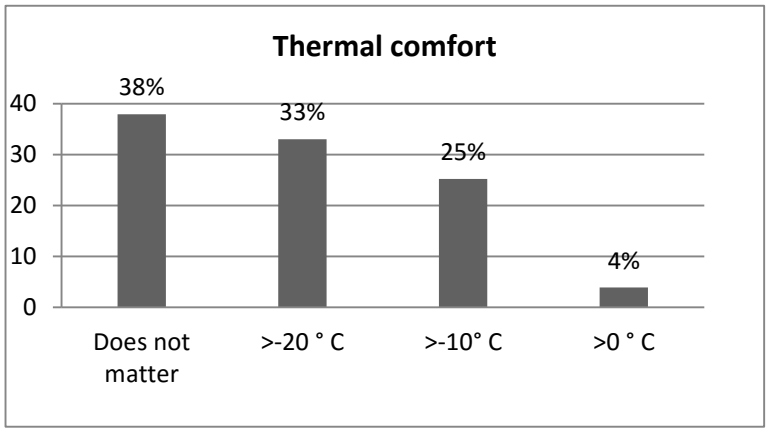

Figure 4: Distribution for thermal comfort of participants ("What Temperature is too cold for you to cycle?")

5.4. Safety

61% of the cyclists identified "icy conditions of the bike lane" as a major safety concern during the winter. Obstacles, other cyclists, and pedestrians on the lane did not seem to be a major concern for the participants (Figure 5). Approximately half (48%) of the cyclists, however, mentioned that they had "Other" safety concerns. When asked to specify, 40% were concerned with the existence of gravel and snow on the lane, and 30% named adjacent fast moving cars as a safety concern. In their explanation, cyclists also noted that besides being a safety issue due to slipping, the existence of the snow and gravel reduces the width of the bike lane, pushing cyclists closer to the adjacent car lane.

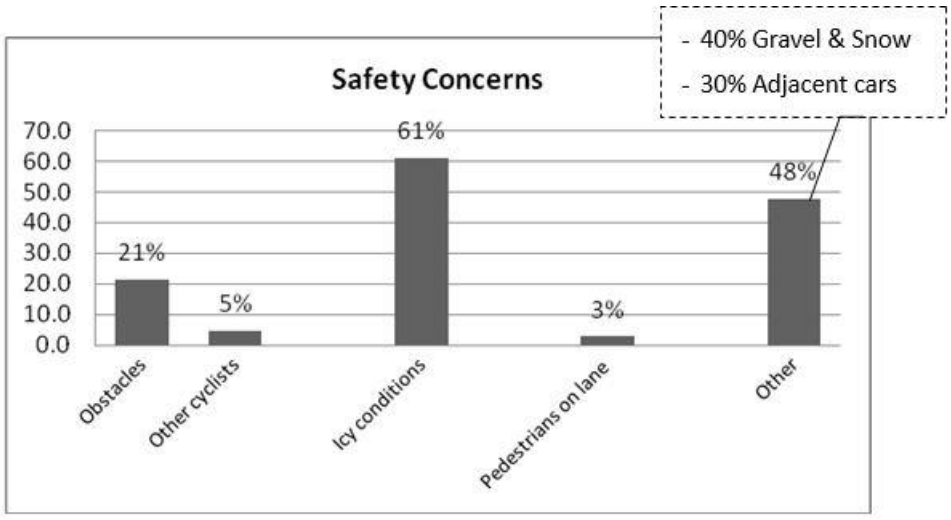

Figure 5. Most important safety concerns (multiple answers allowed).

5.5. Infrastructure Deficiencies

When asked to identify the most important deficiencies on the lane that needed to be addressed, the options mentioned most often by participants were snow and gravel removal under "Other" (25%), followed closely by cracked road surface (24%) (Figure 6). Interestingly and related to this study, both of these deficiencies are caused by cold weather conditions. The gravel used on the lanes in Calgary is in fact part of a sanding chip mixture (3% salt, 97% fine gravel) used by the municipality to melt accumulated snow and ice in Calgary in winter when road surface temperatures are below -5°C. Cracked surfaces can also be at least partly attributed to cold weather, as water from rain and snow penetrates through small existing cracks, and then expands when it freezes, putting stress on the pavement and increasing the size of the cracks.

Insufficient signage and lighting were the next two concerns. Narrow lane width was less of a concern for the participants in this study. The width of the bike lane on this case study ranges between 1.5 to 2 meters along its length.

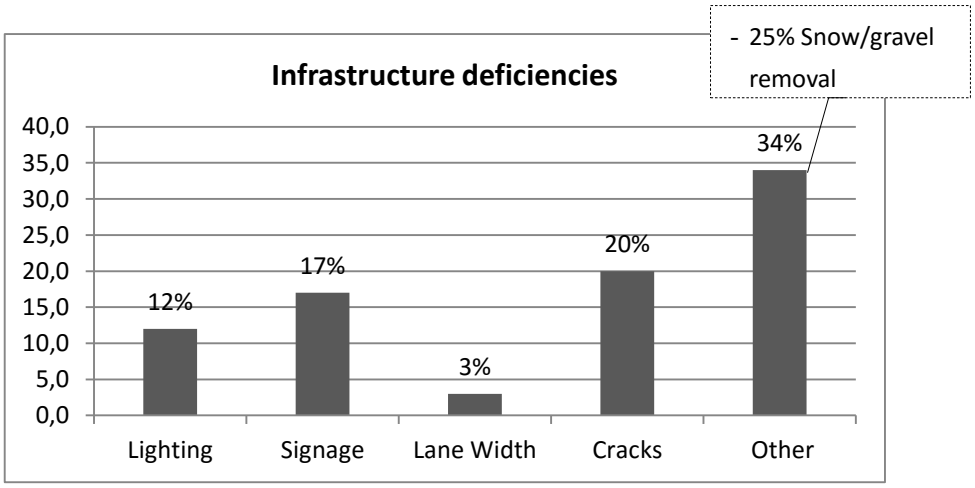

Figure 6. Participants perception of infrastructure deficiencies (multiple answers allowed).

5.6.Trip purpose

75% of the participants indicated that the purpose of their trip was commuting to work (Figure 7). This conforms to findings in previous studies, according to which the majority of winter cyclists are commuters (Brandenburg et al., 2007; Nankervis, 1999; Thomas et al., 2009). It could also be explained by the fact that the location of the survey was on a route exiting the downtown area, and that it was conducted during the afternoon rush hour. As participants were allowed to choose more than one choice for this question, the trip purpose distribution also demonstrated that many cyclists combined different purposes in one cycling trip, for example, exercise or shopping as well as commuting.

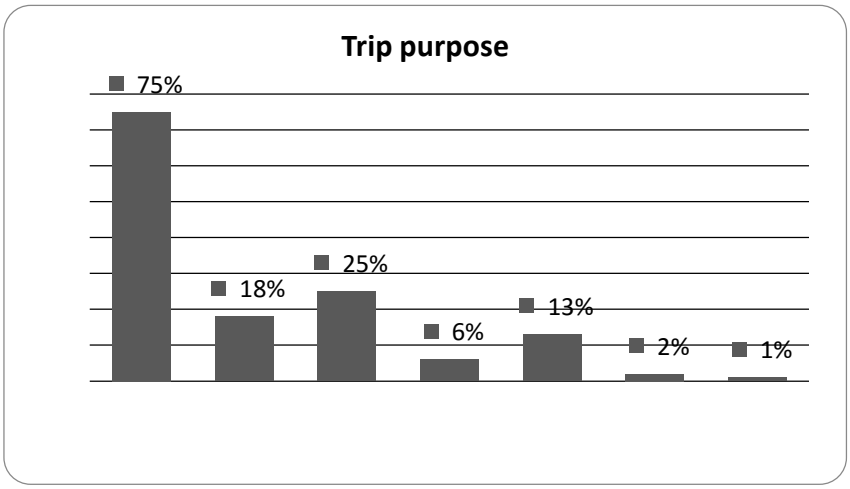

Figure 7. Trip purpose of the participants (multiple answers allowed).

5.7. Trip distance and duration

The average one-way trip distance for the cyclists in this study was 7.4 km, with about one third (28%) traveling distances of over 10 km (Figure 8). The majority of the participants – about 72% – had trip durations between 10 to 30 minutes. The duration of the trip for a quarter (25%) of the participating winter cyclists was more than 30 minutes, and for almost one third (62%) more than 20 minutes. Only 3% of the participants used cycling for trips shorter than 10 minutes. This seems to run counter to the results in Bergström & Magnusson (2003), who consider a distance of over 5 km to be a deterrent to cycling in winter. Moudon et al. (2005) consider a distance of 3 km, and Winters et al. (2011) a distance of 8 km, as being a reasonable for cycling year-round. However, Winters et al. (2011) also distinguish between regular and potential cyclists: while a distance of more than 10 km is found to be a strong deterrent for potential cyclists among the general public, it had no influence on regular cyclists, conforming to the results in the present study. The results here are also aligned with those of a study by Nankervis (1999), in which the mean travelling distance was found to be 7 km, while 25% of the trips were longer than 10 km. However, the study by Nankervis (1999) was carried out in the much milder climate of Melbourne, Australia. The results of the present study suggest that in practice longer distances and durations are not a deterrent for a significant number of regular cyclists, and that a very cold climate does not change this.

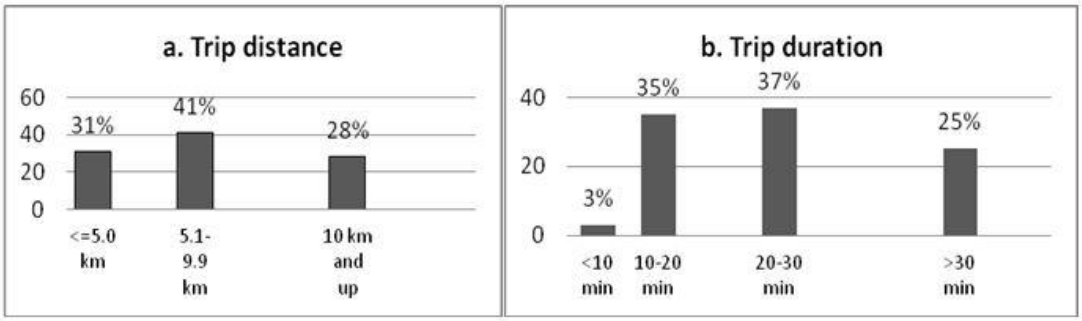

Figure 8. (a) Trip distance and (b) trip duration.

5.8. Usage of bike lane

25% of the participants reported that they had started to cycle on the route in this study only after the implementation of the new bike lane (Figure 9). This underlines the positive role of cycling facilities in increasing cycling rates. Although it was not part of the formal questionnaire, a large number of the participants who had been using this route before the implementation of the new bike lane expressed their satisfaction with the newly allocated bike lane upon answering this question. These findings conform to monitoring data from The City of Calgary's Transportation Department, which reported an increase in the year-round bicycle volumes recorded after the implementation of the bike lane (Pilot, 2013). The attraction of more cyclists to the bike lane reconfirms the results of the previous telephone survey conducted for the City of Calgary, in which more than half (57%) of the respondents reported being uncomfortable cycling on busy roads if specific bike lanes are not present (Har, 2011). This corresponds to the findings in other surveys (e.g. Transportation Research Board, 2006), which report that people living close to bike lanes have significantly increased odds of bike use compared with those living further away from such lanes.

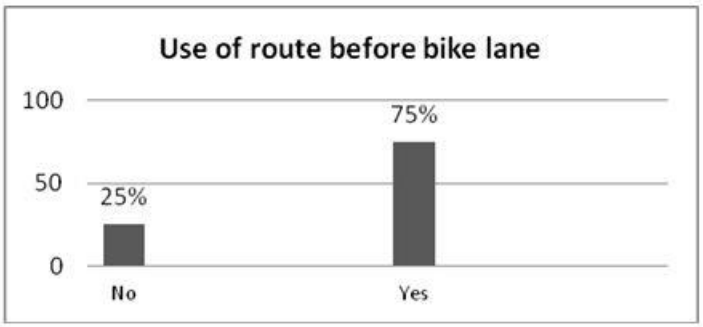

Figure 9. Use of the route before the implementation of the bike lane.

5.9. Intermodal transportation

75% of the participants stated that they used *only cycling* for the particular trip on which they were surveyed, without combining it with other modes of transportation (Figure 10a). Among those who did use intermodal transportation in their trip, the majority (59%) combined their cycling trip with public transit (Figure 10b). Though cyclists are generally allowed in Calgary to transport their bicycles on public transit, this does not apply on trains during rush hour. This might help explain the fact that only a small group of the participants chose to combine their trip with other modes of transportation.

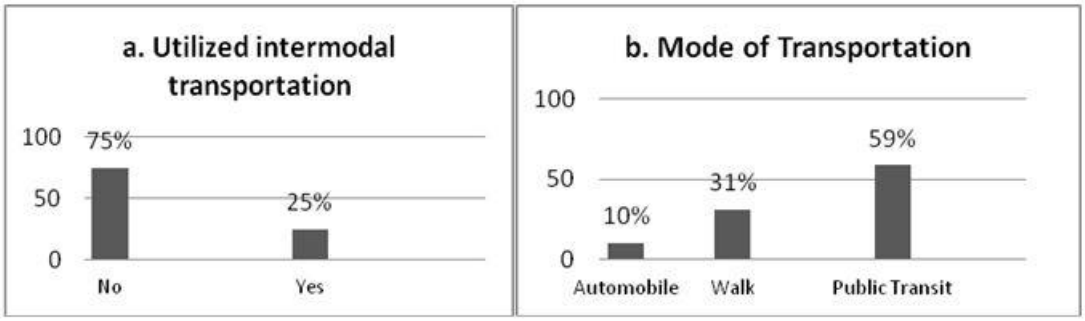

Figure 10. Use of intermodal transportation a) If cycling trip is combined with other modes of transportation; b) If yes: which mode of transportation.

5.10. Frequency of cycling

The majority of the participants in the present study were frequent cyclists: 72% of the participants cycled 10 times or more per week throughout the year, suggesting that they cycled on a daily basis (Figure 11). This is interesting when compared to the answer for that question from the general public in Calgary, where only 6% of the respondents reported cycling on a daily basis (Har, 2011). This indicates that the participants in the present study are significantly regular cyclists, who currently represent a relatively small part of the population. The share of participants who cycle 10 times or more per week *in winter* dropped by almost 1/3rd, to 47%. According to the monitoring data collected by the City of Calgary winter cycling on this lane drops to 30 per cent of summer trips (Pilot, 2013). While other studies have also reported lower cycling rates in winter compared to warmer months (Flynn et al. 2012; Miranda-Moreno & Lahti, 2013; Nankervis, 1999; Thomas et al., 2009; Winters et al., 2007), the present study identified the specific drop rate of cycling among avid winter cyclists.

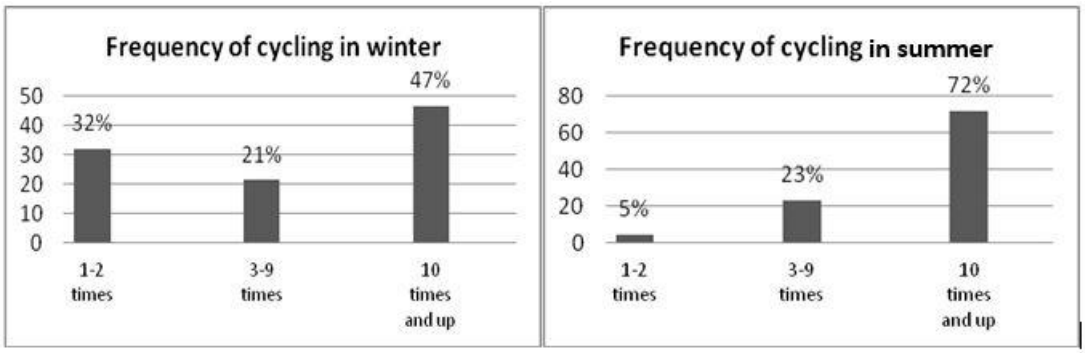

Figure 11. Frequency of cycling: a) in winter; b) in summer

5. SURVEY DATA ANALYSIS

To verify the hypothesized relationships shown in Figure 1, cross-tabulated analysis was carried out using two-tailed chi-squared test and Fisher's exact test. Statistical Package for Social Science (SPSS) was used to assess the relationship between the independent, intermediate, and dependent variables. In this study, a relationship between two variables was considered to be statistically significant when the *P*-value was smaller than 0.05; accepting 5% of type I error, which is commonly used for studies of this nature (Afifi and Azen, 1979). Whenever the sample size in a category was smaller than 5, the chi-squared tests were complemented by a Fisher's exact test to increase the reliability of the results (Agresti et al., 1990). Fisher's test returns exact *P*-values when dealing with small segmentation in the data. The results of the analysis are brought in the two groups below: 1) relationships with statistical significance between the independent and intermediate variable, and 2) relationships with statistical significance between intermediate and dependent variables.

6.1) Relationships between cyclist's inherent characteristics and motivating factors

Of all the three inherent characteristic variables, thermal comfort demonstrated to impact the trip purpose (P<0.000). Table 2 summarizes the results of the cross tabulated examination for this relationship, confirmed by Fisher's exact test.

Table 2. Relationship with statistical significance between *thermal comfort* and *trip purpose.*

Trip purpose: "Other"	Thermal comfort				Chi-squared result			Fisher's Exact Significance
	Doesn't matter	-20°C	-10°C	0°C	Value	df	Asymp.Sig.	
Yes	**0%**	**0%**	**0%**	25%	24.993	3	0.000	0.000
No	100%	100%	100%	75%				

As can be inferred from the table, none of the cyclists with higher tolerance for cycling in temperatures of -10◦C and lower were cycling for a purpose other than those identified in the survey. In other words, the trip purpose of those cyclists with high tolerance for cold temperature was work, exercise, recreation, leisure, shopping or school. Cyclists who traveled for any other purpose, also had relatively less tolerance for winter temperature, up to only 0◦C (Table 2).

Another relationship with statistical significance in this group was that between *age* and *safety concerns* as shown in Table 3. The majority (75%) of cyclists who found *other cyclists being too close or riding too fast* a safety concern were youth – those under 18 years old *(P<0.000)*. Only 16% of those who found other cyclists a safety concern were between the ages of 18 and 24. Almost none of the participants aged over 25 found that a safety concern and an increase in age did not notably affect their view (Table 3). The current study did not find statistical significance for any other relationships between *gender* and intermediate variables, despite the large gender gap that was identified in the survey. Also no relationship with statistical significance was established between concerns regarding *infrastructure deficiencies* and any of the independent variables.

Table 3. Relationship with statistical significance between *age* and *safety concerns.*

Safety concerns	**Age**					**Chi-squared result**			**Fisher's Exact Significance**.
	<18	18-24	25-34	35-44	>44	Value	df	Asymp.Sig.	
Cyclists riding too fast/close	75%	16.7%	3.4%	0%	0%	47.8	4	0.000	0.000

6.2) Relationships between Motivating Factors and Cycling Behavior

The relationship between safety concern of *icy surface* and the use of *intermodal transportation* was statistically significant *(P = 0.035).* A large majority of participants who identified *icy conditions* as a safety concern were *not* using intermodal transportation (82.5%), as compared with those who did not find *icy conditions* a concern (62%) (Table 4). In other words, if *ice on surface* is not a concern, chances are higher to use *intermodal transportation*. In informal communications with cyclists, they mentioned the cultural/social "awkwardness" and difficulty of use (e.g. getting the bike on and off the rack in front of the bus; getting the bicycle on and off a crowded train) as reasons for not combining trips with other modes of transportation. An explanation could be that those who do not find ice on surface a concern, are typically those who are most courageous in cycling, so they also do not shy away from the

difficulties of using multimodal transportation.

Since multimodal transportation enables longer trips, to promote commuting in cities with cold climate, the easy use and access to public transit should be given serious considerations.

Table 4. Relationship with statistical significance between *safety concerns* and use of *intermodal transportation.*

Intermodal transportation	Safety concern: Icy conditions		Chi-squared result			Fisher's Exact Significance
	Yes	No	Value	df	Asymp.Sig.	
Yes	17.5%	37.5%	5.207	1	0.023	0.035
No	**82.5%**	**62.5%**				

Trip purpose showed to have the largest number of statistically significant relationships with variables in the Cycling Behavior group (Table 5). The majority (~ 60%) of those who reported work as being the purpose of their trip (*commuter* cyclists) were *frequent winter cyclists* (i.e. more than 10 times/week) *(P<0.000)* and over 80% were *frequent summer cyclists (P=0.03)*. Therefore as expected, commuters composed the largest portion of the frequent cyclists. Therefore it can be concluded that to increase cycling levels, introducing incentives for commuting to work could be one of the most effective strategies.

Just about half (48.1%) of the *commuter* cyclists had trips with medium distances (i.e. between 5.0 to 9.9 km). The other half was equally divided between those with short trips and long trips *(P=0.03)*; Trips of 5 km to 10 km are most common among winter cyclists who commute to work. If you want them to go longer, make it easier to combine with other modes of transportation.

Table 5. Statistically significant relationships between *dependent variables* and different *Trip Purposes* a) Commuting; b) Recreational; c) School; d) Other.

(a)		Trip purpose - Commute		Chi-squared test			Fisher's Exact Significance
		Yes	No	Value	df	Asymp.	
Frequency of cycling in winter	<=2 times/week	20.8%	65.4%	23.87	2	0.000	0.000
	2-10 times/week	19.5%	26.9%				
	>10 times/ week	**59.7%**	7.7%				
Frequency of cycling in summer	<=2 times/week	3.9%	7.7%	11.56	2	0.03	0.03
	2-10 times/week	15.6%	46.2%				
	>10 times/ week	**80.5%**	46.2%				
	<=5.0km	26.0%	46.2%	7.023	2	0.03	0.03
	5.0 - 9.9 km	**48.1%**	19.2%				

(b)		Trip purpose - Commute		Chi-squared test			Fisher's Exact Significance
		Yes	No	Value	df	Asymp.	
Frequency of cycling in winter	<=2 times/week	**65.4%**	20.8%	17.771	2	0.000	0.000
	2-10 times/week	11.5%	24.7%				
	>10 times/ week	23.1%	**54.5%**				
Intermodal Transp.: Walk	Yes	62.5%	22.2%	3.970	1	**0.046**	**0.078***
	No	37.5%	77.8%				
Intermodal Transportation: Public Transit	No	37.5%	83.3%	5.462	1	**0.019**	**0.06***
	Yes	62.5%	16.7%				
Trip Distance	10 km and up	26.0%	34.6%				
Intermodal Transp.- Walk	Yes	18.8%	**60.0%**	4.626	1	0.031	0.046
	No	**81.1%**	40.0%				

(c)		Trip purpose - School		Chi-squared result			Fisher's Exact Significance
		Yes	No	Value	df	Asymp.Sig.	
Intermodal Transportation	Yes	100.0%	23.8%	6.040	1	**0.014**	**0.062***

(d)		Trip purpose - Other		Chi-squared result			Fisher's Exact Significance
	minutes	Yes	No	Value	df	Asymp.Sig.	
Trip duration	<10	**100%**	2%	33.660	3	0.000	0.000
	10-20	0%	35.3%				
	20-30	0%	37.3%				
	>30	0%	25.5%				

Over 80% of *commuter* cyclists in this study did not combine their cycling trip with *walking*. The majority (60.0%) of those who combined walking with their cycling trip were non-commuters (i.e. those who had trip purposes other than commuting) *(P= 0.046).* As shown previously, non-commuters compose only a small portion (0.25%) of the population in this study compared with commuters (see Figure 6). This indicates that combining cycling with walking is not a big thing for winter commuters. As mentioned, it was not a well-designed question. The actual number can be even smaller.

A good majority (65.4%) of cyclists who were cycling for *recreational* purposes had the lowest frequency of *cycling* in *winter* (i.e. less than 2 times per week). In contrast, more than half (54.5%) of the cyclists who were cycling for purposes other than *recreation*, had the highest frequency of *winter cycling* (i.e. more than 10 times per week) *(P < 0.000).* (Table 5b); Recreational cyclists are not frequent in winter.

The relationship between using cycling for *recreational* purposes and combining the cycling trip with *walking* and *public transit* originally showed to be statistically significant. However, further Fisher's exact tests rejected the statistical significance for both relationships *(P = 0.078 and P = 0.06*, respectively) (Table 5b). Similarly, the statistical significance of relationship between cycling to *school* and use of *intermodal transportation* was rejected by Fisher's exact test (P = 0.062) (Table 5c).

Those participants who mentioned the purpose of their trip was something *other* than those indicated in the survey (i.e. commute, exercise, recreation, leisure, shopping, school) had a *very short* trip durations (less than 10 minutes) *(P<0.000)* (Table 5d). Revisiting Figure 7 also reveals that, interestingly, only a small part of the studied population selected the "Other" answer choice for the purpose of their trip (note that for this question the participants could select as many answers as they deemed relevant). This indicates the majority of longer cycling trips in winter (more than 10 minutes), occurs for the purposes that were listed in the survey.

6.3) Discussion

Figure 12 shows the relationships between cycling variables that were hypothesized and empirically supported in this study. This study could not find statistically significance for any of the relationships hypothesized for *gender* of the cyclists and their perception of *infrastructure deficiencies*. Nonetheless, the eight (8) relationships that were empirically supported by the statistical significance, as shown in Figure 12, provide an insight into the interrelationships among variables that are related to cycling for winter cyclists.

Once the results of assessing the hypothesized relationships were completed, it was speculated if relationship a relationship also existed *between* the motivating factors. In other words, the question raised if there was more than one layer among intermediate variables. More specifically, it was speculated if the *safety concerns* of cyclists affect the *purpose* of their trip. To test this hypothesis, the relationship between trip purpose and safety concerns within the intermediate layer of motivating factors was examined and the relationship in fact was statistically significant (Table 7).

The results of the Chi-squared and Fisher's exact test confirmed that a strong majority (80%) of the cyclists who considered *cyclists who ride too fast/too close* on the path as a safety concern were recreational cyclists. Conversely, the majority (77.6%) of those who did not consider *other cyclists* a safety concern were not cycling for recreational purposes *(P = 0.014)*. This can suggest that bike lanes are designed primarily for recreational cycling should be wider than others.

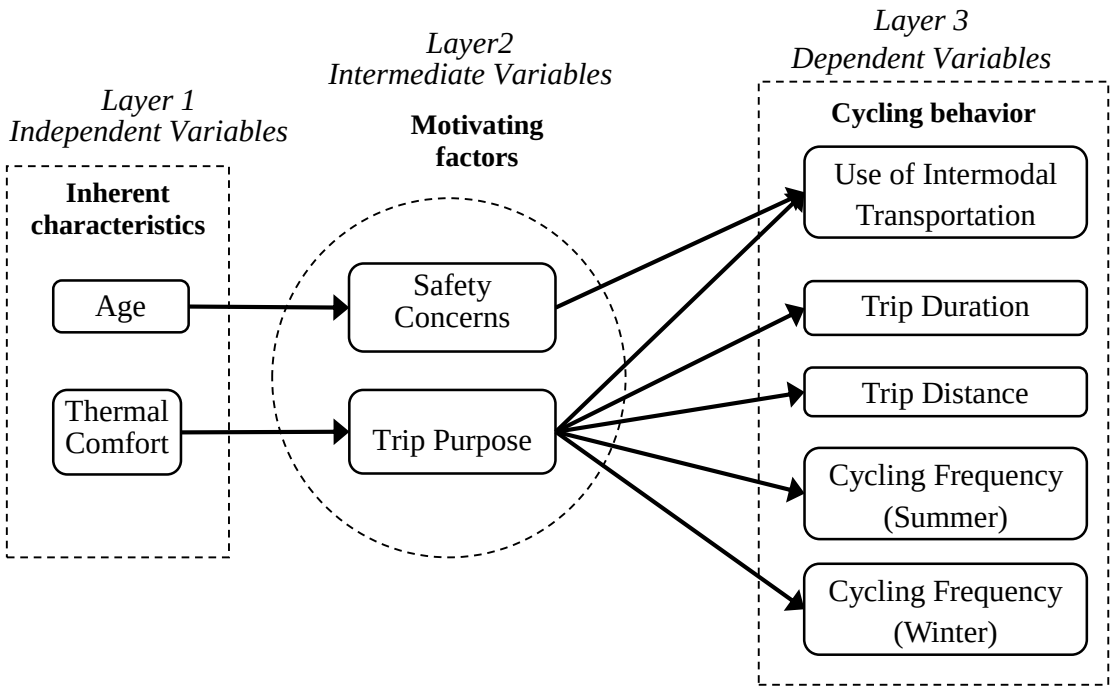

Figure 12. Empirically supported relationships.

6. SUMMARY AND CONCLUDING REMARKS

Cities with very cold climates experience cold weather for a large part of the year, and any effort to encourage cycling or expand their cycling infrastructure has to take the implications of this into account. This study was a very first intercept survey, conducted in a typical n.a. major city, with very cold climate, Calgary, as a case study. The focus of this study was a metropolitan area with a very cold climate. The study offered two contributions to the current body of the knowledge. First, it provided a profile of a typical winter cyclist in a city with very cold climate to provide planners and decision makers an understanding on their characteristics. Second, it examined the relationships between variables affecting cycling for winter cyclists to identify what affects what.

The profile of the average winter cyclist in this study can be portrayed as a middle aged male who is a frequent cyclist and uses cycling mostly for commuting, although he might use the trip for other purposes, such as shopping or exercise, as well. He is not inclined to combine other modes of transportation with his cycling trip. The main safety concern of the typical winter cyclist in this study was ice on the road. He is not deterred by very low temperatures, feeling comfortable to cycle in temperatures down to -20°C or even lower.

This finding of such high tolerance of cold by the cyclists was surprising to the authors as it was unprecedented in any other study. Perceptions of thermal comfort are known to vary by culture and country. Therefore it could be speculated that cyclists in climates with mild winters have a lower tolerance to cold temperatures than those in regions with *very* cold climates. More studies on the tolerance of winter cyclists in other cities are required to examine this speculation.

The most important infrastructure deficiency identified by the winter cyclists was ice or snow on the road, followed by poor physical conditions of the road surface, such as cracks. It is interesting to note that both of these concerns are an indirect result of the cold weather. This indicates that in order to facilitate the needs of winter cyclists and encourage more winter cycling, maintaining good road surface conditions on cycling routes should be a priority. For example, since the ice, snow, gravel or cracks on the road surface represent more of a hazard for cyclists than for cars, it could be worthwhile that the clearing frequency of cycling paths (e.g. ice/snow removal) be higher than that for roads. While this might not be feasible for cycling infrastructure that is combined with regular traffic (e.g. regular traffic lanes), separate bike lanes (cycle tracks) can facilitate different levels and frequency of ice and snow removal in addition to increasing the safety of cyclists. Further research into engineering solutions for offering clear road surface for cycling is needed.

With 25% of new cyclists on the newly implemented cycle path, the present research confirms the conclusion of previous studies that the implementation of cycling facilities increases cycling and provides a quantitative value. It should be noted that this study was conducted one year after the implementation of the new cycle path. It will be interesting to study what the increase rate over a number of years following the implementation of a path will be like.

The winter cyclists in this study traveled relatively long distances, most of which (~70%) exceeding the 3-5 km range that were assumed in previous studies to be reasonable for cycling in winter. This finding may have implications for the planning and construction of cycling networks in cities similar to Calgary with a very cold climate. Since longer trip distances are not uncommon, a cycling infrastructure with well-connected routes would be beneficial.

In order to identify interrelationships between variables related to cycling, a multi-layered model was hypothesized in this study composed of three groups of variables. In addition to the independent and dependent variables, an intermediate layer related to cyclists' motivating factors was considered in this model, which could both affect cycling behavior (the dependent variables), and at the same time be affected by the inherent characteristics of the cyclists (the independent variables).

Eight of the hypothesized relationships were empirically confirmed in this study.

As it can be seen in Figure 12, two clear relationship chains seem to emerge from the confirmed relationships; the first chains consists of Age- Safety Concerns – Use of Intermodal Transportation variables, and the second consists of Thermal Comfort – Trip Purpose – Cycling Behavior variables.

In this study, cyclists decision to combine their trip with other modes of *transportation* showed to be affected by the *safety concerns* of a cyclist, which in turn were affected by cyclist's *age*. The majority of the cyclists who found other cyclists a safety concern were the youth (under 18 years of age). Therefore, if increasing the ridership among the youth is intended, it is recommended to allow wider lanes in the cycling paths to provide more space for speeding cyclists to pass. In addition, regulations could also be created with regards to speed and distance limits when riding close to youth on the path.

In terms of relationship between safety concerns and use of intermodal transportation it was found that if *ice on surface* is not a concern, chances of using intermodal transportation is higher. In personal communications with cyclists, they referred to the social and physical difficulties (e.g. getting the bike on and off the rack in front of the bus while everyone else is waiting; getting the bicycle on and off a crowded train) as reasons for not combining trips with other modes of transportation. This particular finding could be explained as that those who do not find ice on surface a concern are probably most fearless cyclists and as a result they feel more comfortable to use multimodal transportation. However, since use of intermodal transportation makes longer trips more accessible to a wider range of cyclists it is recommended to implement regulations that facilitate used of intermodal transportation for all range of cyclists; for example making taking on and off the bicycles easier on public transit, or provide park and cycle facilities.

Trip purpose showed to have the largest statistically significant relationships with other identified variables in this study. Trip purpose was on one hand affected by the thermal comfort of the cyclists, and on the other hand affecting all five variables describing cycling behavior. In fact, trip purpose showed to be the pivotal core of the second identified relationship chain in this study. This indicates the importance of the trip purpose in determining the behavior of cyclists.

The *trip purpose* of those cyclists with high *tolerance for cold temperature* fell under one of the categories of commuting, exercise, recreation, leisure, shopping or school. Similarly, the most frequent winter cyclists were also conducting their trips for the aforementioned reasons. This is important for municipalities in very cold climate, as it can direct their focus of their attention for who cycles most frequently and in the coldest days. If the intention is to promote winter cycling, the most potential destinations are those associated with these six purposes. Among those purposes, commuters composed the largest portion of the frequent cyclists.

Conversely, the least frequent winter cyclists were recreational cyclists. This is understandable considering the nature of recreation (that it is highly associated with convenience?). Therefore to increase winter cycling, the most potential can be achieved by providing incentives for cycling to work. For commuter cyclists, trips of 5 to 10 kilometers were most common distance. To enable cyclists to reach longer distances, it is recommended to facilitate combining cycling with other modes of transportation – a point that was reached before.

Combining cycling trip with *walking* did not seem to be an attractive option for *commuter* winter cyclists. Although, as mentioned in the paper, the authors feel this was not a well-defined question. It is speculated that a well-defined question in future studies will show even less interest from cyclists' perspective to combine their trip with walking.

Interestingly, the current study did not find statistical significance for any of the hypothesized relationships between *gender* and *intermediate* variables, despite the large gender gap that was identified in the survey. As clearly there is an association between gender and frequency of cycling in winter, further studies are required to identify intermediate variables that can explain the reason for this difference. Similarly, this study did not find an empirically supported relationship between cyclists' perception of *infrastructure deficiencies* and dependent or independent variables. This can suggest that the indentified deficiencies are not biased by inherent characteristics such as age and gender. More importantly, it suggests that cyclists perception of deficiencies of the road, do not necessarily impact the cycling behavior such as frequency and length of trip. Clearly more studies with larger number of cyclists are required to confirm this.

These results indicate that cycling behavior in winter is affected by a large number of variables that are interrelated in complex ways. While this study could be viewed as pilot survey based on the number of respondents, the findings were encouraging, and indicate that the proposed model might be useful to gain a better understanding of cyclists. In particular, studying and addressing their motivating factors might be a key to influencing their behavior, unlike characteristics such as age and gender that cannot be changed.

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USING SYSTEM DYNAMICS MODELLING PRINCIPLES TO RESOLVE PROBLEMS OF REWORK IN CONSTRUCTION PROJECTS IN NIGERIA

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ABSTRACT

Rework in construction projects has brought in two major challenges: cost overruns and delay. In this regards a study was conducted by considering various construction projects in the South West part of Nigeria to understand the causes of rework and the interventions to mitigate it. Survey research methodologies followed by the conceptual system dynamics (SD) modelling were used in the analysis. This study identified the sources of rework in construction projects from the design related, the client related and the contractor related issues and attempted to derive policy/strategic interventions to limit or eliminate rework on construction projects and its delivery by using conceptual SD models based on the influence of the variables on rework. The findings include that inappropriate scheduling for time pressure or delay at the planning stage, lack of adherence to the specifications, and non-availability of skilled human resource are the major causes of rework. However, rework in construction projects would be reduced or eliminated through policy interventions, such as, achieving client satisfaction with scheduling for time pressure or delay at the planning stage, adherence to specifications ensuring quality of work resulting in client satisfaction, and the availability of skilled manpower ensuring quality management.

Keywords: Rework; Construction projects; System dynamics modelling; Client satisfaction; Cost and delay

1. INTRODUCTION

Construction projects particularly large public projects all over the world involve many challenges. The tasks and activities in the Construction Industry relative to the projects are complex and dynamic in nature. The productivity of these projects or the Construction Industry is usually associated with a number of variables e.g. dealing with diverse interests of multiple stakeholders and resultant changes/variations, rework and wastages among others (Alwi 2002; Josephson 2002). These challenges also affect the delivery of the projects which have specified deadlines and fixed budgets (Alwi et al. 1999). However, rework is considered as one of the major non-value adding endemic symptoms that seriously affect the performance and productivity in construction projects delivery. Specifically, it has been established as a primary cause of both cost and schedule overruns in construction (Love, Mandal et al. 2000).

Although rework has not been uniquely and explicitly defined, yet it constitutes several aspects depending upon the context and nature. According to Ashford (1992), it is a process by which an item in the construction project is made to conform to the original requirement by completion or correction. However, the Australian Construction Industry Development Agency (CIDA), defined rework as ‘‘doing something at least one extra time due to non-conformance to requirements’’ (CIDA 2001). Similarly, Rogge (2001) interpreted it as activities in the field, which are required to be done more than once or activities that remove work previously installed as part of the project. Besides, according to Love et al. (2000) it is said to be the unnecessary effort of redoing a process or activity that was incorrectly implemented in the first time. However, rework has various definitions and interpretations within the construction management literature (Love 2002b; Hwang et al. 2009), terms for it includes “quality deviations (Burati et al. 1992), nonconformance (Abdul-Rahman 1995), defects (Josephson and Hammarlund, 1999) and quality failures (Barber et al. 2000). Scholars like Ashford (1992) also argues that repair can be included as rework, as it is a process of restoring a nonconforming characteristic to an acceptable condition even though the item may not still conform to the original requirement. Therefore, rework essentially occurs when a product or service does not meet the requirements of the customer in the form of quality or function. Consequently, the product is altered in accordance with customer’s requirements and specification of the engineers (Alwi et al. 1999).

Rework can also be treated as both positive and negative. While the positive rework adds value to the project, such as, design reworked for a better understanding of client requirement. The negative rework extends projects schedules and the total cost increases (Ballard, 2001). However, despite its positive aspects reduction of rework is crucial for achieving reduced wastages, good performance and enhanced productivity in construction project systems (Love et al. 2000; Fayek et al. 2004; Palaneeswaran et al. 2005a).

However, rework is found to be a menace in Nigerian construction industry (Oyewobi and Ogunsemi 2010). An analysis of 31 projects executed during 2009-2011 in Lagos and Ondo state of the country revealed that due to rework, time overruns can go up to additional 245% of the initial time schedule. Similarly, cost overruns amount up to 11.00% of the initial cost estimate (Appendix 1). According to Oyewobi and Ogunsemi (2010), the critical variables influencing rework are sub-standard services rendered by professionals and defects in the construction work. Besides, improper site management, lack of team work, lack of trust and commitment on the part of the professionals and workers, lead to failure of quality management, which cause rework significantly. Improper planning of human resources is also a significant factor observed to have adverse impact on construction resulting into rework (Oyewobi and Ogunsemi 2010). Concurrently, the causes of rework as observed from these projects are found to vary from collapse of structural elements, poor workmanship, poor finishing, use of poor quality materials, to failure of mechanical and electrical installations and so on (Appendix 1). There is no congruity among the factors observed by the professionals causing rework in construction projects in Nigeria.

Therefore, the objective of this paper is to investigate the causes of rework in a structural way in construction projects and identify mechanisms for developing plausible strategic interventions, which would enable reduction in the rework and improve performance of construction projects. This investigation was conducted by considering construction projects concentrated in the South West part of Nigeria. Survey research methodology was employed to collect primary data from the various stakeholders on construction projects. The data was analysed by using Likert scale (Gravetter and Wallnau 2008) followed by the development of conceptual models by using system dynamics modelling principles based on the systems thinking process.

The merit of the paper lies in applying the systems thinking archetypes and using system dynamics modelling principles to develop conceptual models to understand the causal feedback relationships among the various variables, which cause rework and derive mechanisms for strategic interventions to enable the construction project managers and leaders to take appropriate decisions to reduce or mitigate the impact of rework in construction projects.

2. LITERATURE REVIEW

2.1 Origin and Implication of Rework in Construction Projects

Rework in construction generally originates from the identification of defects. It can also result from changes in the requirements and or when the implemented design lacks required standard of quality, needing some of the implemented design to be scrapped and reworked, and so the term originated (BRE 1981; and Love and Edwards 2004).

Rework has different impacts on project performance depending on the time when it occurs in a construction process. Since rework is the act of performing a task more than once, it can occur at different stages throughout the project life cycle.

Fayek et al. (2004) observed that rework clearly has a huge impact on project performance whether or not projects can be completed within time and cost constraints. Rework also has a large general impact on the industry as a whole; the impact of rework can be direct or indirect. Although rework has some positive aspects, such as, improved quality, fulfilling of client requirements yet, it is a significant factor that contributes negatively to the construction process and can lead to time overruns, inflation, cost overrun, client dissatisfaction, contractor's financial difficulties, contractor dissatisfaction, design team dissatisfaction, and reduces profitability. Besides, there are other likely consequences of rework, such as, end user dissatisfaction, inter-organisational conflict and litigation, stress and fatigue among the stakeholder and workers, work inactivity, de-motivation, and damages to professional image (Ballard 2001; Love and Edwards 2004).

Causes of Rework

Construction process is very complex. Significant attention and supervision is required to avoid mistakes. Bon-Gang (2009) corroborated the findings of other scholars like Ashford (1992), Love et al. (2000), Rogge (2001) and others and suggested that rework can arise from a number of sources such as changes, non-conformances (e.g. quality deviations), and defects. However, Love and Edwards (2004) classified the root causes of rework into three aggregate factors such as design-related factors, client-related factors, and contractor related factors. Besides, Fayek et al. (2004) identified five major causes of rework, which are related to lack in human resource capability, lack of leadership and communications, inefficient engineering and reviews, inappropriate construction planning and scheduling, and inadequate materials and equipment supply. Causes of rework also differ from one country to another and from one project type to another. Therefore, it should not be relied upon its literal meanings but simply can be treated as suggestive, as levels and interpretations of quality will differ. Local practices, industry culture, and contractual agreements may also have a significant influence on the incidence of the work (Love et al. 1999). However, looking at the amorphous perception of the professional towards the causes of rework in Nigerian Construction industry, it was felt relevant to investigate the causes of rework under three aggregate factors such as, design-related, client-related, and contractor related factors as suggested by Love and Edwards (2004), which have significant influence on rework that this study focuses on.

2.1.1 Design-related factors

A number of findings have emphasized the fact that most reworks originate at the design stage than in the construction stage (BRE 1981; Palaneeswaran 2006; Peter and Li, 2000; Trigunarsyah 2004). According to Palaneeswaran (2006) ineffective use of quality management practices, ineffective use of information technologies, lack of manpower to complete the required tasks, insufficient time to prepare the contract documentation, incomplete design at the time of tender, poor conditions between different design team are some causes of rework.

On the other hand another important study by Trigunarsyah (2004) attributed detailing (inaccurate or inadequate detail), specification (incorrectly specified or inappropriate materials and components), legislation (inadequate knowledge of or disregard for legislation or guidelines), co-ordination (inadequate coordination between client / designer, designers, and designers / contractors), communication (poor interaction between client / designer, and designers /contractors), supervision (inadequate supervision by designers), and constructability (lack of design empathy for construction) are the design related problems causing rework (Love 2005). However, under the pressure to improve project cost and schedule performance, many companies have accepted the fast-tracking approach under which the design phase and the construction phase overlap (Peña-Mora and Li 2001; Fazio et al. 1988). Because of this overlap the contractor can start the construction phase with flawed plans that have undiscovered errors, which can cause rework in the later stages of the project (Li and Taylor 2012).

2.1.2 Contractor-related factors

Faniran et al, (1999); Love et al. (2004); Love (2005), and Palaneeswaran et al. (2005b) identified some contributions to rework from the contractors. The most important factors include poor planning and coordination of resources; ineffective use of information technologies; setting-out errors; ineffective use of quality management practices; staff turnover or reallocation to other projects, and failure to provide protection to constructed works. Similarly, Fayek et al. (2003) observed that insufficient skill level, constructability problems, and poor communications. Investment in the placement of a number of on-site planning personnel for each work task on each discipline, and material and equipment supply particularly prefabrication and construction not to project requirements have a larger contribution to rework. Besides, according to Palaneeswaran et al. (2007) poor managerial practices and inadequate quality management in the part of the contractor and non-detection of the errors for rectification during the construction work also lead to rework in the later stages of construction.

2.1.3 Client-related factors

The client contributions to rework in the delivery of projects can be categorised in two forms: (a) from the design related sources, such as, the design changes made at the request of clients; and (b) from the construction related sources, such as, changes initiated by the clients (Fayek et al 2004; Love and Edwards 2004). These changes can however happen both after some work have been undertaken on-site, and when the product / process had been completed. The major contributing factors could be lack of experience and knowledge of the design and construction process, lack of funding allocated for site investigations, lack of client involvement in the project, inadequate time and funds attributed to the briefing process, poor communication with the design consultants, payment of low fees for preparing contract documentation, ineffective use of information technology (e.g., visualization), and inadequacies in contract documentation (Cnudde 1991; Abdul-Rahman 1993; Josephson and Hammarlund,

1999; Love, Li, and Mandal, 1999; Love, Mandal and Li, 1999; Barber et al. 2000).

2.2 System Dynamics Modelling Approaches to Rework

A system constitutes a set of components, which are interlinked and interdependent on each other to perform a function as a whole (Von Bertalanffy 1974; Forrester 1968). In a system, if a subsystem performs at a higher efficiency than others or becomes defunct then the effect is felt on the whole system. As a result, the whole system may perform at a lesser efficiency or even may become paralysed. In order for the system to perform at a higher efficiency all the subsystems of the system are to work in a coordinated manner. A construction project is a system having a complex set of subsystems, which needs to perform in a coordinated manner to achieve the desired outcome, avoid delay, ensure quality, and more so avoid rework. Thus, in a construction project environment systems thinking process would enable a detailed operational thinking process to have a view of the project in a holistic manner and consequently provide insights to avoid rework.

Investigation regarding various aspects of rework and application of SD in evolving solutions has been taken up by several scholars over the last four decades. The initial instances of SD application in rework was seen from the works of Cooper (1980, 1993) followed by important works of scholars like Abdel-Hamid (1984); Ford and Sterman (1998a, 2003b); Rahmandad and Hu (2010); Owens et al. (2011) and Parvan et al. (2012, 2013) to name a few. However, Lyneis and Ford (2007) provide a detailed discussion regarding SD application on various aspects of rework in his review work "System Dynamics Applied to Project Management". The strength of SD model in rework is that it allows estimating the impact of undiscovered design changes on construction phase quality (Parvan et al. 2012, 2013). Further, Rahmandad and Hu (2010) declare that the quantitative analysis of SD allows for capturing significant schedule over-runs due to a few tasks, with multiple defects, that may cycle through rework process multiple times with robustness in the context of multiple project parameters. Recently, Han et al. (2013) used SD to examine how design errors that lead to rework and/or design changes contribute to schedule delays and cost overruns. While design errors are deemed prevalent, most design and construction firms do not measure the number of errors they create, thereby having limited knowledge regarding their mechanism to undermine project performance. Han et al. (2013) concluded based on their case study that as construction projects are known to involve complex, inter-dependent, uncertain and labour-intensive work, the developed model can assist project managers to understand the dynamics of design errors and recovering delays better, particularly when confronted with schedule pressure. Similarly, Gilkinson and Dangerfield (2013) developed a dynamic model of a typical contracting firm and construct a competitive index to model contract allocation in a stylized market. The simulated scenarios from the model offer insights about how endogenous behaviour can shape the future of the enterprise and minimize unexpected behaviour.

Although, both the works provided new paradigm to the operational thinking of the construction industry, they are case studies and need generalisation particularly with respect to rework. Besides, Han et al. (2013) confined their work to examine how design errors that lead to rework and/or design changes contribute to schedule delays and cost overruns. As the construction projects are getting increasingly complex and dynamic and there are three factors- design, client and contractor related factors overwhelmingly influence rework, there is still a need to look into the rework aspect in a more holistic way, understand the system conceptually and derive principles in order to develop policy interventions before developing generalised quantifiable models.

2.3 Justification of the Use of Conceptual Modelling Based on SD Paradigm

A conceptual model provides a consistent and unifying premise of behaviour taken from bits of information about the real world (Wolstenholme 1992; Robinson 2008). The rigorous structural framework offered by SD assists in eliciting and displaying information used to build a conceptual model (Forrester 1994; Lane and Oliva 1998), which allows to understand how and why the dynamics of concern are generated and enable policy and strategic interventions based on causal feedback relations to improve the situation (Forrester, (1968, 1969); Lee, Choi and Park 2005; Montibeller and Belton 2006; Park et al. 2013). Besides, unlike many mechanistic systems or physical modelling, SD is based on the principle of operation thinking with a feedback mechanism of information-decision-action and influence on the environment. This feedback mechanism provides the dynamic hypotheses with distinctive explanatory power to diagnose the problems and visualise the behaviour of the system under different scenarios (Forester 2003, Olaya 2012; Sterman 2000).

The analysis of the literature reveals that there is no unanimity among the scholars on causes of rework although there is agreement on various factors causing rework across various aspects relating to construction projects. Further, the studies on the inter-linkage and causal relations among these factors causing rework are found to be limited (Lyneis and Ford 2007) although it is acknowledged that a few investigations have been attempted in this direction. Therefore, this study focuses on the delineation of the variables causing rework in the construction project environment and their causal relationships by the application of systems thinking and the conceptual SD modelling so that it would enable reduction or mitigation of rework, the problem can be diagnosed, when the need arise and necessary strategic interventions can be at any stage of construction.

3. MATERAIL AND METHODS

3.1 Projects and Professionals Surveyed

Table 1 presents the characteristics of the projects and professionals surveyed. The study was conducted in the South-Western part of Nigeria and confined to Lagos- a high construction activity area and Ondo being the proxy.

The organisations surveyed were distributed over both private and public sectors and include contracting, consulting, private developers, Federal ministry and State ministry. Professionals such as architects, engineers, project managers and quantity surveyors having experience more than five years and professional qualifications have been consulted and surveyed. The projects from which the professionals were chosen for the survey include both medium and large scale construction projects, such as building of hospitals, office complexes, schools and commercial buildings.

Table 1. Background Information of Respondents

Category	**Classification**	**Number**	**%**
Location	Lagos	71	59
	Ondo	49	41
Nature of Organization	Contracting	69	58
	Consulting	17	14
	Federal Ministry	6	5
	State Ministry	12	10
	Developer	16	13
Profession of the respondents	Architecture	32	27
	Engineering	12	10
	Quantity Surveying	15	13
	Builder- Project management	61	51
Academic Qualification	OND/HND	14	12
	BSC/BTECH	84	70
	MSC/MTECH	16	13
	PHD	6	5
Professional Qualification	Graduate Member	68	57
	Corporate Member	10	8
	Fellow	0	0
	Non-member	42	35
Experience of Respondent	5 − 10	32	27
	11 – 20	65	54

	21 − 30	13	11
	31 – 40	6	5
	Above 40	4	3

3.2 Methodology- Data Collection and Analysis

Survey research methodology was employed to collect primary data from the various stakeholders in the construction projects considered for the study. A total of 145 questionnaires were administered, of which 120 were returned (approximately 83% response rate). The simple random sampling technique was used in the selection of samples for the survey. Samples were drawn from the Nigerian Institute of Quantity Surveyors, Federation of Contractor Institution, Nigerian Institute of Architects, and Nigerian Institute of Engineers (Structures).

The sample size and response rate was considered fairly adequate for the statistical analysis because of two main reasons. First, the professionals concerned are from the middle and higher level in the hierarchy in the projects and they are limited in numbers. Second, the result of the survey would be considered biased and of little value if the return rate is lower than 40% (Kothari, 2004) and in this case the response rate is quite significant. Further, the diverse and varied characteristics of the respondents (Table 1) implied that the information provided by the respondents can be relied upon for the purposes of the analyses.

Quantitative descriptive statistics analysis and Cronbach's alpha test of the data collected were conducted to observe the reliability of the data. Likert scale (Gravetter and Wallnau 2008) was employed to measure the relative influence of the variables (as obtained from the surveyed data) on the most important parameters (such as client, design and contractor) causing rework. The influential variables, their positive and negative influences on the related variables and the causal relationships among them were used to develop conceptual models by using system dynamics modelling principles based on the systems thinking process (Von Bertalanffy 1974 and Forrester 1968, 1969). The causal relationships among the variables within and across the major parameters were developed based on the discussions and experiences of the professionals surveyed.

While developing the causal relationships, initially the variables such as information, decision and action and environment (system) variables (Olaya 2012) were identified. The variables are then connected with simple one way causality in terms of one way linkages of information – decisions – actions – impact on the environment (i.e., information assisting in evolving decisions (policy interventions), decisions leading to appropriate actions, and actions influencing the environment (system)) and (Veniix 1996 and El Halabi et al. 2012) with their influence (Fig. 1).

Once the one way causality is established the feedback relationships are checked and established. The constructed causal feedback relations were then discussed with the professional and experts in the field to check the veracity of the causal diagrams and relevant modifications with respect to the variable names, their polarity and causal relations as need be are made. The valid causal feedback diagrams (causal loop diagrams) were then employed to develop the conceptual SD models.

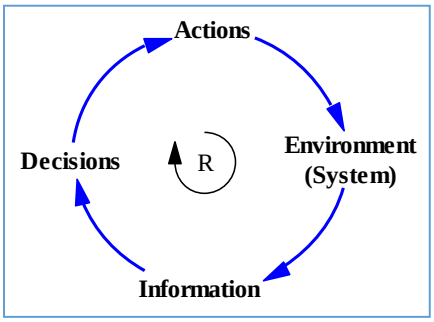

Fig. 1. Methods adopted for construction of causal feedback relations

3.3 Understanding the Causes of Rework and Conceptual Modelling: Findings and Discussions

Rework is a very crucial issue to watch against during construction. As suggested in many previous studies (Ashford 1992; Fazio et al, 1988 Love et al. 2000, 2004; Palaneeswaran et al. 2007, Peña-Mora and Li 2001; Rogge 2001) several factors contribute to rework in a project. However, in this investigation three most important parameters namely, client, contractor, and design related functions are considered as the main controlling parameters, which influence rework. Fig. 2 presents the aggregate causal feedback relationships among these three important parameters and rework. It illustrates that each of the three controlling parameters contributes to rework in three different forms, viz., independently, in combination and in terms of the influence of multiplying effect among the factors of the main parameters.

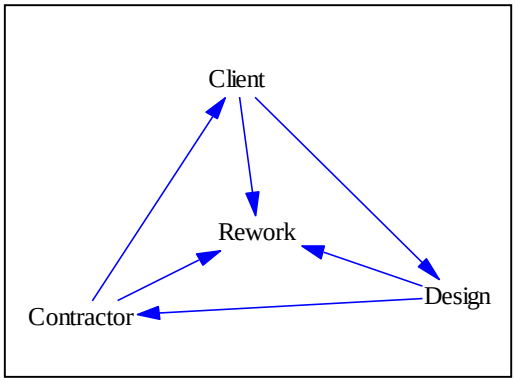

Fig. 2. Aggregate causal feedback model for rework

3.3.1 Design Related Factors Contributing to Rework

Table 2 presents the various factors and their relative influence on rework. There are a subset of 11 design related factors found more influential, from a set of total 30 parameters, which are ranked according to their level of influence based on the mean score in the Likert scale and standard deviation. The outcome of construction activities lies mostly in the quality of design. It is observed that non-adherence to specification, complex design, time pressure / delay and poor communication, lack of understanding and correct interpretation of customer requirements, constraint in carrying out activities, inexperience of personnel, poor technology application, poor quality contract documentation, and lack of information technology use, and design changes are the major factors which influence rework. However, from the expert discussion and established literature (Han et al. 2013; Love, Lopez, Edwards, Goh 2011; Love, Edwards, Han, Goh 2011; Love, Edwards, Irani, Walker 2009; Love, Edwards, Irani 2008; Love and Edwards 2004) non-adherence to specification, complex design, time pressure / delay and poor communication are the four main parameters, which influence rework, and are thus considered in the development of conceptual model.

Table 2. Design-Related Factors Relative to the Causes of Rework

S/N	Design-Related Factors	Not Severe	Less Severe	Severe	More Severe	Most Severe	Mean Score	Standard Deviation
1	Lack of understanding and correct interpretation of customer requirements	4	5	17	36	58	4.16	1.037
2	Constraint in carrying out activities	5	10	20	33	50	3.91	1.250
3	Inexperience of personnel	2	15	24	32	47	3.89	1.113
4	Poor communication	10	6	39	34	31	3.88	0.707
5	Poor technology application	8	17	24	33	38	3.63	0.648
6	Time pressure delay	2	11	30	45	32	3.78	0.997
7	Poor quality contract documentation	23	13	13	23	48	3.51	1.561
8	Lack of information technology use	24	13	14	24	45	3.44	1.560
9	Design changes	6	34	21	19	40	3.44	1.340
10	Non-compliance to standards / specification	11	23	36	12	38	3.36	1.346
11	Complex details	26	6	29	34	25	3.22	1.415
	Cronbach's alpha		0.954					

Source: Field survey

Fig. 2 presents the causal feedback SD model indicating interrelationships among the various variables influencing rework. It is observed that if the quality specification is adhered to, then it will improve standards and afford quality work in construction and in turn will reduce or avoid rework through a reinforcing loop R1. However, on the other hand if specifications are not adhered to, which may happen because of poor communication, poor documentation, lack of proper interpretation of client requirement in a negative feedback mechanism (balancing loop B2), will lead to fall in quality standards and quality in work causing rework (balancing loop B1). Non adherence of specification may also happen because of complex design which could occur because of two feedback mechanisms (1) as lack of expert personals who are not able to cope up with design changes (loop B3) and (2) lack of expert personnel with knowledge and competency in use of computing technology and use of application of technology (loop B4). Thus, while loops B3 and B4 go together to complement loop B2 and B1. Besides the effect of time pressure and delay it enhances the effects of these mechanisms and the chances of rework in construction.

Therefore, adherence for quality specification becomes inevitable. If adherence to quality specification is observed, it will lead to quality standards and products, thereby reducing / eliminating rework. It does mean that if the feedback mechanism R1 is observed in the construction process, it will balance out the feedback mechanism B1, B2, B3, B4 and rework in construction will be avoided. However, the causes of non-adherence to specifications, such as, lack of expert personnel to deal with complex design and design changes, competent use of computing technology, and poor communication among the stakeholders like clients, contractors, and designers need to be addressed at the planning, and design stages. Time pressure on the work and or delay also needs to be envisioned and addressed adequately during the scheduling of the project.

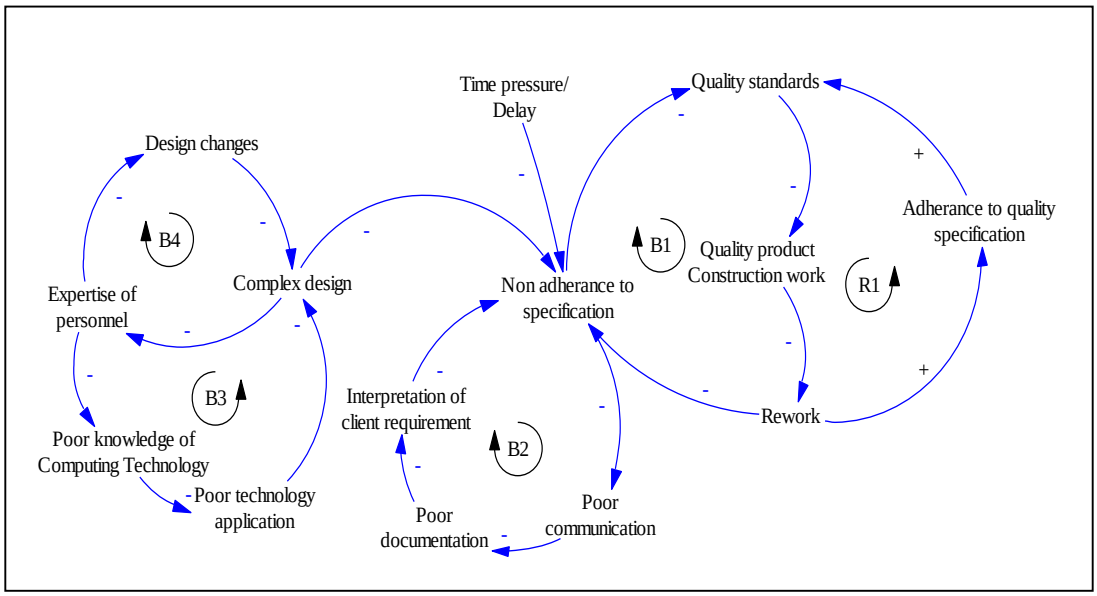

Fig. 2. Conceptual SD modeling showing causal feedback relationships influencing rework due to design related factors.

3.3.2 Client Related Factors Contributing to Rework

Table 3 presents a subset of variables which are more influential in the project environment investigated. According to the evaluation by Likert scale and standard deviation the client related factors, which mostly influence rework are poor communication (instruction), inadequate construction planning, poor management practices, change in plan and scope by client, inaccurate information, inaccurate information, lack of quality management system, unrealistic program, poor information flow, ineffective coordination and integration of project participants, poor contractual relationship, inadequate resources, conflicting information, and change in specification by client (Table 3). The variables having lesser influence have been ignored.

Table 3. Client-Related Factors Contributing to the Causes of Rework

S/N	Design-Related Factors	Not Severe	Less Severe	Severe	More Severe	Most Severe	Mean Score	Standard Deviation
1	Poor communication (instruction)	20	41	20	19	20	3.98	1.365

2	Inadequate construction planning	6	30	7	58	19	3.95	1.173
3	Poor management practices	8	14	28	21	49	3.83	2.539
4	Change in plan and scope by client	9	16	15	32	48	3.78	1.005
5	Inaccurate information	13	21	15	26	45	3.58	1.408
6	Lack of Quality management system	9	18	33	28	32	3.47	2.619
7	Unrealistic program	10	2	60	19	29	3.46	1.131
8	Poor information flow	11	14	25	52	18	3.43	2.532
9	Poor instructions	14	33	12	19	42	3.35	1.482
10	Cost pressure	1	12	44	47	16	3.38	0.777
11	Ineffective coordination and integration of project participants	4	25	47	12	32	3.36	1.377
12	Poor contractual relationship	6	11	36	47	20	3.21	1.257
13	Inadequate resources	15	18	39	27	21	3.18	1.248
14	Conflicting information	27	12	27	22	32	3.17	1.500
15	Incomplete information	13	14	52	30	11	3.10	1.080
16	Change in specification by client	17	21	36	29	17	3.07	1.250
	Cronbach's alpha 0.953							

Fig. 3 shows the causal feedback SD model showing interrelationships among the various variables influencing the rework due to client related factors. It is observed that most of the factors mentioned in Table 3 lead to client dissatisfaction, which inevitably becomes the most important reason for rework in construction along with inadequate planning. In the first place if the client is dissatisfied because of the quality of work or inadequate planning, which would cause addition/ removal/ modifications then there will be a need for rework (balancing loop B1). Further, addition/ removal/ modifications in the construction work can happen because of inadequate construction planning, leading to unrealistic programmes as a result there will be change in plan and scope (loop B1A). It is observed that loop B1A is a subset of loop B1, which enhances the chances of rework. Similarly, quality of work is affected if there is poor communication (instructions) as well as lack of quality management system through a causal feedback system (loop B2). Here it can be noted that poor communication (instructions) happens because of poor information flow which is generally caused by conflicting and inaccurate information (loop B2A). Thus, feedback mechanism formed by loop B2A strengthens the feedback mechanism B2; consequently they influence the quality of rework negatively resulting into rework. Further, inadequate resources availability at the disposal of the client or at the project level would cause ineffective coordination and integration of the project, which with the aid of poor management practices will lead to a poor quality management system that will evidently cause client dissatisfaction (loop B3). Thus, causal feedback mechanisms through loop B2 and B3 complement the loop B1 and enhance the possibility of rework. However, on the other hand if the quality of work is ascertained, the client becomes satisfied or less dissatisfied and obviously there will be reduction or elimination of rework through a reinforcing effect from the feedback mechanism (loop) R1. Therefore, in the project planning there is a need to reinforce the feedback mechanism provided by the loop R1, which essentially will balance out the negative effects of all the balancing loops B1 (B1A), B2 (B2A), and B3. Thus policy or strategic interventions are required at all the feedback mechanisms provided by the balancing loops.

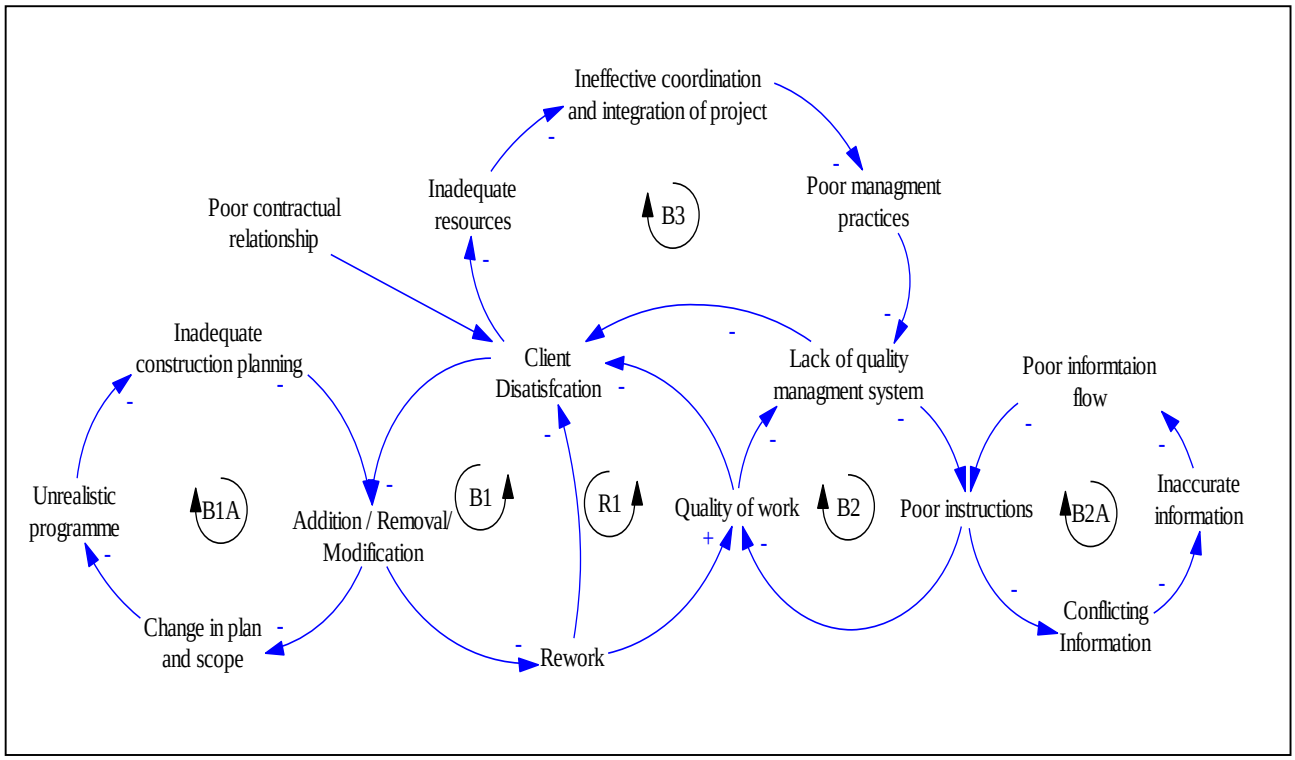

Fig. 3. Conceptual SD modeling showing causal feedback relationships influencing rework due to client related factors

3.3.3 Contractor Related Factors Contributing to Rework

Contractors are essentially critical for the execution of the work. The quality of work depends on the competency of their quality management system and adherence to best practices in the construction work. As it is obvious that quality failure leads to rework, contractor related factors influencing rework become more important both in planning and execution stages of the project to avoid rework. The main contractor related factors, as obtained from the evaluation of the surveyed data, which influence rework are found to be quality failure, lack of quality management, poor workmanship, unavailability of skilled human resources, use of poor construction materials, ineffective site management, lack of coordination, use of poor construction techniques and methods, inadequate procurement of quality materials, defective materials because of poor handling, and lack of safety practices (Table 4). The factors having lesser influence have been ignored.

Table 4. Contractor-Related Factors Relative to the Causes of Rework

S/N	Contractor Related Factors	Not Severe	Less Severe	Severe	More Severe	Most Severe	Mean Score	Standard Deviation
1	Poor workmanship	3	21	12	42	78	4.33	0.950
2	Deflection of part of slab (poor design)	2	15	24	41	38	3.82	1.069
3	Lack of attention to quality	2	11	30	45	32	3.78	0.997
4	Ineffective coordination and integration of components	4	25	12	32	47	3.75	1.550
5	Use of poor materials in sand	11	10	40	17	42	3.58	1.294
6	Defective materials as a result of handling	12	11	40	18	39	3.51	1.194
7	Consultant initiated changes	7	14	31	52	16	3.47	1.053
8	Use of poor materials in Steel	14	6	48	18	34	3.85	1.275
9	Construction error during excavation	4	30	28	31	27	3.39	1.183
10	Poor Safety considerations	15	34	12	19	40	3.29	1.486
11	Quality failure	11	19	29	52	9	3.24	1.100
12	Lack of proper monitoring and evaluation	13	21	26	45	15	3.23	1.200
13	Errors during construction	13	19	38	27	23	3.23	1.268
	Cronbach's alpha	0.951						

Source: Field survey

Based on the interaction of these factors a conceptual SD model indicating the causal feedback relationships has been developed and presented in the Fig. 4. Like in the other two aspects, such as, design and client related factors, in this case also quality failure is the major reason for rework. Rework occurs because of the lack of quality management leading to quality failure (loop B1). However, poor workmanship due to the unavailability of skilled manpower in the possession of the contractor also causes rework (loop B2). Similarly, contractor/client initiated changes because of the architectural design deficiency also cause rework (loop B3). Thus, feedback mechanisms provided by loop B2 and loop B3 strengthens loop B1, and consequently enhance the chances of rework. Besides, lack of quality management, which is the essential cause of quality failure leading to rework is influenced by a causal feedback mechanism constituting lack of coordination, lack of proper site management and lack of monitoring and evaluation (loop B4), and in turn complement loop B1 to enhance rework. Similarly, quality failure occurs because of poor workmanship leading to poor

construction (loop B5), deficiency in design (loop B6), and use of poor quality materials (loop B7) respectively. However, while poor construction is caused by the use of poor construction techniques and methods and lack of safety practices; the deficiency in design is caused due to structural design deficiency (both at substructure and super structure stages). These could be due to a lack of coordination between the designer and the contractor. Likewise, the use of poor quality materials is caused by non-procurement of adequate quality materials, as well as, the defects that occur due to poor handling of materials. Therefore, from the causal feedback mechanisms of the model, it is observed that rework is an outcome of both independent and aggregate effects of the various above discussed contractor related factors. It implies that the appropriate selection of the contactors with requisite capability to handle the challenges is of paramount importance. As shown in the loop R1, quality failure will be avoided if a contactor with the right ability is selected through following the best practices, and he could ensure quality management, then quality failure will be eliminated leading to reduction in rework (loop R1). Thus, loop R1 can balance out most of the negative factors and their causal feedback relationships provided by the loops B1, B2, B3, B4, B5, B6, and B7.

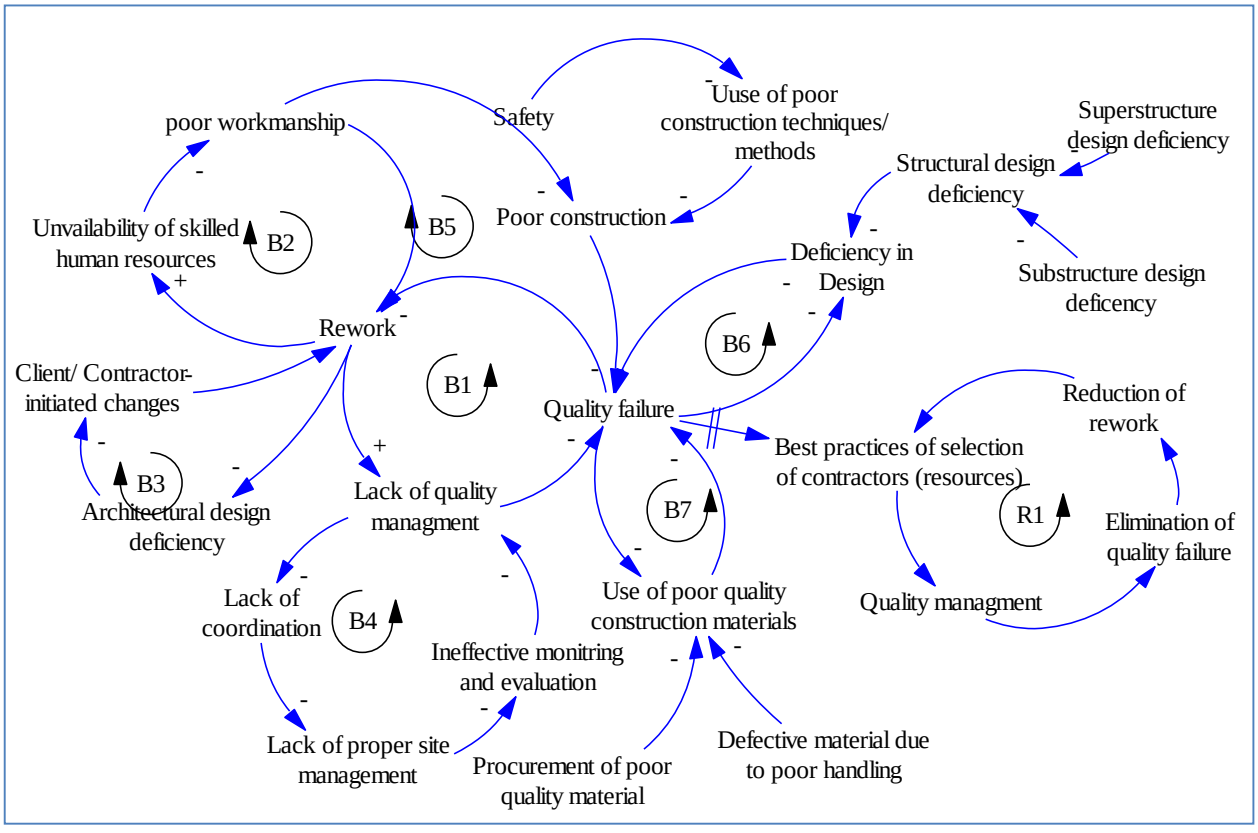

Fig. 4. Conceptual SD modeling showing causal feedback relationships influencing rework due to contractor related factors

3.4 Integrated SD Model for Developing Policy/Strategic Interventions

It was felt necessary to build an integrated model by synthesizing the above three discussed models in order to derive policy interventions to reduce or eliminate rework in construction projects. However, it was also necessary to validate the models for their veracity and their applicability in the real system. Therefore, the models were discussed with the experts in the construction industry and project managers involved in the construction projects. According to their judgment and suggestions the models were modified and causal feedback loops were adjusted and their veracity were tested qualitatively. Further, a synthesis of the causal feedback relationships of rework from the above discussed three models has been done to derive a conceptual integrated SD model (causal feedback system) (Fig. 5) and again validated qualitatively with the help of expert judgment and used for developing policy interventions. The synthesis of the various causal feedback relations of the three prime aspects (design, client and contractor related) revealed that there are three primary causal feedback mechanisms, which essentially influence the rework and can aid to reduce or eliminate rework in any construction projects, if addressed properly. The causal feedback mechanisms are (1) achieving client satisfaction with scheduling for time pressure or delay at the planning stage (loop ER1); (2) adherence to specifications ensuring quality of work resulting in client satisfaction (loop ER2) and (3) availability of skilled manpower ensuring quality management leading to quality work and consequent client satisfaction (loop ER3), through the use of proper construction techniques and methods (loop ER3A), and the use of proper construction materials (loop ER3B).

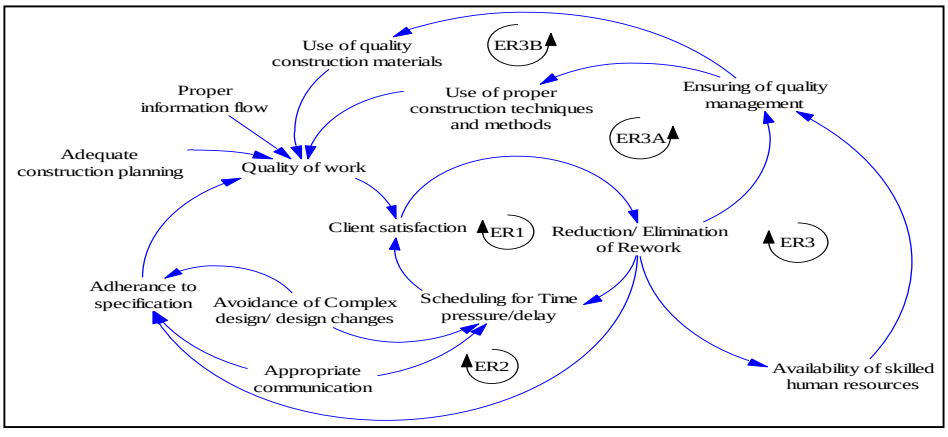

Fig. 5. Conceptual SD modeling showing causal feedback relationships to reduce or eliminate rework

3.5 Validation of the Causal Relationships

After the development of the causal relations, they were discussed with a different set of professionals and experts, than those who have been consulted during the survey from the construction industry, for the validation of the causal relationships used in the models. The feedbacks were checked with the constructed causal relations and adjusted accordingly. Besides, the veracity of the causal relationships was tested qualitatively through structure verification test so as they depict the real world behaviour in the construction project environment.

3.6 Mechanism for Policy Interventions

Fig. 6(a-e) presents the cause and use trees of these feedback mechanisms based on which policy interventions can be derived. Fig. 6a shows how rework is influenced by various factors. Quality of work- adherence to specifications, client satisfaction-scheduling for delay/ time pressure, ensuring quality management and availability of skilled human resources would able to reduce or mitigate rework. Adequate construction planning, adherence to specifications (avoidance of complex design), proper information flow, use of proper construction materials, and application of construction techniques and methods will ensure quality of work (Fig. 6b). Proper communication and information flow can help scheduling for time pressure and delay, which will address the issues of the problems related to complex design or design changes. Adherence to specifications can be achieved through appropriate communication, avoidance or limiting complex design or design changes (Fig. 6c). Ensuring of quality management, which is a function of skilled manpower can lead to the use of proper construction techniques and methods, and use of quality construction materials (Fig. 6d)). Further, ensuring quality of work and scheduling to absorb the time pressure or delay will lead to client satisfaction, which in turn will lead to reduction or elimination of rework in construction projects (Fig. 6e).

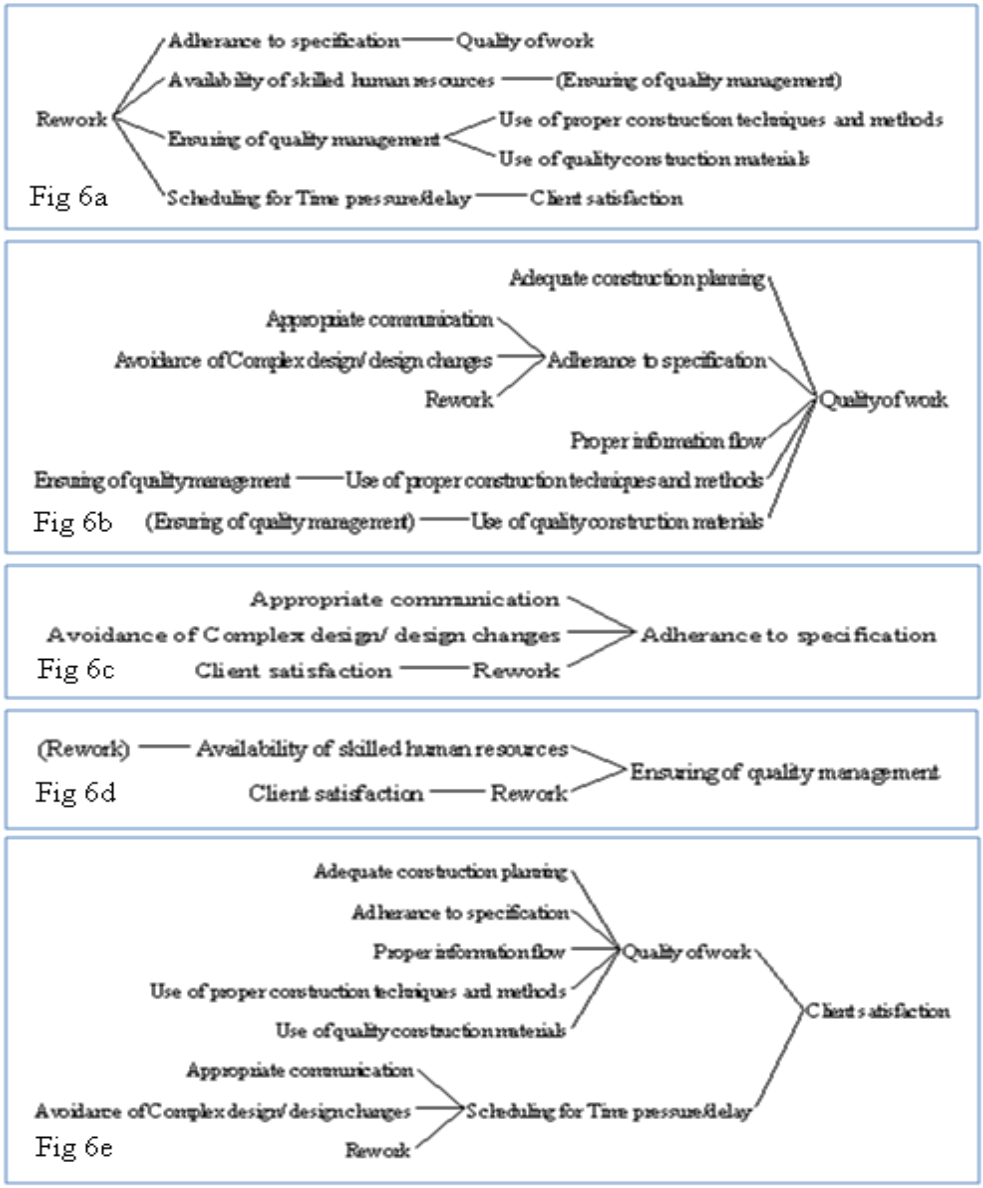

Fig. 6 (a-e). Cause and use trees to develop policy interventions reduce or eliminate rework in construction projects

The cause and use trees as presented in the Fig.6 (a-e) also indicate that all the parameters are linked to each other through feedback mechanisms and influence each other. If any link in the mechanisms fail or work at a reduced efficiency then it will hinder the functions of the other mechanisms. However, it also clearly provides how the mechanisms work and how they influence each other.

So, if any problem occurs at any stage or any link is broken at the various stages of construction work, it can be diagnosed easily and appropriate interventions can be taken to address the problem.

3. CONCLUSION AND RECOMMENDATION

Rework in construction projects is a concern both from the cost and time point of view. Its influence has been explicitly in many projects in Nigeria in terms of both cost and time over runs. Many scholars like Fayek et al. (2003), Han et al. (2013), Love et al. (2000), Love and Edward (2004), (Oyewobi and Ogunsemi 2010) and Palneeswaran (2006) have attributed various reasons for rework and also have recommended interventions to reduce rework, including zero rework strategy. However, rework still remained an unwarranted concern for various stakeholders of the construction projects including clients, contractors and more specifically project managers in general and specifically in Nigeria. Therefore, this investigation examined the causes of rework from the three most important aspects, such as, design, client and contractor related factors point of view. Also, it explored the degree of the influence of the factors of these three aspects on rework; the systems thinking approach, and SD principles were applied to analyse the causal feedback relationships among the various factors causing rework and develop mechanisms to derive policy interventions.

The study revealed that the design related factors which influence rework are non-adherence to specification, complex design, time pressure / delay and poor communication, lack of understanding and correct interpretation of customer requirements, constraint in carrying out activities, inexperience of personnel, poor technology application, poor quality contract documentation, and lack of information technology use, and design changes. Similarly, poor communication (instruction), inadequate construction planning, poor management practices, change in plan and scope by client, inaccurate information, inaccurate information, lack of quality management system, unrealistic program, poor information flow, ineffective coordination and integration of project participants, poor contractual relationship, inadequate resources, conflicting information, and change in specification by client are the client related factors which influence rework. Besides, quality failure, lack of quality management, poor workmanship, unavailability of skilled human resources, use of poor construction materials, ineffective site management, lack of coordination, use of poor construction techniques and methods, inadequate procurement of quality materials, defective materials because of poor handling, and lack of safety practices are the major contractor related factors causing rework.

However, from the causal feedback relationships in the conceptual SD models it was observed that many of the factors are directly or indirectly interrelated through feedback mechanisms and influence one another based on their interactions. The synthesis of the causal feedback relationships in the integrated model revealed that adherence to specifications, scheduling for time pressure and delay, avoiding/limiting complex design/design changes, and ensuring quality management are the major

factors along with the variables linked to them (as mentioned in Fig. 6 (a-e), will bring in quality work and consequent client satisfaction, which in turn will lead to reduction or elimination of rework. Further, the cause and effect linkages developed through the systems analysis (cause and use trees) also are able to diagnose the problems adequately enabling appropriate interventions to limit or eliminate problems which will help to avoid rework.

The study has its limitations. The major limitation is that the modelling was done conceptually, although the basic premise behind it was to see the problem of rework in a more holistic way. However, there is a need for the quantitative modelling to examine the extent to which rework can be reduced or eliminated under different scenarios of strategic/policy interventions. Although, scholars like Gilkinson and Dangerfield (2013) and Han et al. (2013) in their recent case study works have attempted to resolve the challenges of rework by applying SD modelling principles quantitatively, there is still a need to investigate it in a more generalised and holistic way, which provides the further scope to this research. However, despite its limitations this study can assist construction project managers and leaders to analyse and diagnose the problems of rework in their projects and enable them to make strategic/policy interventions to reduce or eliminate rework in construction projects.

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MANAGING CONSTRUCTION STAKEHOLDERS' FOR EFFECTIVE PROJECT DELIVERY: A CASE OF CONSULTANT QUANTITY SURVEYORS

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ABSTRACT

Meeting stakeholders' needs and satisfaction is a primary project success factor in addition to cost, time and quality. Though studies have suggested stakeholders' dissatisfaction with project success, however, there is lack of studies on quantity surveyors' role and management in developing countries in achieving project success. This paper explored and evaluated quantity surveyor's consultant's management approach as part of a broader study aimed at 'Developing sustainable stakeholder management framework for construction projects in Ghana'. Firstly, literature on construction stakeholder management from journals and published dissertations were reviewed. Whilst, GETFund tertiary education projects in Ghana were used as case study for the research. Data was analysed using the stakeholder circle, salience and matrix approaches suggested by scholars and used in similar researches to identify and evaluate key stakeholders role and management. The study confirmed the identification and role of Quantity Surveyors as key stakeholders, though not managed as such by project managers. Project failures was also establish the an effect of stakeholder management absence and recommends the education, consideration of stakeholder management by project managers, keeping Quantity Surveyors well informed, monitored and actively involved in the project planning.

Keywords; stakeholders, project success, quantity surveyor, stakeholder, stakeholder management

1. INTRODUCTION

Construction projects' success have been associated with the achievement of the "golden triangle" set goals of cost, time and quality. In recent past, meeting stakeholder needs and satisfaction has been a major success factor for project success (PMI, 2013). Researchers have identified effective stakeholder management as contributing towards meeting stakeholders needs and project success (Sutterfield et al., 2006; Yang, 2010).

Project success is critical in developing countries where construction infrastructure projects are development intervention for enhanced socio-economic development (Othman, 2013). The Ghana Education Trust Fund GETFund Act, 2000 was set up by Ghana's parliament for enhanced educational infrastructure delivery and growth in Ghana. According to the Performance Audit Report of the Auditor General on GETFund funded infrastructural projects in public tertiary institutions in Ghana (March 2013), GETFund projects have not been successfully delivered and are faced with several challenges including governments dissatisfaction of key stakeholders' role.

The 2014, 9th Annual Meeting of the Ghana Institution of Surveyors, Quantity Surveying Division emphasized the need for raised standards in project delivery by quantity surveyors. Esubonteng (2014) states that though professionals in the construction industry, at their best, deliver creditably on projects, clients and other stakeholders have had cause to be concerned about under-achieving performance. Quantity surveyors are identified with all the key players; client organization, sponsors, design team, contractors, suppliers playing a major role in these firms. This raises the question of whether quantity surveyors role, responsibilities, and engagement as key stakeholders are well considered and impacts positively on project delivery.

This paper therefore explores quantity surveyors stakeholder management approach as key stakeholders in project delivery with the objectives of (1) exploring their role and responsibilities of as key stakeholders, (2) evaluating their engagement on a project in relation to stakeholder management approach and (3) suggesting how they ought to be managed as part of a study aimed at 'Developing sustainable stakeholder management framework for construction projects in developing countries'. This study was achieved through a detailed literature review and evaluation of empirical data using developed stakeholder management approaches for construction projects.

2. QUANTITY SURVEYORS ROLE AND RESPONSIBILITIES

A quantity surveyor QS is normally a member of the design team, by profession handles construction costs and contracts of a construction project. Traditionally, QSs provide several services including, cost planning, estimating, contracts negotiation procurement advice and preparation of project Bill of Quantities (BOQ). In addition monitoring budget, preparation of payment invoice and certification, assessment of variations, dispute resolution, preparing feasibility studies, cost control, advice on cost limits and budgets among others are done by the QS.

Providing project life-cycle costing, information on contractual disputes and final project account are additional responsibilities (RICS). Quantity Surveyors have specific roles and responsibilities during the 3-stages of project execution namely pre-contract, tendering and post-contract stages and as such are considered internal, primary and key stakeholder.

Quantity Surveyors are team players with influence on the project team, client organization, financiers, contractors and suppliers, also primary key stakeholders (Esubonteng, 2014).

The QS's role in achieving project set goals of cost, time, quality and stakeholder satisfaction is underestimated and hence not properly managed. Activities that act as barrier to the enhanced performance of the QSs' and their management are obstacles to effective stakeholder management.

3. PROJECT STAKEHOLDERS

The unique nature of construction projects brings together several people, professional and organizations that have a different stake, interests or are affected by the project outcome and are referred as stakeholders. Researchers have defined and classified project stakeholders differently following the first introduction of stakeholder concept into the management domain by the Stanford Research Institute (SRI) in 1963 which defined stakeholders as any groups or individuals who are crucial for organizations survival and can affect or are affected by the achievement of the firm's objectives (Freeman, 1984). Project managers or team leaders must strategically manage such stakeholders (Savage et al. 1991). According to Carroll (1993) quoted by Gibson (2000) stakeholders refer to groups or individuals with whom the organisation interacts or has interdependencies". Stakeholders were redefined as those who are, could influence or could by themselves influence an organization (Starik,1994; Kolk and Pinkse, 2006), internal members of project coalition, team or scope, who provide finance and external as those affected significantly or to the project scope (Calvert, 1995; Winch, 2002; Sutterfield et al. 2006). They are further described as those that by virtue of their interaction with an organisation may initiate or trigger a project if perceived to be beneficial, antagonistic, disrupt, and stop an ongoing project if perceived not (Mintzberg et al, 1995; Newcombe, 2003). Yang (2010) adopts Freeman (1984) definition of stakeholders as those that affect and are affected by an organization and the outcome of its activities.

Following this definition researchers and scholars have identified several construction stakeholders to include the client, contractor, customer, sponsor, local community member, NGO, media, lobbying organization, and government agency (Cova & Salle, 2005). The client, project managers, designers, subcontractors, suppliers, funding bodies, users and the community as a whole (Newcombe, 2003). The client, project management team, consultant and design team, contractor, subcontractor, supplier, employees, local community, funding bodies, government authorities have been identified by other scholars (Olander and Landin, 2005; Atkin and Skitmore, 2008; Yang, 2010, Heravi et al., 2015).

4. KEY STAKEHOLDERS IN A CONSTRUCTION PROJECT DELIVERY

Construction stakeholders are classified severally depending on their relationship, contractual agreement, impact or effect as a result of the project outcome. Carroll and Buchholtz (2006), suggest that stakeholders can be categorized as primary; with a formal agreement with the project owner and secondary if not.

Primary stakeholders are essential or critical to project delivery (Clarkson, 1995; Calvert, 1995) but could be without strong influence due to buyer dominance (Walker, 2007). Chinyio and Olomolaiye (2010), agree that some stakeholders are more critical to the project success though others may change position as the project progresses and increase their support base. Stakeholders may be referred as internal (key stakeholders) or external to the project (OGC, 2003; Calvert 1995; Winch and Bonke, 2002), Mitchel et al, (1997) however suggest that stakeholder classification should be based on salience to a project considering power, urgency, and legitimacy. Stakeholders are classified as dormant, discretionary, demanding, dominant, dangerous or definitive. Key stakeholders are thus, primary, internal, definitive stakeholders and include the project team: client, project manager, main designer, other designers, contractor, sponsors and consumers/end users. Quantity Surveyors as cost designers are key stakeholders who affect the outcome of the project and needs to be effectively managed.

5. STAKEHOLDER MANAGEMENT PROCESS

According to Eskerod and Jepsen (2013), stakeholder management consist of all purposeful activities carried out in connection to the project stakeholders in order to enhance project success Project stakeholders are numerous with diverse interest introducing a level of complexity to stakeholder involvement and project management in the construction industry. This coupled with increasing diversity, power, influence, needs and satisfaction of stakeholders as a success factor has led to the construction industry embracing the need for stakeholder consideration (Meding et al., 2013). To achieve this, there is the need for all stakeholders especially key stakeholders to be identified, their required contributions, power in relation to the project, expectations, and decision on strategy to influence each stakeholder considered (Jepsen and Eskerod, 2009).

Stakeholder management (SM) should entail systematic identification, analysis, planning actions, communication, and negotiation aimed at influencing project stakeholders (Lock, 2007). Mitchell et al. (1997) suggest stakeholder identification and salience framework in classifying stakeholders according to their power, legitimacy and claim's urgency, Bourne (2005) provides a five-step process: identify, prioritise, visualise, engage and communicate with stakeholders while monitoring the effectiveness. Chinyio and Olomolaiye (2010) suggest the use of stakeholder matrix. Further studies have confirmed that there is no such formal approach to the SM process neither a consensus on the best model developed for developing countries (Yang et al., 2011) nevertheless.

This paper adopts the use of stakeholder matrix and circle to explore quantity surveyors consideration during the project planning and development.

1.5 Stakeholder engagement

Engaging project stakeholders is an essential part of stakeholder management to ensure project success. It is a two-way communication process involving stakeholders' exchange of information and promoting interaction between decision makers and other stakeholders. Mot et al. (2015) suggest that delivering the correct message, using a suitable means, clarifying project values and benefits are essential for effective communication in stakeholder engagement. Bourne and Walker (2005), mention stakeholder circle as a useful tool for project managers to understand the nature of SM impact as a result of power and influence for effective engagement. It identifies, prioritizes key project stakeholders for developing engagement strategy for an active relationship.

Research suggests that stakeholders' interactions with a project are either through co-operation or conflict and competition in the political arena (Mintzberg, 1995). Newcombe (2003) suggests the use of power/predictability matrix and the power/interest matrix in assessing the importance of stakeholder expectations in project strategy analysis. A project manager can therefore engage with key stakeholders on "how likely each stakeholder group is to enforce its expectations on the project", "the means to do so" and the possible impact of stakeholder expectations on future project strategies. This study adopts the stakeholder circle and matrix to analyze the Quantity Surveyors as a key stakeholder and the quantity surveyors' engagement for the projects under review. It considers also the fact that studies have revealed that stakeholder management process involving high level of pre-project planning effort, can save up to 20% from cost and 39% of schedule in facilities projects if considered (Cho & Gibson, 2001).

6. METHODOLOGY

This paper employed a two stage approach research design. Firstly, there was an exploratory survey that aimed at identifying data on how Quantity Surveyors (QS) are considered and managed by team leaders and project managers. This was followed by an in-depth examination of the Performance Audit Report of the Auditor General on GETFund funded infrastructural projects in public tertiary institutions (March, 2013) and the report on the 9th annual meeting of the Ghana Institution of Surveyors, Quantity Surveying Division in 2014, as case studies. The main aim of the study was to explore and evaluate stakeholder management approach of consultants (quantity surveyors). The objectives were to ascertain if QS were considered as key stakeholders, evaluate the extent of engagement and make recommendation for SM approach that will enhance project delivery.

To achieve these objectives, three research questions were developed to address the research objectives as follows; (1) "are quantity surveyors identified as project key stakeholders", (2) "what is the extent of engagement in relation to stakeholder management approach" and (3) "how should they be managed?".

The literature review was conducted mainly using about 50 journals and publications on stakeholder, stakeholder engagement and management selected through filtering process of the institutional database using keywords such as stakeholder, stakeholder management, quantity surveyors and a combination of the keywords. Ten (10) SM models and approaches for stakeholder management and engagement were identified.

A further analysis and filtering identified stakeholder circle, salience model, and matrix as suitable for this study as it has also been used for similar studies on stakeholder management. These were used in evaluating the stakeholder consideration by project managers and team leaders. Considering the Performance Audit Report of the Auditor General on GETFund Funded Infrastructural Projects in Public Tertiary Institutions (March, 2013) and Esubonteng (2014) presentation at the 9th annual meeting of the Ghana Institution of Surveyors, Quantity Surveying Division, as case studies, five polytechnics in Ghana were used namely: Cape Coast, Accra, Kumasi, Tamale and Bolgatanga.

The quantity surveyors role as key project stakeholders were reviewed using the stakeholder management tools since all projects were found to have cost overrun or project cost escalation. This was necessary since quantity surveyors were the cost managers and achieving cost targets constitute project success and stakeholder satisfaction. The study accessed for each project considered, the role of QS in the client, sponsor, contractor's organization and in the supply chain. This paper therefore considered in addition responsibilities, communication during the project planning and development stages and relationship with project manager and owner.

Using the stakeholder circle methodology which provides a means for the project team to identify and priorities project's key stakeholders and develop an appropriate engagement strategy (Bourne, 2005), the research explored whether quantity surveyors were identified as key stakeholders, prioritized, involved in the planning stages and engaged to impact positively on project cost decisions. Following that, the stakeholder matrix was used to analyze qualitatively, the QS as a stakeholder, engagement, influence, importance, positions and communication during the project execution phase (Bourne and Weaver, 2010). This is necessary as scholars suggest an engagement approach for every key stakeholder for a positive impact. This enabled the researcher assess key stakeholders engagement and impact on project success as part of a broader study aimed at "developing a stakeholder management framework for construction projects in developing countries". The quantity surveyor's engagement was analysed using the tools mentioned and conclusions drawn. Finally the study considered how, they ought to have been managed to ensure that stakeholder satisfaction is achieved and that project success enhanced.

7. FINDINGS AND DISCUSSION

7.1 "are quantity surveyors considered as key construction project stakeholders"?

The Performance Audit Report of the Auditor General (PARAG, March 2013): The purpose of the report was to ascertain if GETFund Secretariat and the National Council for Tertiary Education (NCTE) had adequate measures considered to ensure that beneficiary tertiary institutions planned and implemented their infrastructural projects to achieve the projects objectives of timely completion within the budget and of good quality which will constitute stakeholder satisfaction and covering the period between 2005 and 2010.

Quantity surveyors services rendered in relation to the projects and stakeholder management are closely related to these set goals.

According to the report, key players identified are NCTE, the public tertiary institutions, development offices of the institutions, consultants, contractors and suppliers. Quantity surveyors were found to be associated with these stakeholder groups. This agrees with literature (Esubonteng, 2014) and confirms quantity surveyors identification as key stakeholders (Chinyio and Olomolaiye (2010). The study found out that, consultants, contractors, client representatives at physical development offices, financiers and official of NTCE interviewed are closely associated with the project have quantity surveyors who are responsible for budget estimates, contract preparations, and project cost management. QSs are close to project development in all the institutions studied (Fig 1, Fig 2). This confirms literature reviewed on their role as key stakeholders (Bourne, 2005). This further agrees with research that QSs are critical and salient to the project (Mitchel et al., 1997; Chinyio and Olomolaiye, 2010)

Stakeholder Circle (Bourne, 2005): The effects of key stakeholders by literature (Bourne, 2005) confirms the findings that, project failure can be attributed to QS's at GETFund and NCTE negligence in ensuring that projects were adequately planned, and due diligence carried out before commencement to avoid cost and time overruns due to variations. Stakeholder concept indicates that primary, internal and key stakeholders can influence or affect project outcome. Quantity surveyors' play significant roles in determining project duration, cost and material specification to ensure good quality. The situation though may vary due to the post contract stage role by the beneficiary institutions in contractor's claim. The report indicates that contractors were paid for some works not executed.

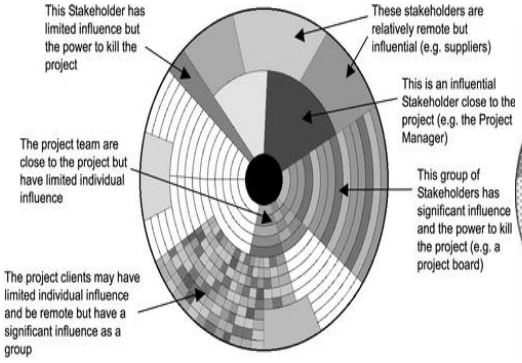

Fig 1 Stakeholder types and attributes

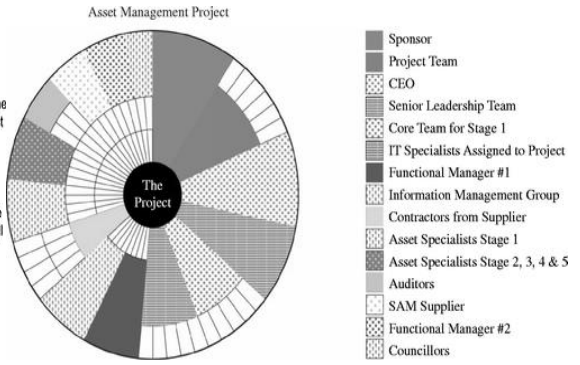

Fig 2 individual Project Stakeholders impact

7.2 "what is the extent of engagement in relation to stakeholder management approach"?

The report indicates that generally the projects were not successful in terms of achievement of cost targets and that stakeholders were not satisfied. All the institutions used as case studies had significant variations between final and initial project costs and durations.

Table 1 shows the 5 institutions studied and the changes in contract sums

Name of institution	% change in contract sum	Reasons assigned
Accra polytechnic	25.6-39.42	Addition of one more floor
Kumasi Polytechnic	0-92	Changes in substructure design
Bolgatanga Polytechnic	1.7-41.6	Scope changes, fluctuation
Cape Coast Polytechnic	18-26.57	Scope changes to modernize design
Tamale Polytechnic	Figures not available	Project are still ongoing

According to Table 1, all projects had variation in contract sums. The Audit team not satisfied with the key stakeholders role then recommends as follows:

- Technical Unit of GETFund should be proactive, draw monitoring schedules and use the schedules to inspect on-going GETFund projects;
- GETFund, through the NCTE, should insist on regular progress reports throughout the project life and not only when certificates are prepared.
- Need for effective planning and budgeting, managing project quality and maintaining the project schedule.

- GETFund and NCTE should ensure that projects were planned and budgeted for.

The fact that most projects had cost and time overruns is an indication of poor planning on the part of the project team. Literature suggests the need to manage stakeholders for a positive impact (Jespen and Eskerod, 2009). The report further indicates that new project were always undertaken though there were lack of funds to complete on-going projects as a result of the appointment of new institutional managers who preferred to start project during their term of office. Though this confirms literature on the political influence on project stakeholder management and project delivery QSs had a role to ensure that project cost was managed for project success. Project managers' inabilities to manage QSs indicate failure to control them rightfully. The need for monitoring confirms that key stakeholders were not monitored and again actually communicated during project planning and implementation stages.

Using the stakeholder matrix (Fig 1 and Fig 2), stakeholders are plotted at positions identified at the beginning of the project and project execution stages and their communication, role and responsibilities determined for monitoring and active management. It was obvious that QSs as members of the design were key stakeholders. Their inability to control project cost and also regularly communicate with the sponsor, client and project managers which is their fundamental role and to ensure that projects were completed within cost budget implies that they were not effectively managed. Newcombe (2003); PMI (2008) suggest the use of a matrix to identify and monitor interest, influence, impact and salience of each stakeholder to ensure effective project success. QSs interest and impact (Fig 3) were to be predicted while their roles and output were to be carefully monitored (Fig 3) did not affect positively on project outcome.

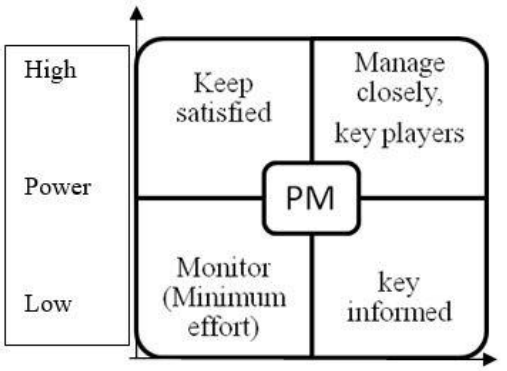

Fig 3 Power/Interest matrix

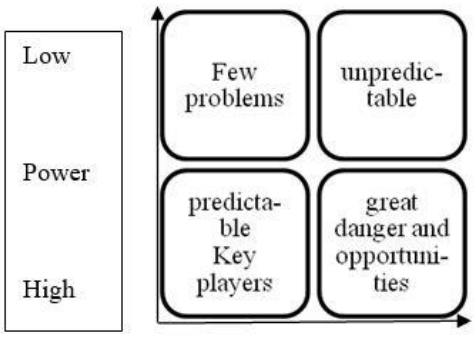

Fig 4 Power/predictability matrix

Stakeholder Matrix (Newcombe, 2003, Chinyio and Olomolaiye, 2010)

7.3 How should quantity surveyors be managed as stakeholders?

Quantity surveyors as key stakeholders in a project development play a significant role in achieving project cost target and cost information. The Performance Audit Report suggests the need for proper planning. All necessary information should be communicated to the quantity surveyor from inception to project signing off and be actively involved during the planning stages. The literature also reviewed suggests the need to enhance the role of a positive impact. A systematic approach to identification, analyzing, engagement and monitoring are essential using stakeholder management framework (Lock, 2007). Effective communication, sharing information about stakeholders, developing strategies, follow-up (Karlsen, 2002) the use of power/impact, interest, influence, importance to predict and monitor key stakeholder attitude is essential (PMI, 2008; Chinyio and Olomolaiye, 2010). The study, therefore, found the following recommendation as focused towards effective stakeholder management:

- improve upon the planning process during pre-contract in order to minimise project variations
- proposals of projects presented for funding are accompanied by documents to show that the projects were duly planned
- approve projects that can be done within the stipulated time and planned cost
- should be proactive, draw monitoring schedules, using the schedules to inspect ongoing projects;
- should insist on regular progress reports throughout the project life and not only for certificates prepared.

By using the stakeholder matrix, the quantity surveyor ought to have been kept actively involved, informed and monitored as a key stakeholder. The decision to vary project scope without cost provision and approval from the sponsors is an indication of poor communication and stakeholder management.

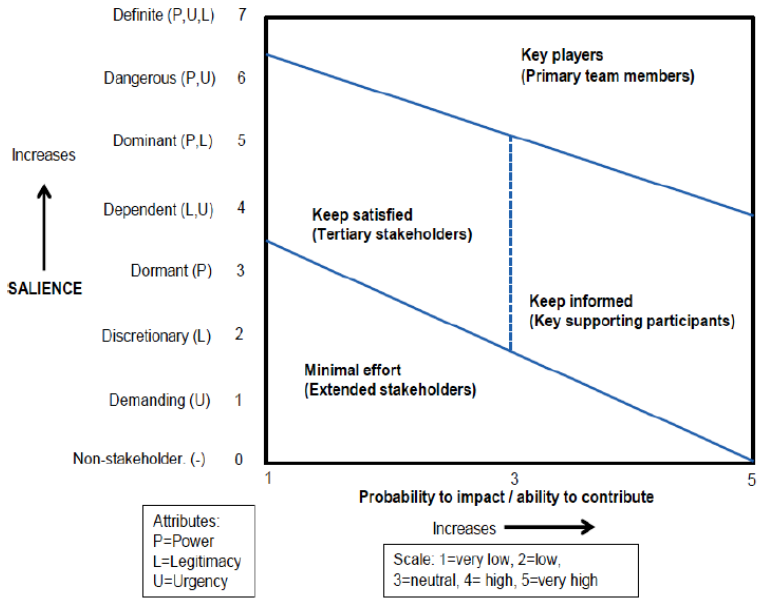

Figure 4. Stakeholder assessment matrix.

Culled from Aapaoja and Haapasalo (2014),

Aapaoja and Haapasalo (2014) stakeholder assessment matrix suggests that key stakeholders should be assessed using their salience, the probability to impact, ability to contribute and identified primary team members as key stakeholders, definite and with high ability to impact on project success. QSs as key stakeholders are to be engaged as definite stakeholders with high probability t and ability to influence and contribute towards effective stakeholder management aimed at enhanced project delivery.

8. CONCLUSION AND RECOMMENDATION

This paper explored QSs' role, responsibilities and management as key stakeholders, assessed their engagement and how they ought to be engaged for enhanced stakeholder management (SM) and project success. This study identified and confirmed their role as key, primary, internal and definite stakeholders who impact project success due to their professional role in managing, planning project cost targets and delivery.

Secondly, it agreed with the literature that quantity surveyors are involved in project delivery either with the client, consultant, contractor, supplier or NTCE, but were not properly engaged as key stakeholders for enhanced SM as their role and performance were found unsatisfactory particularly at the initial stages of the project.

These projects were characterized by delays in finalizing tender documents, inadequate reporting on cost issues, irregular site meetings and monitoring resulting in poor project management and delays which the project manager ought to have considered for enhanced engagement. Strategies were not formulated for cost reporting, monitoring, and effective communication to achieve project cost targets. There was no SM approach in place to ensure enhanced stakeholder impact on the project outcome hence the proposals for effective monitoring and reporting which are focused on improved stakeholder management.

Thirdly this paper identified absence of formal SM process, approach or framework which informs project managers on how to manage key stakeholders. It therefore proposes the need for a framework for key stakeholders' engagement for effective project planning, implementation, procedure for managing scope and cost targets. Quantity surveyors role in project execution is affected by the procurement approach, planning, monitoring and lack of SM approach. It impacts on the achievement of set targets of cost, quality, schedule, and stakeholder satisfaction. Enhancing critical stakeholder engagement will improve stakeholder management and achievement of project set goals. This study contributes to the body of knowledge by assessing QSs as key stakeholders role and impact on project delivery in a developing country and affirms the need for a construction stakeholder management framework. It is however limited to the review of selected projects by GETFund in Ghana only.

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