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CONTRIBUTORS TO SCHEDULE DELAYS IN PUBLIC CONSTRUCTION PROJECTS IN SAUDI ARABIA: OWNERS' PERSPECTIVE

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Abstract
This study aims at identifying the contributors to delays in public construction projects in Saudi Arabia from owners' viewpoint. To do so, 22 public owners of construction projects completed a structured questionnaire survey. 35 factors were identified through literature review. The results indicated that the top delay contributors are: bid award for lowest price, poor site management, poor communication and coordination between construction parties, payments delay, poor labor productivity, and rework. These findings can support the Government in improving the regulations to meet the construction market needs, owners in planning and designing and evaluating policy, contractors and managers in planning and taking external and internal risks when costing and scheduling contracts, consultants in applying comprehensive contract information, and workers in conducting their day-to-day activities. Results will fill an important research and practice gap and help in improving time performance in public construction projects in Saudi Arabia and other developing countries.

Keywords: Delays, construction, public owners, contributors, risk map

INTRODUCTION

The construction industry is large, complex and diverse and covers a wide range of business interests and activities, united by their common usage and development of land (Chan, 2007). It gives rise to many other related industries such as steel, concrete, lumber, carpet, furniture, paint, paving, mining, shipping and other industries. It is one of the largest dollar generating segments of the world economy, construction is a big business, totaling more than $3.9 trillion annually worldwide, and there is no slowdown in sight (Jackson, 2010). However, it is at or near the top in the annual rate of business failures and resulting liabilities compared to other industries (Chapman et al., 2001).

This is because it is a risky business with too many uncertainties that management has to deal with (Enshassi and Abu Mosa, 2008). One of the most recurring problems in construction industry is schedule delay. The history of the construction industry worldwide is full of projects that were completed with significant time and cost overruns (Amhel et al., 2010)

Saudi Arabia has experienced a construction boom during the past three decades, attracting construction professionals from all over the world. According to the Saudi Ministry of Planning, the construction industry contributed between 30% to 40% of the non-oil productive sectors at the end of each National Development Plan from 1980 to 2000 (Al-kharashi and Skitmore, 2009). However, project delay is considered to be one of the most serious and frequent problems in the Saudi Arabian construction industry (Faridi and Al-Sayegh, 2006). Assaf and Al-Hejji (2006) conducted a survey on time performance of different types of construction projects in Saudi Arabia. The survey concluded that 70% of projects experienced time overrun and found that 45 out of 76 projects considered were delayed. They found that the average time overrun was between 10% and 30% of the original contract duration. From the aforementioned, it appears that the problem of delay in construction projects is critical and should be studied more to overcome this problem and to improve the sector of construction industry. This paper presents the findings of a survey that aims at identifying the contributors to schedule delay in public construction projects in Saudi Arabia from the owners' perspective. It is hoped that these findings will guide efforts to enhance the performance of the construction industry in Saudi Arabia and other developing countries.

CONSTRUCTION DELAY - LITERATURE REVIEW

A number of studies have been conducted to examine delay contributors in construction projects. Mahamid et al. (2012) conducted a study to identify and rank delay causes in road construction projects in the West Bank in Palestine. Contractors indicated that the top five delay causes are: segmentation of the West Bank and limited movement between areas, political situation, progress payments delay by owner, delays in decision making by owner, and low productivity of labors. While the consultants indicated that the top five affecting causes are: political situation, segmentation of the West Bank and limited movement between areas, awarding project to lowest bid price, shortage in equipment's, and ineffective scheduling of project by contractor. Al-Khalil and Al-Ghafly (1999) investigated three components of delay in the construction of water and sewage works in Saudi Arabia. The components are: the frequency of delayed projects, the extent of delay, and the responsibility for delay. The results indicated that a high proportion of projects were subjected to delay. The frequency of delayed projects seems to be associated with the contractor classification grade. They also found that the project owners and consultants assigned the major responsibility for delay to the contractors while contractors believed that the owner is mostly responsible.

Odeh and Battaineh (2002) found that contractors and consultants agreed that the most important causes of construction delay in Jordan are: owner interference, inadequate contractor experience, financing and payments, labor productivity, slow decision making, improper planning, and incompetence of subcontractors. Alghbari et al. (2007) examined delay causes in construction projects in Malaysia. 31 variables examined in the study. They concluded that the major delay causes in construction projects are: financial causes, coordination problems, and material problems. Al-Momani (2000) investigated contributors to delay in 130 public building projects constructed in Jordan during the period of 1990-1997. He presented regression models of the relationship between actual and planned project duration for different types of building facilities. He concluded that the main causes of delay are: related to designer, user changes, weather, site conditions, late deliveries, economic conditions and increase in quantity.

Frimpong et al. (2003) conducted a survey to identify and evaluate the relative importance of significant causes contributing to delay and cost overruns in Ghana groundwater construction projects. A questionnaire with 26 causes was designed. The questionnaire was directed towards three groups in both public and private organizations: owners of the groundwater projects, consulting offices, and contractors working in the groundwater works. Results revealed that the main contributors to delay and cost overruns in construction of groundwater projects are: monthly payment difficulties from agencies; poor contractor management; material procurement; poor technical performance, and escalation of material prices. Koushki et al. (2005) conducted a study in Kuwait to investigate the contributors to time and cost overrun in construction projects. A person-interview survey of 450 randomly selected private residential project owners and developers have been done.

They concluded that the main contributors to delays are: changing orders, owners' financial constraints, and owners' lack of experience. Al-Najjar (2008) concluded that the top affecting causes of time overrun in building construction projects in Gaza Strip as perceived by contractors are: strikes, Israeli attacks and border closures, lack of materials in markets, shortage of construction materials at site, delay of material delivery to site, cash problem during construction, poor site management, poor economic conditions (currency, inflation rate, etc), shortage of equipment at site, equipment's and tool shortage on site, and owner delay in freeing the contractor financial payments.

RESEARCH METHOD

From the detailed review of literature, 35 delay contributors in public construction projects were defined. The delay contributors were tabulated into a questionnaire form. Then the draft questionnaire was discussed with three experts in the construction industry to evaluate the content of the questionnaire. Modifications and changes have been done. The questionnaire is divided into two main parts. Part I is related to general information for the agency. The surveyed owners were requested to answer questions pertaining to their experience in public construction. Part II includes the list of the identified contributors to schedule delay in public construction projects.

Data collection and analysis

Twenty-two public owners from the Northern Province of Saudi Arabia were successfully questioned. The questionnaire gave each respondent an opportunity to identify variables that they perceived as likely to contribute to delays by responding on a scale from 5 (very severe) to 1 (not severe). Participants then rated the frequency of occurrence for each contributor on project that they have experienced on an ordinal scale: very high (5), high (4), medium (3), low (2), or very low (1). For each contributor, the mean value of the respondents' severity rating was named the severity index. Secondly, the mean value from respondents' frequency rating was named the frequency index. Accordingly, the severity and frequency levels are categorized using Table 1. Finally, the contributors' matrix map was identified using Figure 1 (Mahamid, 2011).

Table1: Categories of the severity and frequency of occurrence

Index value	Severity level	Frequency level
≤ 20%	very low (VL)	very low (VL)
20% - 40%	low (L)	low (L)
40% - 60%	moderate (M)	moderate (M)
60% - 80%	high (H)	high (H)
80% - 100%	very high (VH)	very high (VH)

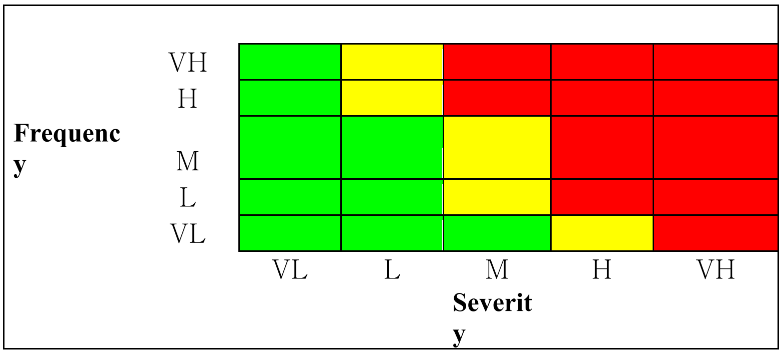

Figure 1: The risk map

The risk map includes three zones: red, yellow, and green; such that:

- **Green zone**: risks in this zone are low level, and can be ignored.
- **Yellow zone:** risks in this zone are of moderate importance, and should be controlled.
- **Red zone**: risks in this zone are of critical importance. These are the top priorities, and close attention should be paid to them.

Statistical analysis

The statistical analyses for delay contributors as assessed by owners were performed. The tests include the computation of the weighted mean, standard deviation, and coefficient of variation. These tests are used to check the compactness and consistency of the responses.

RESULTS AND DISCUSSION

Participants

The target populations in this study are the public owners of construction projects in the Northern Province of Saudi Arabia. Simple random sampling was used.

The questionnaire was sent out to a total of 22 public owners asking their perception in ranking the identified 35 contributors in terms of severity and frequency using an ordinal scale. A total of 22 owners filled the questionnaire. The response rate by the owners is 100%. On average, the respondents have experience of more than 15 years in public construction projects.

Contributors' risk map

Table 2 shows the results of risk map for contributors to schedule delays in public construction projects in Saudi Arabia from owners' perspective. It shows that 6 contributors are located in the red zone (critical contributors), 26 contributors are located in the yellow zone (moderate importance), and 3 contributors are located in the green zone (low level).

Table 2: Risk map for delay contributors from owners' perspective

Contributor	**S.I***	**Level**	**F.I***	**Level**	**Map zone**
additional work	48.48	M	42.66	M	yellow
bid award for lowest price	67.46	H	90.01	VH	red
changes in material types and specifications during construction	57.03	M	52.33	M	yellow
contract management	50.51	M	40.27	M	yellow
contractual procedure	45.29	M	40.99	M	yellow
disputes on site	50.51	M	44.83	M	yellow
duration of contract period	57.90	M	54.83	M	yellow
economic instability	53.55	M	47.33	M	yellow
effects of weather	47.03	M	49.83	M	yellow
fluctuation of prices of materials	57.9	M	53.14	M	yellow
frequent changes in design	54.42	M	51.75	M	yellow
government policies	33.99	L	34.83	L	green
high interest rates by bankers	36.16	L	36.49	L	green
inadequate production of raw materials by the country	54.86	M	52.33	M	yellow
labor cost	51.81	M	41.49	M	yellow
lack of adequate manpower	53.55	M	41.31	M	yellow
lack of contractor experience	55.73	M	49.83	M	yellow
late design work	53.12	M	55.66	M	yellow
level of competitors	59.20	M	45.66	M	yellow
long period between design and time of implementation	55.29	M	50.88	M	yellow
manipulation of suppliers	53.12	M	47.33	M	yellow
mistakes in design	54.42	M	49.83	M	yellow
number of competitors	55.73	M	43.99	M	yellow
number of projects going at the same time	56.59	M	46.49	M	yellow

payments delay	75.03	H	61.23	H	red
Poor communication and coordination between construction parties	69.64	H	78.88	H	red
poor financial control on site	58.33	M	51.49	M	yellow
poor labor productivity	67.90	H	62.18	H	red
poor relationship between managers and labors	58.68	M	50.66	M	yellow
poor resource management	53.99	M	42.33	M	yellow
Poor site management	62.68	H	56.96	M	red
project location	56.59	M	35.66	L	yellow
rework	61.81	H	59.14	M	red
social and cultural impacts	36.59	L	39.83	L	green
unreasonable project time frame	56.59	M	53.99	M	yellow

**S.I = Severity index, F.I = Frequency index.*

Top delay contributors

Table 3 shows the top contributors to delays in public construction projects in Saudi Arabia from owners' perspective, they are:

1. Bid award for lowest price: in general, the clients award bids to the lowest bidder to execute their projects. However, the lowest bidders might be low qualified contractors. Consequently, poor performance will occur that will affect the project schedule. This result is supported by Mahamid et al. (2012) in that award project to the lowest bid price is one of the main delay contributor.
2. Poor communication and coordination between construction parties: since there are many parties involved in any construction project (i.e. client, consultant, contractor, supplier, subcontractor), the communication between the parties is very important for the success of the project. Proper communication channels between the various parties should be established during the early project phases and should be continued during all project phases. Lack of coordination and communication between parties could lead to many negative causes that affect the project schedule such as: delay in decision making, frequent design changes, rework, etc. This result was not pointed out by any of the investigated studies as a critical contributor to schedule delay.
3. Poor site management: site management includes resources management, coordination with construction parties, procurement management, labor management, and construction activities management. In many cases and due to the contractor to the lack of experience, the construction site faces obstacles that lead to poor site management.

Poor site management mainly affect the projects schedule in addition to many other negative impacts on construction projects such as: rework, bad labor morale, poor productivity, bad relation between labors and management team, misuse of time schedule, interrupting construction activities, and bad relation between construction parties. This result was concluded by Al-Najjar (2008) and Frimpong et al. (2003).

5. Payments delay: construction works involve high daily expenses and most of the contractors cannot fulfill these expenses when the payments are delayed. Work progress can be delayed because of payment delay; this is because of inadequate cash flow to support the construction expenses by contractor. The problem is more acute for those contractors who are not financially sound. This result is in line with many of the investigated studies (Frimpong et al., 2003; Al-Najjar, 2008; Koushki et al., 2005; Mahamid et al., 2012; Odeh and Battaineh, 2002; Alghbari et al. 2007; Almomani, 2000)
6. Poor labor productivity: labor productivity is one of the most important keys of project success. It affects the activity duration and consequently the total project duration. Poor productivity will increase the actual time for a specific activity to be completed. Accordingly, the project will delay. This result is in line with Mahamid et al. (2012) and Odeh and Battaineh (2002).
7. Rework: it can be simply defined as redoing the same activity for more than one time. It can be as a result of many reasons such as poor workmanship, poor material quality, late changes, scope changes, and mistakes in design. Redoing the same duty again and again will lead to time overrun. This result is in line with Frimpong et al. (2003).

Table 3: Top delay contributors from owners' perspective

Contributor	**S.I**	**Level**	**F.I**	**Level**	**Map zo ne**
bid award for lowest price	67.46	H	90.01	VH	red
Poor communication and coordination between construction parties	69.64	H	78.88	H	red
Poor site management	62.68	H	56.96	M	red
payments delay	75.03	H	61.23	H	red
poor labor productivity	67.9	H	62.18	H	red
rework	61.81	H	59.14	M	red

Statistical analyses

Table 4 presents the statistical analyses for delay contributors as assessed by the surveyed owners. The table contains the computation of the weighted mean, standard deviation, and coefficient of variation. The results show good data compactness and reasonable values, indicating a good data consistency and agreement between the respondents on the severity and the frequency of the identified contributors.

Table 4: Statistical analyses for delay contributors as assessed by public owners

Contributor	Severity			Frequency		
	X'*	Sn*	C.V (%)*	X'	Sn	C.V (%)
additional work	2.42	0.82	28.97	2.13	0.81	34.10
bid award for lowest price	3.37	0.82	27.36	4.50	0.70	15.69
changes in material types and specifications during con struction	2.85	0.77	18.66	2.62	0.34	7.19
contract management	2.53	0.83	18.67	2.01	0.36	2.27
contractual procedure	2.26	0.41	19.73	2.05	0.39	16.46
disputes on site	2.53	0.74	30.68	2.24	0.97	36.45
duration of contract period	2.90	0.94	23.83	2.74	0.74	19.85
economic instability	2.68	0.95	27.37	2.37	0.73	34.07
effects of weather	2.35	0.68	31.42	2.49	0.76	32.82
fluctuation of prices of materials	2.90	0.90	22.62	2.66	0.55	6.50
frequent changes in design	2.72	0.74	19.38	2.59	0.72	15.53
government policies	1.70	0.78	28.66	1.74	0.77	39.06
high interest rates by bankers	1.81	0.65	31.33	1.82	0.62	29.72
inadequate production of raw materials by the country	2.74	0.73	16.09	2.62	0.30	3.97
labor cost	2.59	0.78	28.01	2.07	0.63	17.43
lack of adequate manpower	2.68	0.89	25.87	2.07	0.40	1.96
lack of contractor experience	2.79	0.88	24.77	2.49	0.81	14.87
late design work	2.66	0.86	30.57	2.78	0.85	27.28
level of competitors	2.96	0.74	21.13	2.28	0.78	23.48
long period between design and time of implementatio n	2.76	0.53	19.08	2.54	0.71	18.46
manipulation of suppliers	2.66	0.58	17.02	2.37	0.86	30.97
mistakes in design	2.72	0.72	18.21	2.49	0.71	15.64
number of competitors	2.79	0.81	31.03	2.20	0.99	34.78
number of projects going at the same time	2.83	0.74	19.38	2.32	0.93	30.10
payments delay	3.75	0.78	27.31	3.06	0.86	32.78
Poor communication and coordination between constru ction parties	3.48	0.60	19.27	3.94	0.68	23.31
poor financial control on site	2.92	0.89	22.64	2.57	0.74	12.11

poor labor productivity	3.40	0.78	24.91	3.11	0.62	34.06
poor relationship between managers and labors	2.93	0.70	15.93	2.53	0.49	5.32
poor resource management	2.70	0.85	24.50	2.12	0.95	30.28
Poor site management	3.13	0.78	28.66	2.85	0.78	30.95
project location	2.83	0.82	28.19	1.78	0.49	24.31
rework	3.09	0.71	32.07	2.96	0.77	18.46
social and cultural impacts	1.83	0.69	28.66	1.99	0.83	17.67
unreasonable project time frame	2.83	0.86	29.77	2.70	0.85	24.00

**X' = Mean, Sn = Standard deviation, C.V = Coefficient of variation.*

CONCLUSION

Time performance of a project is usually a particularly important consideration for the construction parties. Often, the most troublesome construction disputes involve delay and failure to complete the work in the specified time frame. Many variables have an impact upon construction delay in Saudi Arabia. A questionnaire survey was undertaken of 22 public owners of construction projects in the Northern Province of Saudi Arabia. 35 delay contributors were identified through literature review. The risk map for the considered contributors was identified according to their perceived severity and frequency of occurrence. Three zones were considered in the risk map: red, yellow, and green. The results showed that 6 contributors are located in the red zone, 26 contributors are located in the yellow zone, and 3 contributors are located in the green zone of the risk map.

The study concluded that the top delay contributors in public construction projects in Saudi Arabia from owners' perspective are: : bid award for lowest price, poor site management, poor communication and coordination between construction parties, payments delay, poor labor productivity, and rework. The statistical analyses showed that the data has good compactness, indicating a good data consistency and agreement between the respondents on the severity and frequency of occurrence of the identified delay contributors.

Based on the findings of this study, the following points are suggested in order to reduce and control delay in public construction projects:

1. The Government and Contractors' Association should conduct workshops and training courses to improve the managerial skills of the construction parties, especially the contractors to improve their site management skills.

3. Construction parties should have more communication and coordination during planning, design, and execution phases of the project.
4. Bids must be awarded to the bidder with reasonably estimated cost and not necessarily to the lowest bidder.
5. Contractors should manage their financial resources and plan cash flow by utilizing progress payment.
6. Owner should pay progress payment to contractors on time because it affects the contractors' ability to finance the work.
7. Construction parties should conduct a detailed and comprehensive site investigation at the design phase in order to avoid variations and late changes during the construction phase that will control rework.
8. The Government should improve the regulations and laws in terms of increasing labor wages and benefits; this will obviously improve their motivation to work and increase their productivity.

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DETERMINING THE EFFECTIVENESS OF CONCURRENT ENGINEERING THROUGH THE ANALYTICAL HIERARCHY PROCESSING OF PROJECT SUCCESS CRITERIA

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Abstract
The emergence of Concurrent Engineering (CE) as the Project Procurement method of choice for effective integration and coordination into construction has been gaining grounds. However, this is based mainly on empirical data that were derived majorly from the implementation of CE within the manufacturing environment. Thus the theoretical foundations of CE has been more empirical that statistical. Although science is driven by data, strong theoretical foundations must exist in order to explain that data. This work seeks to confirm statistically, the prominence of concurrent engineering as the method which offers the most scope for effective attainment of construction objectives of Cost, Time, Quality and Clients Satisfaction. Using the Analytical Hierarchy Process (AHP) model, these project success criteria were used as the primary criteria, along with its sub-criteria, to calculate the Eigen-vectors, in order to synthesize a pair-wise comparison matrix of the criteria. Thus the priority weight vectors were obtained and used for the ranking of the four principal construction delivery methods: Traditional method, the Design and Build method, the Programme management method and the Concurrent Engineering method. The results of the data computations gave a ranking of the four (4) principal project delivery methods of; Traditional sequential delivery, Programme management, Design and build and CE, with the values 0.0001, 0.1027, 0.2062 and 0.6910 respectively. CE ranked highest in its effectiveness in attaining construction goals. The work thus confirm statistically, the prominence of concurrent engineering as the method which offers the most scope for effective attainment of construction objectives of Cost, Time, Quality and Clients Satisfaction.

Keywords: Project Success Criteria, Project Delivery Method, Analytical Hierarchy Process, Eigen-vectors.

INTRODUCTION

The principal aim of a client on initiating a construction project is to acquire a sound finished work at a minimum price, time, quality and utility. However, most clients do not have the desire or competence to undertake this on their own, hence they delegate the responsibility to the appropriate experts with the necessary competence for certain considerations. The construction procurement process is complex in its separation of functions into discrete sub-processes, in its structures and procedures, in its proliferation of actors and activities, in the diversity of the resources employed, their sources and their mobilization (Aouad et al, 1994). This fragmented nature of the construction process and the industry, evident in the large number of firms operating within it, the distinct separation of the professions and the resultant poor communication, lack of concurrency, institutional barriers, ad-hoc problem solving approach, lack of trust and collaborative spirit within the client/design/construction team amongst other factors have led to consistently low levels of performance (Banwell 1964, Aniekwu, 1986, Latham 1994).

To reduce the difficulties encountered with procuring projects, industry practitioners and researchers have turned to the manufacturing industry as a point of reference and a potential source of innovation. Accordingly, a method known as concurrent engineering which advocates for the use of a multi-disciplinary project team whereby participants are brought together during the design stage to determine how downstream issues may be affected by design decisions has become dominant. It refers to an approach used in product development in which functions of design engineering, manufacturing engineering and other functions are integrated to reduce the elapsed time required to bring a new product to the market. The portability of this method makes it possible to be relatively adaptable to other industries. Apart from these empirical data, no fundamental theoretical basis has been proffered for the advantage of concurrent engineering over other major construction delivery methods. This work tries to confirm statistically, the prominence of concurrent engineering as the method which offers the most scope for effective attainment of construction objectives of Cost, Time, Quality and Clients Satisfaction.

PROJECT DELIVERY METHODS

A project delivery method is a system used by a client for organizing and financing design, construction, operations, and maintenance services for a facility by entering into legal agreements with one or more entities or parties. There are four most common construction delivery methods, while the other methods are considered “hybrid” methods or some combination of the four (Construction Industry Institute (CII) (1997). They include:

1. The Traditional Construction Delivery Method;
2. The Construction (Programme) Management Method;
3. The Design and Build Method; and
4. Concurrent Engineering Method

The Traditional Construction Delivery Method

The Owner’s architect and engineers (AE) carry out the design after the program of requirements and budget are set and the site is defined. The AE prepares the Contract Documents (i.e. construction documents, bid documents, working drawings and specifications) and Competitive bids are received from contractors, or a price is negotiated with a selected contractor. When a price is obtained, the construction contract is executed and the Owner authorizes construction to proceed (Elbeltagi, 2009).

The Programme Management Method

Program management or Construction management is the process of managing projects through a fee-based service in which the construction manager is responsible exclusively to the owner and acts in the owner's interests at every stage of the project. The construction manager offers advice, uncolored by any conflicting interest, on such crucial matters (Elbeltagi, 2009).

The Design and Build Method

The Design and Build method gives the client a single point of contact in which the contracting organization is responsible for design and construction. The client commits to the cost of construction, as well as the cost of design, much earlier than with the traditional approach.

THE CONCURRENT ENGINEERING METHOD

Concurrent engineering (CE) is the systematic approach to the integrated, concurrent design of products and related processes, including manufacturing and support. This approach is intended to cause the developers to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements. The primary goal of CE is to reduce the lead-time, or the total time from designing a product to releasing it into the market, while creating better designs as well (Elbeltagi, 2009).

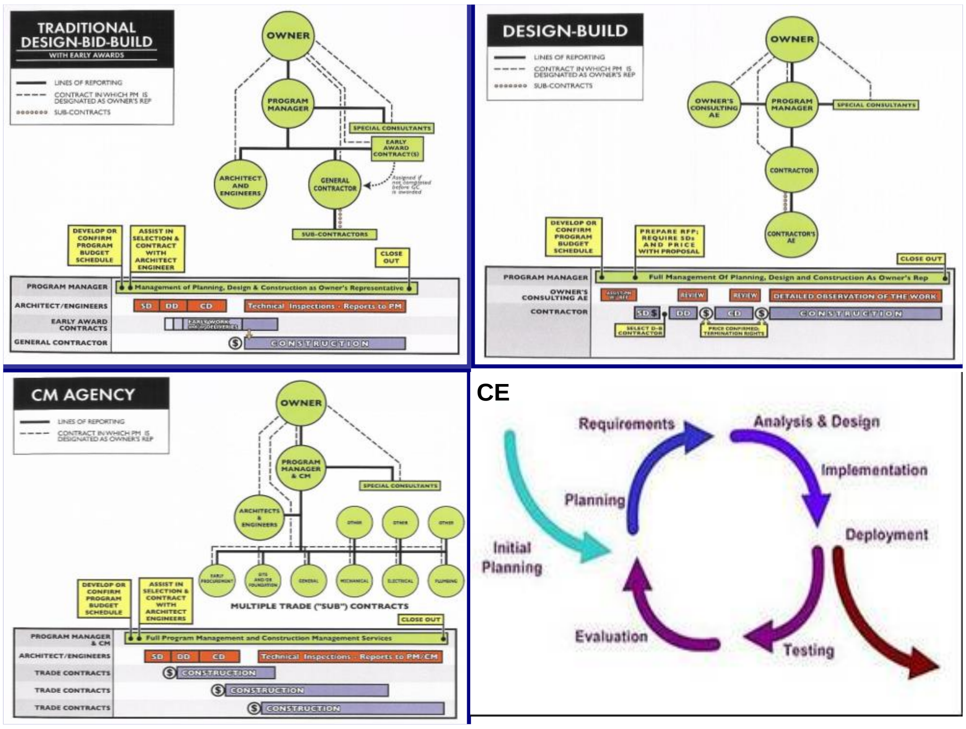

Fig. 1: Summary of Procurement Methods (After Construction Industry Institute, 1997)

PROJECT SUCCESS CRITERIA

Over 50 years ago, Oilsen, (1971) suggested cost, time and quality as the success criteria. Many other writers Turner, (1993), Morris and Hough, (1987) and Ballantine, (1996), all agree that cost, time and quality should be used as success criteria. Cost, time and quality became known as "The Iron Triangle" (Fig.2). In more recent times many research have proved that this is not a satisfactory success criteria and more is required beyond this. The reality is that the notion of success is a much more complex issue and often an illusory construct (Westerveld, 2002).

Thus Clients satisfaction was added to the criteria. Irrespective of the procurement methods adopted, the desire of the client is to acquire a good quality project at the lowest possible cost and on time, while satisfying the clients' needs.

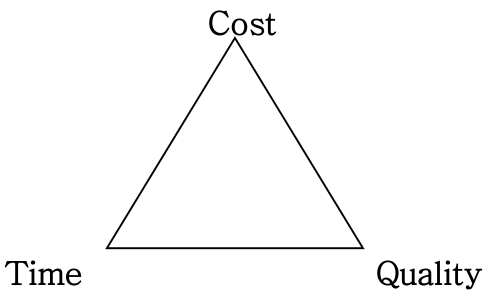

Fig 2: The Iron triangle.

Project success criteria is identified as the primary criteria clients use to assess the level of successful attainment of their primary objectives. Our approach therefore was to use the project success criteria of Cost, Time, Quality and Client's satisfaction as the primary criteria in an Analytical Hierarchical process and compute the eigen-values of the alternative construction delivery method and rank them. The various components of the individual success criteria were identified through literature and related to the delivery methods in terms of their inherent advantages and disadvantages and used to develop a diagram of the relationship between project success criteria and the delivery methods (Table. 1).

Table 1: Relationships of Project Delivery Methods to Project Success Criteria

Primary Criteria	**Secondary Criteria**	**Traditional Method**	**Program Management**	**Design/Build Method**	**Concurrent Engineering**
COST	Reworks/ Variations	✖	◕	◕	◕
	Cost Escalations	✖	✖	◕	◕
	Cost Over-Runs	✖	✖	◕	◕
TIME	Simultaneous Production	✖	◕	✖	◕
	Integration of Sub-Processes	✖	◕	✖	◕

	Material Supply Logistics	✖	✖	✖	✖
QUALITY	Lack of Testing Facilities	✖	✖	✖	✖
	Lack of Standardization	✖	✖	✖	✖
	Poor Workmanship	✖	✖	✖	✖
CLIENT SATIS FACTION	Cost Target	✖	✖	◕	◕
	Time Target	✖	◕	✖	◕
	Quality Target	✖	◕	✖	◕

◕ = *Favourable Relationship;* ✖ = *Unfavourable Relationship*

ANALYTICAL HIERARCHY PROCESS (AHP)

The Analytic Hierarchy Process (AHP) is a multi-criteria decision aiding method based on a solid axiomatic foundation. It involves a systematic procedure for dealing with complex decision making problems in which many competing alternatives (projects, actions, scenarios) exist [Forman and Selly (2002), Saaty and Vargas (1994), Saaty (1990), Saaty (1995), Vargas (1990)]. The alternatives are ranked using several quantitative and/or qualitative criteria, depending on how they contribute in achieving an overall goal.

AHP is based on a hierarchical structuring of the elements that are involved in a decision problem. The hierarchy incorporates the knowledge, the experience and the intuition of the decision-maker for the specific problem. The simplest hierarchy consists of three levels. On the top of the hierarchy lies the decision's goal. On the second level lie the criteria by which the alternatives (third level) will be evaluated. In more complex situations, the main goal can be broken down into sub-goals or/and a criterion (or property) can be broken down into sub-criteria. People who are involved in the problem, their goals and their policies can also be used as additional levels (Anagnostopoulos & Vavatsikos, 2006).

The hierarchy evaluation is based on pair-wise comparisons. The decision maker compares two alternatives Ai and Aj with respect to a criterion and assigns a numerical value to their relative weight.

The result of the comparison is expressed in a fundamental scale of values ranging from 1 (Ai, Aj contribute equally to the objective) to 9 (the evidence favoring Ai over Aj is of the highest possible order of affirmation) (Anagnostopoulos & Vavatsikos, 2006). Given that the "n" elements of a level are evaluated in pairs using an element of the immediately higher level, an n x n comparison matrix is obtained (Fig. 3). If the immediate higher level includes m criteria, m matrixes will be formed. In every comparison matrix all the main diagonal elements are equal to one (aii=1) and two symmetrical elements are reciprocals of each other (aij x aji = 1) (Anagnostopoulos & Vavatsikos, 2006).

K	P_1	P_2	$\cdots$	P_n
P_1	1	a_{12}	$\ldots$	a_{1n}
P_2	$1/a_{12}$	1	$\ldots$	a_{2n}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
P_n	$1/a_{1n}$	$1/a_{2n}$	$\ldots$	1

Fig. 3. Pair-wise comparison matrix A of alternatives P~ with respect to criterion K

Since n(n-1)/2 pair-wise comparisons are required to complete a comparison matrix, mn(n-1)/2 judgments must be made to complete the evaluation of the n elements of a level using as criterion the m elements of the immediately higher level. For large evaluations, the number of comparisons required by the AHP can be somewhat of a burden. For example, if 5 bids are to be evaluated, in a model containing 20 criteria, at least 10 x 20 = 200 judgments must be made. The decision-makers' judgments may not be consistent with one another. A comparison matrix is consistent if and only if aij x ajk = aik for all i, j, k. AHP measures the inconsistency of judgments by calculating the consistency index CI of the matrix

$$CI = \frac{\lambda_{\max} - n}{n-1} \quad \text{---------------------------------(1)}$$

Where: λmax is the principal eigenvalue of the matrix.

The consistency index CI is in turn divided by the average random consistency index RI to obtain the consistency ratio CR.

$$CR = \frac{CI}{RI} \quad \text{-------------------------------------(2)}$$

The RI index is a constant value for an n x n matrix, which has resulted from a computer simulation of n x n matrices with random values from the 1-9 scale and for which aij = 1/aji. If CR is less than 5% for a 3 x 3 matrix, 9% for a 4 x 4 matrix, and 10% for larger matrices, then the matrix is consistent (Anagnostopoulos & Vavatsikos, 2006).

Once the values are defined, a comparison matrix is normalized and the local priority (the relative dominance) of the matrix elements with respect to the higher level criterion is calculated. The overall priority of the current level elements is calculated by adding the products of their local priorities by the priority of the corresponding criterion of the immediately higher level. Next, the overall priority of a current level element is used to calculate the local priorities of the immediately lower level which use it as a criterion, and so on, till the lowest level of the hierarchy is reached. The priorities of the lowest level elements (alternatives) provide the relative contribution of the elements in achieving the overall goal. Hence, Saaty (1994) states that there are three basic principles in the AHP method, which are as follows:

1. Decomposition: After the problem has been defined, decomposition is necessary to be done, which is dividing a problem into smaller parts. The division process will resolve some levels of a problem. That is why this process of analysis is named hierarchy.
2. Comparative Judgment: This principle assesses the relative importance of two elements in a certain level related to those at higher level. This assessment is the main point of the AHP method because it influences the priority of the elements. This assessment result can be observed better if displayed in the form of Pairwise Comparison Matrix.
3. Synthesis of Priority: From each of Pairwise Comparison Matrix, the eigenvector value can be determined to acquire local priority. Because the Pairwise Comparison Matrix is available in each level, the global priority can be acquired by synthesizing between those local priorities.

The procedure of synthesizing is different according to each hierarchy. To rank the elements according to its relative importance through synthesizing procedure is called priority setting.

According to Saaty (1994), this AHP method is appropriate to be used in making decision that involves decision element comparison, which is difficult to be assessed quantitatively. This matter is based on the assumption that human beings' natural reaction when facing a complex decision making, is by grouping the decision elements according to its common characteristics. This grouping process includes rank the decision elements, and then comparing between each pair in each group in a form of matrix. Afterward, inconsistency ratio and weight for each element will be acquired. Thus, it will provide ease in testing the data consistency.

The ratio-scale form is used as an input in the AHP method, which states one's perception when facing the decision-making situation. The values in the ratio are then organized in a matrix, which is called the pairwise comparison matrix. Due to the limitation of human beings' brain capability, the ratio-scale is limited as well. In the AHP method, the scale range 1–9 is assumed sufficiently representing human beings' perception. The reason why te AHP method limits the ratio-scale 1–9, is acording to the research conducted by a psychologist (Miller, 1956), which shows that human beings cannot simultantly compare more than seven objects, either it increases or decreases two objects. In such condition, human beings will lose their consistency in making the comparison. The Standard Preference Scale used in the AHP method is provided in Table 2 as follows:

Table 2: Preference Scale for Pair-wise Comparisons

Preference Level	Numerical Value
Equally Preferred	1
Equally to Moderately Preferred	2
Moderately Preferred	3
Moderately to Strong Preferred	4
Strongly Preferred	5
Strongly to Very Strongly Preferred	6
Very Strongly Preferred	7
Very Strongly to Extremely Preferred	8
Extremely Preferred	9

Source:http://www.s.scribd.com/doc/2908406/Modul-6-Analytic-Hierarchy-Process/21 Juni 2009

THE APPLICATION OF AHP METHODOLOGY

Although science is driven by data, strong theoretical foundations must exist in order to explain that data. Otherwise, all we have is a collection of possibly related facts, and what good is that? Science isn't merely an attempt to collect data, but rather an effort to explain that data in an accurate, coherent, and useful manner. In order to assess the effectiveness of each procurement type in meeting client's objectives, several criteria must be taken into account and a consistent evaluation methodology must be applied. The model for the analysis is a multi-criteria decision making approach, based on the Analytic Hierarchy Process (AHP). The decision problem is decomposed into qualitative criteria and sub-criteria that are further analyzed in quantitative indicators on which the procurement types are evaluated.

The definition of project success changed over the years. In the 1960s, project success was measured entirely in technical terms: either the product worked or it did not. In the 1980s, [Kezner, 1998] defined project success in terms of meeting three objectives: 1) time, 2) Cost, and 3) quality. The quality of a project was commonly defined as meeting technical specifications. Client satisfaction was later included as a criteria. Thus the assessment of the viability of a project delivery method is basically an assessment of how well the method is able to attain the project success criteria of cost, Time, Quality and Client's satisfaction. These criteria are considered as the primary criteria in this particular study. The primary criteria were weighted as shown below using the preference scale for Pair-wise Comparism.

Table 3: Weighting of the Primary Criteria using the Preference Scale for Pair-wise Comparison

Primary Criteria	Preference Level	Numerical Value
COST	Equally Preferred	1
TIME	Strongly Preferred	5
QUALITY	Very Strongly Preferred	7
CLIENT SATISFACTION	Extremely Preferred	9

Four levels form the hierarchy whose goal, the optimal ranking of Construction Delivery Method, is placed on the first level. The secondary criteria which constitute the second level consist of the four principal criteria that describe construction success criteria; Cost Time, Quality and Clients' Satisfaction.

The next level which constitute the Secondary criteria of the hierarchy are the three elements (sub-criteria) that make up the success factors in the second level criteria.

The lowest level of the hierarchy consists of the construction delivery methods to be evaluated in order to rank them according to the selected criteria. The various elements that make up each criteria were weighted based on the experience, values and knowledge, using the Preference Scale for Pair-wise comparison as given in table 2.

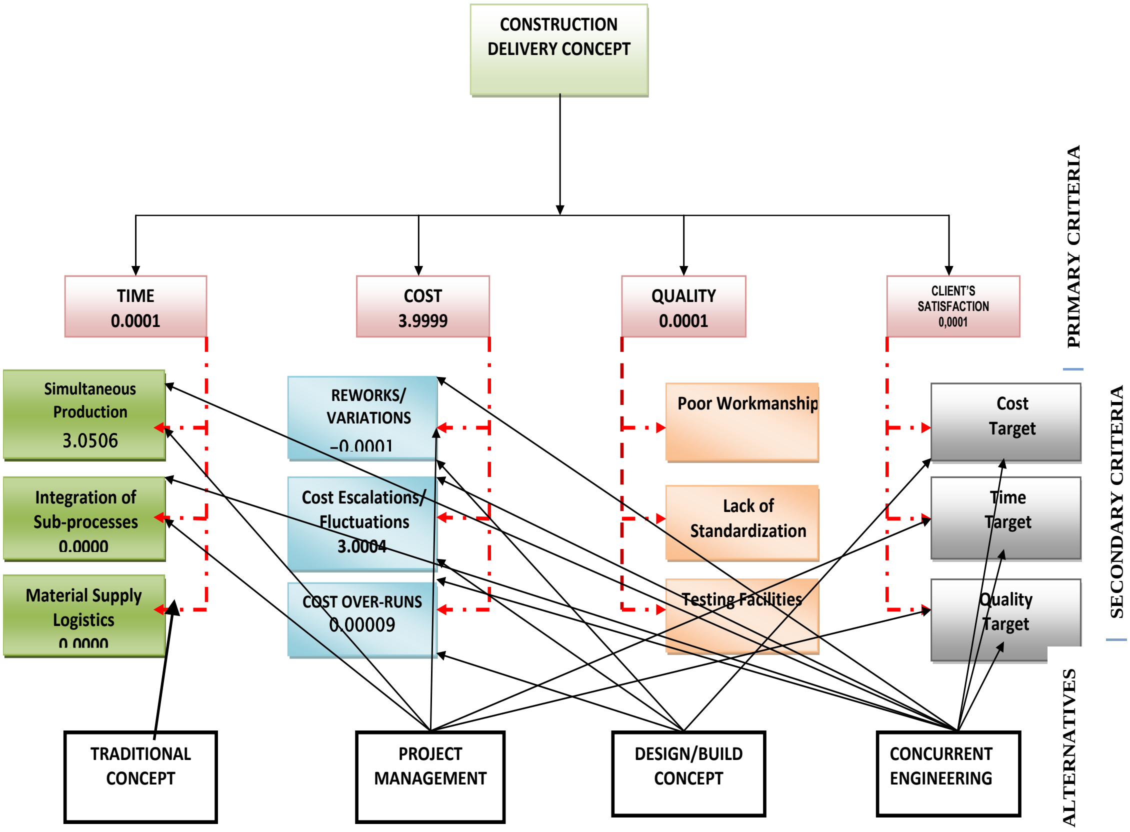

Fig. 4. The Affinity Diagram of Construction Success and Construction Delivery Methods

A Professional commercial software, “Expert Choice”, developed by Expert Choice, Inc. [2011], was used to implement the AHP's steps, which automated many of its computations (Winston & Albright, 1997).

RESULTS

The analytical hierarchy process is used to confirm the preference of CE as the method of choice that has yielded itself to effective adaptation to the construction industry.

The Construction project success criteria of cost, time, quality and clients satisfaction are used as the primary criteria for assessing the well-suitedness of the various project delivery methods for construction. The Traditional sequential project delivery method; the Programme management method, the design and build method and concurrent engineering method, are the four (4) alternatives to be selected from. Each of the four (4) primary criteria were further broken down into three (3) secondary or sub criteria and decomposed into a hierarchy of criteria and alternatives as shown in Fig 4.

Basically, we decompose the decision problem into criteria and sub-criteria, then we establish the relative importance of each criteria over another based on experience and judgment, using the Preference Scale and then express it as a comparison matrix as shown in Table 4. We sum the values in each column of pairwise comparison matrix. We then divide each element by its column total (gives normalized pairwise comparison matrix) and then compute the average of elements in each row (gives estimate of relative priorities of elements being compared).

Table 4: Preference Matrix of Pairwise comparisons of the criteria with respect to goals

	Cost	**Time**	**Quality**	**Satisfaction**
Cost	1.00	5.00	7.00	9.00
Time	0.20	1.00	4.00	5.00
Quality	0.14	0.25	1.00	2.00
Satisfaction	0.11	0.20	0.50	1.00

The comparison matrix is synthesized to get the priorities of the alternatives, with respect to each criterion and the weights of each criterion with respect to the goal (Table 5). This was implemented on Microsoft Excel and computed weight and ranking of the various criteria. To determine the overall weight, each entry is divided by the sum of the column it appears in. And then each entry is expressed as a percentage of this sum. By averaging across each row, we correct for any small inconsistencies in the decision making process. The details of the manual computations are given in the appendix 1.

Table 5: Normalized matrix

	Weights	**Products**	**Ratio**
Cost	0.6381	2.821202	4.421291
Time	0.2267	0.94677	4.176721
Quality	0.0837	0.334616	3.999475
Satisfaction	0.0516	CI/RI should be less than 0.1 if consistent comparisons were ma	

The Consistency Index, Consistency ratio, were also computed) Table 6) and the Matlab Software was used to compute the principal Eigen-vector and eigenvalues λ.

Table 6: Consistency Index

n	1	2	3	4	5	6	7	8
CI	4.2	4.2	0.0256	0.1729	0.1440	0.2208	-0.1754	4.494
CR/RI	0.00	0.00	0.04	0.300	-0.25	0.24	-0.19	4917

The test result is inconsistent if CR ≥ 10%, The RI index is a constant value for an n x n matrix, which has resulted from a computer simulation of n x n matrices with random values from the 1-9 scale and for which aij = 1/aji. If CR is less than 5% for a 3x3 matrix, 9% for a 4x4 matrix, and 10% for larger matrices, then the matrix is consistent. The result of the analysis as shown above is consistent. The results in table 6, indicate that all the items compared were consistent.

The ranking is obtained by raising the pairwise matrix to powers that are successively squared each time. The row sums are then calculated and normalized. The Local priorities are then multiplied by the weights of the respective criterion. The results are summed up to produce the overall priority of each alternative. Multiplying together the entries in each row of the matrix and then taking the nth root of that product gives a very good approximation to the correct answer. The nth roots are summed and that sum is used to normalize the eigenvector elements to add to 1.00. The Table. 7 below gives the results for the four attributes of Cost, Time, Quality, and Satisfaction.

Table 7: Composite Relative Ranking

	Cost	Time	Quality	Satisfaction
Cost	0.6878	0.7752	0.5600	0.5294
Time	0.1376	0.1550	0.3200	0.2941
Quality	0.0983	0.0388	0.0800	0.1176
Satisfaction	0.0764	0.0310	0.0400	0.0588

The results in table 8 also indicate the Concurrent Engineering is by far the most preferred method with a ranking of 0.6910, while design and Build was ranked 0.2062, Programme management 0.1027 and the traditional method was ranked 0001.

Table 8: Final ranking of project delivery methods

CONSTRUCTION DELIVERY METHODS	FINAL RANKING
Concurrent Engineering	0.6910
Design & Build	0.2062
Programme Management	0.1027
Traditional Method	0.0001
	1.0000

This result confirms that CE is the most advantageous method to apply to construction in order to better achieve project success criteria. It is also consistent with the results of other empirical studies (Madan, 1993; Carter, 1994; Constable, 1994; Dowlatshahi, 1994; Evbuomwan et al., 1994; Frank, 1994; Nicholas, 1994; Thamhain, 1994; Smith et al., 1995; Prasad, 1996).

CONCLUSION

The research objective was to confirm statistically that CE is the most advantageous method to apply to construction in order to better achieve project success criteria. This work was motivated by the fact that the emergence of CE as the method of choice for effective integration and coordination into construction was based mainly on empirical data that were derived from the implementation of CE within the manufacturing environment.

The approach adopted the use the project success criteria of Cost, Time, Quality and Client's satisfaction as the primary criteria in an Analytical Hierarchical process and computed the Eigen-values of the alternative construction delivery method and ranked them. The AHP model was thus used to statistically select the best option out of the four principal construction delivery methods; the Traditional method, the Design and Build method, the Programme management method and the Concurrent engineering method as the alternatives. The results clearly determined statistically that concurrent engineering is the project delivery method which offers the most scope for effective co-ordination and integration into the industry with an eigenvector of 0.6910 and has advantages over other delivery methods.

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APPENDIX 1.0

Manual Implementation of the Analytical Hierarchy Process

Table 1.1: PAIRWISE MATRIX FOR COST

	Cost Escalations	Rework/Variations	Cost Over-run
Cost Escalations	1	7	3
Rework/Variations	1/7	1	3/7
Cost Over-run	1/3	7/3	1
pair-wise relative importance [1:Equal, 3:Moderate, 5:Strong, 7:Very strong, 9:Extreme]			
Table 1.1.1. CONVERT THE PAIRWISE MATRIX FOR COST TO DECIMALS			
Cost Escalations	1.0000	7.0000	3.0000
Rework/Variations	0.1429	1.0000	0.4286
Cost Over-run	0.3333	2.3333	1.0000
Iterate 1. Take successive squared powers of matrix 2. Normalize the row sums			
Table 1.1.2. EIGEN VECTORS FOR SECONDARY CRITERIA (COST)			
Cost Escalations	-0.940094510931664	-0.976223446860008	-0.690571816418779
Rework/Variations	-0.134315629728619	0.186689993991042	-0.199323247388269
Cost Over-run	-0.313339467872721	-0.110157287295892	0.695255930876295
Eigen Values	3.00004126165477	-0.00013792865767	0.000096667002

Table 1.2: PAIRWISE MATRIX FOR TIME

	Simultaneous Production	Integration of Sub processes	Material Supply Logistics
Simultaneous Production	1	5	7
Integration of Sub processes	1/5	1	5/7
Material Supply Logistics	1/7	7/5	1
Table 1.2.1. CONVERT THE PAIRWISE MATRIX TO DECIMALS			
Simultaneous Production	1.0000	5.0000	7.000
Integration of Sub processes	0.2000	1.0000	0.7143
Material Supply Logistics	0.1429	1.4000	1.0000
Iterate 1. Take successive squared powers of matrix			
Table 1.2.2. EIGEN VECTORS FOR SECONDARY CRITERIA (TIME)			
Simultaneous Production	0.972430087362219	.972437371246157	0.972437371246157
Integration of Sub processes	0.155405783767796	-0.077720913294414 - 0.134567747658694i	-0.077720913294414 + 0.134567747658694i
Material Supply Logistics	0.173864221633506	-0.086920305268690 + 0.150537040168224i	-0.086920305268690 - 0.150537040168224i
Eigen Values	3.050613711143587	-0.025306855571793 + 0.391717301440150i	-0.025306855571793 - 0.391717301440150i

Table 1.3: PAIRWISE MATRIX FOR QUALITY

	Poor Workmanship	**Lack of Standardization**	**Testing Facilities**
Poor Workmanship	1	3	7
Lack of Standardization	1/3	1	3/7
Testing Facilities	1/7	7/3	1
Table 1.3.1. CONVERT THE PAIRWISE MATRIX TO DECIMALS			
Poor Workmanship	1.0000	3.0000	7.0000
Lack of Standardization	0.3333	1.0000	0.4286
Testing Facilities	0.1429	2.3333	1.0000
Table 1.3.2. EIGEN VECTORS FOR SECONDARY CRITERIA (QUALITY)			
Poor Workmanship	-0.953895173370751	0.953919610688564	0.953919610688564
Lack of Standardization	-0.180648382173457	-0.090309953459839 - 0.156421622101547i	-0.090309953459839 + 0.156421622101547i
Testing Facilities	-0.239687630548800	-0.119853979027236 + 0.207482019703686i	0.119853979027236 - 0.207482019703686i
EIGEN VALUE	3.327046642366458	-0.163523321183227 + 1.030599707360593i	-0.163523321183227 - 1.030599707360593i

Table 1.4: PAIRWISE MATRIX FOR CLIENT'S SATISFACTION

	Cost Target	**Time Target**	**Quality Target**
Cost Target	1	7	9
Time Target	1/7	1	9/7
Quality Target	1/9	7/9	1
Table 1.4.1. PAIRWISE MATRIX FOR CLIENT'S SATISFACTION CONVERTED TO DECIMALS			
Cost Target	.000000000000000	.000000000000000	.000000000000000
Time Target	.142900000000000	.000000000000000	.285700000000000
Quality Target	0.111100000000000	0.777800000000000	1.000000000000000
Table 1.4.2. EIGEN VECTORS FOR SECONDARY CRITERIA (SATISFACTION)			
Cost Target	-0.940094510931664	-0.976223446860008	-0.690571816418779
Time Target	-0.134315629728619	0.186689993991042	0.199323247388269
Quality Target	-0.313339467872721	-0.110157287295892	0.695255930876295
EIGEVALUES	3.000041261654774	-0.000137928657672	0.000096667002897

Table 1.5: COMPUTATION OF EIGEN VALUES FOR THE ALTERNATIVES BASED ON SUCCES CRITERIA ©ST)

COST	Conc. Engineering	Programme Management	Design & Build	Traditional Method
Conc. Engineering	1	3	1	9
Programme Managt	1/3	1	1/3	3
Design & Build	1	1/3	1	9
Traditional Method	1/9	1/3	1/9	1

Table 1.5.1. CONVERT THE PAIRWISE MATRIX TO DECIMALS

Conc. Engineering	1	3	1	9
Programme Managt	0.3333	1	o.3333	3
Design & Build	1	0.3333	1	9
Traditional Method	0.1111	0.3333	0.1111	1

Table 1.5.2. EIGEN VECTORS FOR ALTERNATIVES CRITERIA (COST)

	Conc. Engineering	Programme Managt.	Design & Build	Traditional Method
Concurrent Engineering	0.765413394240525	0.336769136113986	0.456913301373799	-0.993197677534924
Programme Management	0.255079235122342	0.113516136723891	-0.000924492109134	-0.000019063361346
Design & Build	0.584675269915522	-0.933969792651174	-0.888207318711479	0.050967701388543
Traditional Method	0.085039687651186	0.037430763810615	0.048136673435152	0.104693201264410
EIGEN VALUE	3.763565649699764	0.238218468757986	-0.001832804486538	0.000048686028791

Table 1.6: COMPUTATION OF EIGEN VALUES FOR THE ALTERNATIVES BASED ON SUCCES CRITERIA (TIME)

TIME	Concurrent Engineering	Programme Management	Design & Build	Traditional Method
Concurrent Engineering	1	1	5	7
Programme Management	1	1	1/5	1/7
Design & Build	1/5	1/5	1	7/5
Traditional Method	1/7	1/7	5/7	1

Table 1.6.1. CONVERT THE PAIRWISE MATRIX TO DECIMALS

Concurrent Engineering	1	1	5	7
Programme Management	1	1	0.2000	0.14229
Design & Build	0.2000	0.2000	1	1.4000
Traditional Method	0.1429	0.1429	0.7143	1

Table 1.6.2. EIGEN VECTORS FOR ALTERNATIVES CRITERIA (TIME)

	Concurrent Engineering	Programme Managt.	Design & Build	Traditional Method
Concurrent Engineering	0.894433401441585	0.378272829320866	-0.707106781186712	-0.690069993971249
Programme Management	-0.389432157639848	-0.921015791093129	-0.707106781186383	- 0.703861983484055
Design & Build	-0.178886680288317	0.075654565864173	-0.000000000003284	0.138013998779344

Traditional Method	-0.127792959888388	0.075654565864173	0.000000000002298	-0.096611840720209
EIGEN VALUE	3.435526529744007	0.564480542955276	-0.000000000000001	-0.000007072699281

Table 1.7: COMPUTATION OF EIGEN VALUES FOR THE ALTERNATIVES BASED ON SUCCES CRITERIA (CLIENTS SATISFACTION)

CLIENTS SATISFACTION	**Concurrent Engineering**	**Programme Management**	**Design & Build**	**Traditional Method**
Concurrent Engineering	1	7	5	9
Programme Management	1/7	1	7/3	9/7
Design & Build	1/5	3/7	1	3
Traditional Method	1/9	7/9	1/3	1
Table 1.7.1. CONVERT THE PAIRWISE MATRIX TO DECIMALS				
Concurrent Engineering	1.0000000000	7.0000000000	5.0000000000	9,00000000000
Programme Management	0.1429000000	1.0000000000	2.3333000000	1.28570000000
Design & Build	0.2000000000	0.4286000000	1.0000000000	3.00000000000
Traditional Method	0.1111000000	0.7778000000	0.3333000000	1.0000000000
Table 1.7 2. EIGEN VECTORS FOR ALTERNATIVES CRITERIA (CLIENTS SATISFACTION)				
	Conc. Engineering	Programme Managt.	Design & Build	Traditional Method
Concurrent Engineering	0.958915965422118	-0.995970544188139	0.854423243971900	0.854423243971900
Programme Management	0.202303117006599	0.069702125844793	-0.151680094285592 + 0.358185520821917i	-0.151680094285592 - 0.358185520821917i
Design & Build	0.173296917415277	0.000031297034410	-0.222388076561240 - 0.221858785419826i	-0.222388076561240 + 0.221858785419826i
Traditional Method	0.097579703434394	0.056429493908717	0.132522581021958 - 0.049164927400453i	0.132522581021958 + 0.049164927400453i
EIGENVALUE	4.296246856877315	0.000033869399334	-0.148140363138324 + 1.118322071399122i	-0.148140363138324 - 1.118322071399122i

Table 1.8: WEIGHTING OF ALTERNATIVE

EIGEN VECTORS FOR ALTERNATIVES CRITERIA (CLIENTS SATISFACTION)				
	Conc. Engineering	**Programme Managt.**	**Design & Build**	**Traditional Method**
COST	3.763565649699764	0.238218468757986	-0.001832804486538	0.000048686028791
TIME	3.435526529744007	0.564480542955276	-0.000000000000001	-0.000007072699281
QUALITY	-0.000000000000001	-0.000007072699281	-0.000000000000001	-0.000007072699281
CLIENT SATISFACTION	4.296246856877315	0.000033869399334	-0.148140363138324 + 1.118322071399122i	-0.148140363138324 - 1.118322071399122i

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LEVEL OF COMPLIANCE OF CORE CONSTRUCTION PROFESSIONALS TO ETHICAL STANDARDS IN NIGERIA

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Abstract
The study assessed the level of compliance of construction professionals to ethical practices in the Nigerian construction industry. The study area was Lagos State and the target respondents were the registered professionals including architects, quantity surveyors, builders and engineers. A total of one hundred and seventy (170) questionnaire were randomly administered on the professionals and one hundred and thirty eight (138) were retrieved representing 81.18% response rate. Findings revealed that professionals displayed high level of compliance to clients service delivery with Mean Item Score (MIS) ranged 3.22 to 3.79, educational and professional qualification MIS ranged 3.18 to 3.71 and standards of practice MIS ranged 3.16 to 3.63. The overall rating revealed that professionals have highest level of compliance to standards of practice with 54.76%, while the least ranked ethical standards was fair compensation with 49.31%. ANOVA test established a statistical significant difference among the professionals view about compliance of the professionals to clients service delivery (F value=2.447, P value=0.020) and professional development (F value=3.774, P value = 0.001). The overall level of compliance of construction professionals to ethical standards was 52.37%. The study concluded that professionals have average level of compliance to the ethical standards. The study therefore recommended that professionals should continue to uphold good ethical conducts, for better project performance and delivery in the Nigerian construction industry.

Keywords: Compliance, Core, Construction Industry, Ethics, Professionals, Standards

INTRODUCTION

The nature of construction industry is complex and dynamic. Besides, the industry is fragmented and thereby requires the involvement of various professionals and specialists that work together to achieve a common goal (Gray 2000); Gido, Kerzner and Meredith (2003).

Construction activities involves conceptualizing, designing, managing, organizing and coordinating project requirements including time, money resources, technology and methods. All these must be integrated in the most efficient manner possible to complete construction projects on schedule, within estimated budget, in accordance to the required quality and performance expected by the client as established by Nadeem, Sohail and Muhammed (2009).

The industry's primary goal therefore focuses mainly on achieving value for the money the clients has paid for. This is achieved through good service delivery which centres on ethical standards displayed by the professionals' participants. Construction industry has the sole responsibility of providing physical development through the provision of infrastructures, manpower development, resource employment, fixed capital formation and improvement of the gross domestic product (Omole, 2000; Hillebrandt, 2000). In the light of this, it is therefore expected that construction professionals should discharge their duties with utmost compliance to professional ethics and standards. This professional ethics is the justification of standards of behaviour against practical tasks, which is not necessarily limited to technologies, transactions, activities, pursuits and assessment of institutions. It rather involves practical conceptualization of public expectations in the interest of responsibilities, willingness to serve public interest with high competencies (Chalkley, 1990, Fan et al., 2003; Poon, 2003; Poon, 2004a, 2004b). The strength of the link between the construction industry and the public therefore sustains its existence through overwhelming recourse to demand for the services of its practitioners and unique products such that the relationship is a function of the pride of professionalism.

However, the most important threat to the harmonious relationship between the public and the construction industry is the cultural misalignment between public expectations and the professional conducts of construction practitioners (Pollington, 1999). This has brought various criticisms and wrong perception of the public about the professionalism of construction professionals in relation to professional ethics. Based on this fact, it is quite evident that the industry needs to be dynamic and re-appraise the ethical ideology and perception of her professionals so that services provided by the industry can be improved. (Lam et al., 2001; Doree, 2004).

In response to this, the study therefore appraised the level of compliance of construction professionals (focusing on some selected professionals that are engaged throughout the life cycle of any project) to ethical standards in the nation's quest for modality for combating the endemic and intractable monster of corruption.

THE THEORY AND PRACTICE OF ETHICS IN BUSINESSES ENVIRONMENT

Generally, business ethics involves two tasks. The normative task of defining standards of behaviour and the practical task of applying these standards to business conduct. This is interpreted to be the normative vs the positive approach. The normative approach is concerned with developing models of expected behaviour and seeking out example in the real world that validate the model, that is what ought to be done and what is actually done. The positive approach is about describing real world practice whereby prescriptions of the ideal are suspended until the characteristics of real world behaviour are ultimately understood. Normative and positive ethics can in some ways be considered in relation to the theory and practices of ethics and how they are combined (De - George, 1990). The normative definition of professional ethics is tied up with practical concepts and expectations from the public, such as competence and responsibility.

Allen and Davis (1993) established that combination of professional values and real life practice are not easy to combine in real life practice. It is therefore, important for business consultants to be familiar with the field within which they operate if they are to determine whether an action in ethical choices made by consultants is influenced by their values and ideas. Actions may or not coincide with professional norms. However, economic and political considerations may override commitment to ethical values and responsible behaviour, particularly in those situations where individual is placed under pressure, or exposed to a set of opportunistic circumstances. Yang (2000) supported and acknowledged the conflict between theory and practice and explained that consultants who maintain high personal and professional values in theory disintegrate in practice through actual ethical dilemmas.

PREVIOUS STUDIES ON PROFESSIONAL ETHICS

Professional ethics are embodies in codes of practice which define the roles and responsibilities of professionals that are expected to be the upholders of these virtues otherwise known professional ethics {Harris et al., (1995); Calhoun and Wolitzer, (2001)}. Codes of practice addresses client service delivery, qualification, standards of practice among others, among construction professionals Terrenzio (2004). Professionals must therefore adhere strictly to these standards when discharging their duties. There have been several criticisms about construction professionals concerning adherence to ethical standards. Integrity of construction professionals have been questioned with many empirical studies that emphasised practices such as illegal agreements between tenderers that result in seemingly competitive bids, price fixing, or market distribution schemes that circumvent the spirit of free competition and defraud clients, bid-cutting, bid-shopping, cover pricing, hidden fees and commissions and compensation for unsuccessful tenderers after consultation with other tenderers as established by (Ray et al, (1999), Zarkada-Fraser and Skitmore, (2000), Zarkada-Fraser (2000) May et al., (2001)

Shankatu (2003) studied corruption in the construction industry; forms susceptibility and possible solutions, the study noted that uniqueness of many projects made costs difficult to compare. The study revealed the prevalence of uncovered unethical practices such as bad workmanship, which may not be easily detected. Vee and Skitmore (2003) examined professional ethics in the construction industry; findings revealed that various unethical issues surrounding construction activities as unethical conduct include unfair conduct, negligence, conflict of interest, collusive tendering, fraud, bribery and violation of environmental ethics among others. The study concluded that all participants, regardless of professional allegiance, require a common understanding of ethical and professional values to move the construction industry forward.

Competence of professionals was assessed in the South African construction industry by Nkado (2000) and Poon (2004a).

The study found out that the industry's performance cannot only be measured with respects to meeting clients demands through the dynamism of technical competencies and innovative skills only, but by the behavioural pattern of professionals to protect client's interest and sustain public industry harmony. This shows that the attitude, behaviour and integrity by which professionals' handles matters are quite observed by the public. In the South African construction industry, Pearl, Bowen and Makanjee (2005) examined professional ethics in the South African construction industry. The study observed that several unethical conduct and ethical dilemmas in the construction industry such as corruption, negligence, bribery, conflict of interest, cover pricing, front loading among others were rampant. The study established significant areas of concern pertaining to the practice of ethical conduct among construction professionals. The research further established that 79% of construction professionals were being involved in unethical behaviour, which is on increasing trend with adequate means of curbing the practices yet unavailable. Hamzah, Saipo, Mohd, Mohammed and Yap (2007) examined professional ethics as it affects construction quality by investigating the relationship between professional ethics and construction quality in Malaysian construction industry. The study found out that unethical practices among professionals have direct negative consequences on the output of the construction industry. Despite the importance of ethical standards on image of the construction industry and practice of professionals in the industry, it appears little attention had been paid to examine the level of compliance of professionals to ethical standards in the Nigerian construction industry. Thus this research intends to fill this gap.

METHODOLOGY

This paper is part of M.sc thesis aimed at appraising professional ethics in the Nigerian construction industry carried out in Obafemi Awolowo University, Ile- Ife. The study was conducted in Lagos State on the premise that 75% of construction firms in Nigeria are either based in Lagos States or have their branches located in Lagos (Fagbemi 2008.) Data for the study were collected through one hundred and seventy questionnaire (170) copies of questionnaire administered on the professionals in the Nigerian construction industry comprising architects, builders, quantity surveyors and engineers in this area.

The choice of these core professionals as the target population was that in the construction industry, these professionals' works throughout the various stages of construction work and is involved in the procurement of building projects as established by Ameh and Odusami (2009).

Section A of the questionnaire consisted of the demographical information of the respondents, while section B focused on the study objectives. Fifteen (15) major ethical practices were identified from literature and the professionals were asked to rank the level of compliance of professional to these ethical standards identified. Respondents were asked to rank themselves and also rank their co-professionals on the degree of compliance of professionals to different ethical practices on a 5-point likert scale where 5=very high, 4=High, 3= Moderate, 2=Low and 1=very low. The overall level of compliance by professionals was rated from 0-10% - 91-100% where 0 is the lowest and 100 is the highest. A total of hundred and thirty eight (138) questionnaire were retrieved which represents 81.18% response rate of the total 170 copies administered. Data collected were analysed using Descriptive and inferential statistics including percentages, Mean Item Score (MIS) and Analysis of Variance (ANOVA). The results of the analysis are presented in tables below.

Mean Item Score (MIS) was calculated from the formula given below:

$$\text{Mean} = \frac{5_{n5} + 4_{n4} + 3_{n3} + 2_{n2} + 1_{n1}}{(n_5 + n_4 + n_3 + n_2 + n_1} \text{ ……………………Equation 1.0}$$

Where:

n5= number of respondents who picked 5

n4= number of respondents who picked 4

n3 =number of respondents who picked 3

n2 = number of respondents who picked 2

n1 = number of respondents who picked 1

RESULTS AND DISCUSSION

Table 1 shows the type of organisation of the respondents. The result revealed 24.27% were represented by respondents from the contracting firms, while 33.33% of the respondents were from consulting firms and 34.78% were in the government organisations.

This formed a good representation of respondents, as their various wealth of experience will provide a reliable data for this study.

Table 1: Types of organisation

Type of Organization	Frequency	Percentage (%)
Contracting	35	24.27
Consulting	46	33.33
Government	48	34.78
No response	9	6.52
Total	138	100

Table 2 shows the year of establishments of firms, the average years of establishments of these firms is approximately 18.5 years. The result showed that these professionals were experienced in construction activities, and their responses could be relied upon.

Table 2: Year of Establishment of Firms

Years of Firms	Frequency	Mid-Point	Fx	Percentage (%)
0-10 years	28	5	140	20.28
11-20 years	37	14.5	536.5	26.81
21-30 years	29	24.5	710.5	21.01
31-40 years	5	34.5	172.5	3.62
40 -49 years	18	44.5	801	13.04
Above 50	4	50	200	2.89
No response	17	-	-	12.31
Total	138		2560.5	100

Mean=18.5 years

Table 3 presented the profession of the respondents. The result shows that 29.70% of the respondents were Architects, 18.10% were Builders, and 23.91% were Quantity Surveyors while only 28.26% were engineers. Responses from these different categories of professionals will assist this research work to evaluate different perspective of the professionals as regards ethical standards.

Table 3: Profession of the Respondents

Professional	Frequency	Percentage (%)
Architect	41	29.70
Builder	25	18.10
Quantity Surveyor	33	23.91
Engineer	39	28.26
No response	4	2.89
Total	138	100

Table 4 shows that the highest academic qualification of the respondents. The results indicated that 48.50% were B.Sc/ B.Tech holders, 7.24% were M.Sc holders, 2.89% were Ph.D holders. Only 8.69% were PGD holders while 28.97% of the respondents had academic qualification not less than HND. This results shows that 58.63% of the respondents had the minimum qualification of B.Sc/B.Tech. This indicated that the respondents had the required academic qualification that could assist to provide a meaningful data from which inferences could be drawn for the study.

Table 4: Highest Academic Qualification of the Respondents

Professional Qualification	Frequency	Percentage (%)
OND	8	5.79
HND	32	23.18
B.Sc./B.Tech.	67	48.55
M.Sc.	10	7.24
Ph.D	4	2.89
PGD	12	8.69
No response	5	3.62
Total	138	100.0

Table 5 shows that 86.16% of the respondents belong to various professional bodies in construction industry while only 13.76% of the respondents were not professionally qualified. This shows the ability of these professionals to provide and supply reliable information for the study.

Table 5: Professional Qualification of Respondents

Professional Qualification	Frequency	Percentage (%)
Nigerian Institute of Architects (NIA)	37	26.80
Nigerian Institute of Builders (NIOB)	22	15.90
Nigerian Institute of Quantity Surveyors (NIQS)	29	21.0
Nigerian Society of Engineers (NSE)	31	22.46
No response	19	13.76
Total	138	100

Table 6 shows the number of years of working experience of respondent. The results indicated that the respondents have the mean of 20.9 years working experience which would have exposed them to various experiences and ethical issues in construction projects. This implied that the respondents have adequate professional experience to supply adequate and meaningful information for this study.

Table 6: Respondents' Work Experience

Years	Frequency	Mid-Point	Fx	%
0-10 years	**39**	**5.5**	**214.5**	**28.26**
11-20 years	**32**	**15.5**	**496**	**23.18**
21-30 years	**28**	**25.5**	**714**	**20.28**
31-40 years	**21**	**35.5**	**745.5**	**15.21**
>40 years and above	**18**	**40**	**720**	**13.04**
No response	**5**	**0**	**0**	**3.62**
Total	**138**	**122**	**2,890**	**100**

Mean=20.9

Table 7 presented the nature of projects the respondents have undertaken during the course of their professional practice. The results indicated that 93.46% of the respondents have undertaken projects ranging from residential and commercial to engineering. This shows that the professionals must have accumulated wealth of experience based on their exposure to various practical ethical issues in the project, which would have come up in the management and administration of these projects. The response from the professionals could also be relied upon to achieve the objectives of this study based on the result.

Table 7: Nature of Projects Executed by Respondents between 2001-2010

Nature of Projects	Frequency	Percentage (%)
Residential	**46**	**33.33**
Commercial	**35**	**25.36**
Educational	**9**	**6.52**
Engineering	**25**	**18.11**
Service installation (mechanical & electrical)	**14**	**10.14**
No response	**9**	**6.52**
Total	**138**	**100.0**

Table 8 shows the mean item score (MIS) for the level of compliance of ethical practices as perceived and ranked by each professionals. From the result of the analysis, generally all the fifteen (15) ethical practices identified by the study were highly ranked with MIS ranged 3.79 ≤ 2.93 which showed ranking above average. Three ethical standards were ranked 1st, 2nd, & 3rd by the professionals. These are client's service delivery, educational training and professional qualification and standards of practice respectively indicating client service delivery as the most significant ethical standard. The MIS ranking shows the following values, Architects (MIS= 3.79, Rank=1st), Builders (MIS=3.38, Rank=1st), Quantity surveyors (MIS=3.29, Rank=1st) and Engineers (Mean=3.22, Rank=1st).

Architect prepares both the sketch and final drawings and also have the general knowledge of planning, designing and oversight of a building's construction. Simson and Atkins (2006) established that architect must have standard of care and should be responsible to the client by discovering and reporting works that are not in conformity to clients' taste. It is crystal clear that client service delivery is paramount in all professions. In most construction projects architects are usually the client's representatives that protect the clients' interest. Builders also ranked this ethical practice 1st which shows they are also in agreement that client service delivery is very important for construction professionals. In most cases builders are the contractors that execute construction projects. They are therefore liable and responsible to the clients directly. In all the stages of the contracts ranging from award, procurement of materials, site operations and unto completion, they should therefore ensure that clients achieve value for the work paid for. The quantity surveyors were also in agreement to client service delivery as the first ethical standard that construction professionals should consider when performing their professional obligations. Quantity surveyors in some cases can also be contractors or consultant quantity surveyor, either working for an organization or for the contractor. Whichever the case, they are saddled with the responsibilities of preparing the cost estimate of any proposed project, preparation of interim valuation and physical measurement of works among others to enable payment to the contractor among others. They are to monitor the clients' resources to ensure services are delivered with the best standards and at minimum cost which is the major service delivered by Quantity surveyors.

The engineers ranking also supported other professionals ranking on client service delivery as one of the ethical standards the professionals must comply with. Engineers are at the helm of providing the structural design details of the projects and as such hold the duty of care to the client or whosoever appoints them. Jackson and Powell (1992) established that an engineer is a person in the engineering construction contract performing the same function as an architect under the traditional construction contract. The nature of their profession makes them to have direct effect on the lives of people, and must therefore as professionals owe special moral responsibility John (1991). Due to their knowledge and importance in society, they should have standard of conducts to attend to all issues as regards the construction activities and also to answer ethical questions as established by Belis and Impe (2001).

This shows that as much as engineer stays in same role with the architects as a member of design team, they must be versatile, experienced, dynamic and well trained to be suitable for the diverse roles expected in the construction activities and also adapt to the changing environment to overall deliver client service delivery. The results indicated that majority of the professionals have high level of compliance to this ethical practice and this shows the need for professionals in the construction industry to discharge their duties in a way to always satisfy and protects the client's interest. This is contrary to the work of Yakub (2005), Masidah and Khairudeen (2005) which affirmed that professional services and opinions are under chronic criticism as they are mostly unnecessary and unsatisfactory.

The 2nd highly ranked ethical practice was educational and professional qualification. The MIS values are as follows: Architects (MIS=3.71, Rank=2nd), Builders (MIS = 3.26, Rank= 2nd), Quantity Surveyors (MIS = 3.24, Rank = 2nd) and Engineers (MIS = 3.18, Rank = 2nd). The MIS values of the four professionals ranged 3.71≤3.18. This shows a correlation in the ranking and a level of agreement in the professionals' opinion with respect to as educational and professional qualification as one of the ethical standards the professionals must put into consideration. Architects ranked this with highest MIS value (3.71), while other professionals' rankings fall between 3.26 ≤ 3.18. This shows that Architects believe that educational training & professional qualification is a cogent criterion for professionals to dutifully discharge their professional duties. This result is expected, majorly in most of the construction sites, Architects are majorly the client representative or the site manager (lay men even refer to them as "site engineer"). Educational training is therefore needed to relate with other professionals and to communicate well with the semi-skilled artisans as they might not understand the technical terms used on site. Generally, apart from the academic and professional training acquired while in school, some core values such as human relations are taught in tertiary institutions which are equally important in all fields of learning to successfully relate with people of diverse family and cultural background and to perform the expected roles by each professional.

The rankings by the Builders, Quantity Surveyors and Engineers indicated were similar which shows their perceptions about educational training and professional qualifications as ethical standards are correlated. Their rankings also supported the imperativeness of professionals to be academically and professionally qualified in their respective fields.

Moreover, educational training and professional qualification is of great importance, because this is where professionals gain academic training, technical competence and skills about a particular profession. It is therefore important for professionals to have sound educational background to be able to cope with the projects challenges. This finding conforms to Chan and Chan (2002) that; professionals need to be placed in appropriate educational framework to ensure their continuous relevance. Professionals should only accept to offer services for which they are qualified by education, training and professional experience.

The third most ranked ethical practices by the professionals is standard of service. This ethical standard was ranked 3rd by two professionals, that is Architects (MIS = 3.63, Ranking = 3rd) and Engineers (MIS = 3.16, Ranking =3rd). The rankings showed agreement between architects and engineers on standards of practice as the 3rd important ethical standards for professionals in discharging their duties. This correlation is not farfetched as their roles are interchangeable as earlier established. Therefore a level of agreement is expected in their responses, this established the fact that they have the same perception on the subject matter. Also, builders and quantity surveyors ranked standards of practice as the 4th ethical standards with MIS = 3.19 and 3.17 respectively, the closeness in their mean ranking could be interpreted that they share the same view on this ethical standard.

The Builders (as in most cases) the contractors believed that confidentiality was more important than standards of practice as it was ranked 3rd (MIS = 3.20). On the contrary, quantity surveyors ranked integrity as the 3rd (MIS =3.18) important ethical standards. Contractors' perspective on confidentiality is expected to be high as they are involved in several monetary issues which is the backbone of ethical issues in the construction industry. Money is a strong sager in construction industry and centres so much on the contractors, ranging from the pre contract stages to post contract period. They wish to win contract at all cost and also maximise profit as much as possible. In the quest to win at all cost, some might engage in bid shopping from careless consultants so as to have an idea of the tender figures of other contractors. They also engage in front and back loading of items both rates and quantities in the bills of quantities among others. All these acts are unethical standards with respect to confidentiality of information.

The position of information confidentiality have been established by Vee and Skitmore (2003) that unless otherwise stated should a professional release public statements that are truthful and objective, information and records that are confidential should be kept when appropriate. Improper information flow, internally and externally within a practice should be discouraged.

Therefore confidentiality ranked 3rd by the Builders or contractors cannot be compared with other professionals ranking because contractors are not mostly a professionals in quote. Architects ranked 5th; Quantity Surveyors ranked 6th while Engineers ranked it 9th, the view and perception of different professionals on each ethical standards are indicated and revealed in their respective rankings. Quantity Surveyors ranked integrity as the 3rd (MIS=3.39) most significant ethical standard in the construction industry. Architects ranked it 4th, while Builders ranked 5th, and Engineers ranked it 6th. Quantity surveyors deals basically with financial management of the contracts and this is the area where the integrity of most professionals are put into the mud especially if there is a conflict between personal and professional values. The moral standing and upbringing of each individual professional appears on how they protect their own integrity in dealing with clients rather than being mindful of their personal gain. In the case of safety as an ethical standard, Architect ranked it 8th (MIS=3.31), Builders ranked 10th (MIS = 3.07), Quantity surveyors ranked 11th (MIS=3.04) while engineers ranked 5th (MIS=3.04). The 5th ranking of safety by engineers shows they see safety both on human resources and equipment as core due to the technicalities involved in construction projects. This even manifested in the safety precautionary measures usually taken on construction sites to safeguard dangers and accidents such as wearing of helmet, restricting unnecessary visitation to site, employing safety/heath personnel among others. Little lapses could lead to great human and financial losses that might not be regained easily, and this will not be cost effective for the client. This is also manifested in engineers ranking of cost effective as 4th (MIS= 3.06) most significant ethical standard. Architect ranked 11th (MIS = 3.27), Builders ranked 8th (MIS= 3.14) and quantity surveyors ranked 7th (MIS=3.12).

Table 8 showed, the overall rating of professionals regarding ethical standards. Standards of practice (MIS=2.73) was ranked 1st, educational & professional qualification and clients service delivery (MIS=2.71) were both ranked 2nd, while clients service delivery & professional development were both ranked 4th.

The least ranked was fair compensation (MIS=2.46), which indicated that these ethical standards are important for professionals in their professional services.

The overall ranking by all the professionals also strengthens the importance of these ethical standards for professionals to discharge their duties with greatest professionalism and integrity. Quality services are expected by the clients for all the services paid for. The professionals should therefore note that good value for money is of utmost importance. Furthermore, clients create the market for the construction industry, and so should be placed at the centre of the construction process as established by (Latham (1994); Langford and Male (2001). Professionals should clearly define project performance in the services they render which is the achievement of fitness-for-purpose in construction and the absolute realization of the client's satisfaction of his requirements as established by Male and Mitrovic (2005). In addition to this, the findings also corroborated Cardammone (2011) that established that professionals are linked with notion of services they provide, professionals should therefore focus more on their personal professional development so as to provide services that are of high quality for all that needed their services.

Table 8: Level of Compliance of Professionals to Ethical Standards

Ethical Standards	**Arc.**		**Bldr. (Cont)**		**QS**		**Engr.**		**All Professionals**	
	Mn.	Rk	Mn.	Rk.	Mn.	Rk	Mn.	Rk	Mn.	Rk.
Standards of practice	3.63	3	3.19	4	3.17	4	3.16	3	2.73	1
Education& Professional Qualification	3.71	2	3.26	2	3.24	2	3.18	2	2.71	2
Safety	3.31	8	3.07	10	3.04	11	3.04	5	2.71	2
Clients' Service Delivery	3.79	1	3.38	1	3.29	1	3.22	1	2.68	4
Professional Development	3.36	5	3.16	6	3.15	5	3.03	6	2.68	4
Integrity	3.39	4	3.17	5	3.18	3	3.03	6	2.64	6
Sustainability	3.25	12	3.06	11	3.00	13	3.03	6	2.63	7
Confidentiality	3.36	5	3.20	3	3.14	6	2.97	9	2.62	8
Environmental Friendliness	3.30	9	3.03	13	3.02	12	3.03	6	2.60	9
Cost Effectiveness	3.27	11	3.14	8	3.12	7	3.06	4	2.58	10
Fair Competition	3.35	7	3.09	9	3.10	8	3.03	6	2.58	10
Maintenance Culture	3.25	12	3.03	13	3.01	9	3.00	8	2.56	12
Public Welfare	3.24	14	3.05	12	2.98	14	3.02	7	2.54	13
Conflict of Interest	3.29	10	3.16	6	3.01	9	2.98	10	2.50	14
Fair Compensation	3.23	15	3.03	13	2.96	15	2.93	11	2.46	15

Source: Authors Survey 2012

Legend: Rk: Ranking; Mn: Mean; Arc: Architects; Bldr: Builder; Cont: Contractor; QS: Quantity Surveyors; Engr: Engineer

Table 9: ANOVA Test of Level of Significance of Ethical Standards

Ethical Standards	ANOVA		Overall Rating of Professionals
	F – Value	P- Value	%
Standards of practice	0.431	0.882	54.76
Educational& professional qualification	1.824	0.084	54.33
Safety	1.193	0.307	54.03
Clients' service delivery	2.447	0.020*	53.73
Professional development	3.774	0.001*	53.61
Integrity	2.146	0.400	52.83
Sustainability	1.475	0.177	52.79
Confidentiality	1.707	0.108	52.45
Environmental friendliness	1.422	0.197	52.10
Cost effectiveness	1.184	0.313	51.72
Fair competition	1.686	0.113	51.63
Maintenance culture	0.351	0.929	51.29
Public welfare	0.779	0.630	50.94
Conflict of interest	1.024	0.415	50.04
Fair compensation	1.561	0.148	49.31

Source: Authors Survey 2012

Significant at P≤0.05

$$\textbf{Mean} = \frac{54.76 + 54.33 + 54.03 + 53.73 + 53.61 + 52.83 + 52.79 + 52.45 + 52.10 + 51.72 + 51.63 + 51.29 + 50.94 + 50.04 + 49.31}{15}$$

$$\text{Mean of level of compliance} = \frac{785.56}{15} = \mathbf{52.37\%}$$

ANOVA Test: Research Hypothesis

In order to determine the professionals perception of the level of compliance to ethical standards identified in this study, two hypotheses were drawn below;

H0: There is no statistically significant difference in professionals' perception of the level of all professionals' compliance to ethical practices

H1: There is statistically significant difference in professionals' perception of the level of all professionals' compliance to ethical practices

The hypothesis was tested using ANOVA. The results showed that, only two (2) out of all the fifteen (15) ethical standards were significant.

This indicated that a different opinion on the two ethical standards (P value < 0.05), that is clients service delivery (F value=2.447, P value=0.020) and professional development (F value=3.774, P value = 0.001). This implies that the null hypothesis could not be accepted, and established a statistically significant difference between all the professionals view about compliance of all the professionals to these two ethical standards. It means all the professionals were of the opinion that the entire professionals have different views and perception to compliance. While some professionals believe that some ethical practices were significant, other professionals are of the opinion that other elements are more important and significant than others.

Also from Table 8, the result also showed the overall general rating of all professionals, as rated by the professionals themselves in percentages (0% - 100%). The percentage rating of respondents ranged from 49.30% ≤54.70%, which indicated that professionals ranked themselves on average. It can therefore be concluded that the professionals have average of 52.37% level of compliance to all ethical standards identified by the study. From this result, there is an indication that professionals in the industries know the importance of conformity with ethical standards. The construction industry in Nigeria is gradually coming up to change the perception of the public against the notion that the construction industry is the most corrupt industry due to high frequency of construction failures that have challenged the integrity of the professionals in the building sector as affirmed by Nduese (2010). Improving compliance to the ethical standard of the industry would not only come from individual professional and the industry, but would also require some inputs from governments as opined by John (2006) that governments have responsibility in ethical matters relating to the construction industry.

CONCLUSION

The research objective was to confirm statistically that CE is the most advantageous method to apply to construction in order to better achieve project success criteria. This work was motivated by the fact that the emergence of CE as the method of choice for effective integration and coordination into construction was based mainly on empirical data that were derived from the implementation of CE within the manufacturing environment.

The approach adopted the use the project success criteria of Cost, Time, Quality and Client's satisfaction as the primary criteria in an Analytical Hierarchical process and computed the Eigen-values of the alternative construction delivery method and ranked them. The AHP model was thus used to statistically select the best option out of the four principal construction delivery methods; the Traditional method, the Design and Build method, the Programme management method and the Concurrent engineering method as the alternatives. The results clearly determined statistically that concurrent engineering is the project delivery method which offers the most scope for effective co-ordination and integration into the industry with an eigenvector of 0.6910 and has advantages over other delivery methods.

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ASSESSMENT OF KNOWLEDGE MANAGEMENT AMONG CONSTRUCTION PROFESSIONALS IN NIGERIA

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Abstract

Knowledge management is a developing area in the construction industry that can contribute immensely to the success of any organisation. This research work therefore examined the areas of the construction industry that will improve as a result of the contributions of knowledge management. Data for the analysis were collected through questionnaires administered on construction professionals using convenient sampling method. The data were analyzed using percentiles and mean item score. The study revealed that the knowledge management adoption is being hindered the most in Nigeria by funding as there is no adequate fund to carry it out in construction organizations. Assessment of the level of sharing knowledge among construction professionals showed that Architects ranked first in sharing knowledge with other construction professionals while top managers, Quantity surveyors, Estate Surveyors, and Civil Engineers followed respectively. In conclusion, it was observed that colleague's experience was ranked first among the sources of knowledge available to construction professionals in Nigeria as most construction professionals in Nigeria don't read much and are not exposed to other methods of acquiring knowledge within the organisation, and fund is the highest ranked problem hindering the adoption of knowledge management among Construction Professionals. It was then recommended that Civil Engineers, Builders, Middle managers, Lower managers and Technicians should improve in the level at which they transfer and share knowledge with other construction professionals and that the Federal Government of Nigeria should inject more fund to the construction industry of the country as this is a very productive sector of the economy.

Keywords: Construction Industry; Construction Professionals; Knowledge management; Nigeria.

INTRODUCTION

According to Botha (2004), knowledge management (KM) is a process of systematic management of vital knowledge and its associated process of creating, gathering, organising, diffusion, use and exploitation. It requires turning personal knowledge into corporate knowledge that can be widely shared throughout the organisation. All organisations are awash with information and knowledge. The problem is that it is invisible and most people in organisations simply don't know what their colleagues know. The organisations don't know what their employees know, nor do they have any way to find out or organise it. They typically have fewer grips on the knowledge available outside – owned by competitors, suppliers, universities and the government.

Knowledge management is about getting the right knowledge to the right people at the right time. Knowledge management according to Blumentritt and Johnson (1999) is about sharing and acquiring knowledge in ways that can be translated into improved organizational performance. The intellectual capital of individuals and teams are presented in a tangible form that facilitates the adding of value to the organization and ultimately its customers (Ravishankar, Pan and Leidner, 2011). This process of added value is achieved through continuous recycling and creative use of shared knowledge and experience. This is followed by the structuring of shared competencies with the help of technology, process maps and descriptions, manuals, networks and so on, to ensure that competence remains in the organization even when staff leaves. The knowledge, once packaged, becomes part of the capital of the organization. This creates an environment for the rapid sharing of knowledge as well as sustained and collective knowledge growth. Lead times between learning and knowledge sharing are shortened and human capital becomes more productive through intelligent work processes. Knowledge management is about acquiring, structuring, and transmitting intellectual material for the benefit of the organization. One of the major misconceptions of knowledge management is that it is about information technology (Laudon and Laudon, 1998). Knowledge management application among construction professionals in developing economy is still an under chartered territory hence its role and application cannot be over emphasized.

Paul and Alain (2011) believed that the role of knowledge management is to identify what information and knowledge is important to the organisation, finding out where it is held, and mobilising it so that staff can apply it in their work.

However, it is now being recognised that the management of project knowledge (especially within the construction industry where projects are implemented by temporary 'virtual' organisations) is open to considerable improvement, both within construction organisations, and between firms in the supply chain (Gold, Malhotra and Segars, 2001). The emphasis on Knowledge Management according to Kamara, Anumba and Carrillo (2000) reflects the growing realisation that it is a core business concern, particularly in the context of the emerging knowledge economy, where the know-how of a company is becoming more important than the traditional sources of economic power (capital, land, etc.)

Given the relative importance of the construction sector to the Nigerian economy, this seems to present a fruitful area for investigation. KM has become an increasingly important issue due to rapid changes in market conditions, competition and technological developments, which have led to changes in the way work is organized. KM is considered vital for the survival of organizations. It is asserted that knowledge is fast overtaking capital and labour as the key economic resource in advanced economies (Edvinsson, 2000). Within the construction industry, it is increasingly being acknowledged that KM can bring about the much needed innovation and improved business performance the industry requires. The aim of this study is to examine the ways by which knowledge is being transferred among construction professionals and impact on project delivery.

CONSTRUCTION PROFESSIONALS IN NIGERIA

The construction industry is made up of both the formal sector and informal sector, with the formal sector consisting of organized companies. Due to the multi-disciplinary nature of the industry the formal sector consist of the Architects, the Quantity Surveyors, the Estate Surveyors, the Civil Engineers and the Builders. All these professionals join forces together to promote the construction industry. The informal sector consist of trades and artisans; but for this purpose, knowledge is acquired transferred and managed within the industry with the construction professionals responsible for these.

The construction of a project of any kind be it building, civil or heavy engineering works involves the services of many people directly and indirectly (Fadamiro and Ogunsemi, 1996). These are people responsible for the overall design, construction and maintenance of a construction project from inception to completion. They are even involved in the sales and/or letting of the property on practical completion. Hence they carry the course of construction industry's workload and most of the construction project managers available today are construction professionals that have construction knowledge as background. However it is necessary to have a thorough knowledge of the professionals in the industry and the interrelationship that exist between them.

Bamisile (2003) affirms from observation that, there seems to be confusion and misinterpretation of the roles of these professionals within the construction industry in developing countries in general and in Nigeria in particular due to many factors. One of which is lack of proper working knowledge on the part of majority of people as to the roles of each professionals in the industry. He stressed further that the construction industry is unique when compared with other industries in terms of design and manufacturing of its product in which case the design phase is separated from the construction phase (except for some modern procurement method). While Architect and some sections of the engineering profession (civil engineers) carry out the design of the buildings, the cost control and the construction is the role of the Quantity Surveyors and builders respectively. The Estate Surveyors on the completion of the project is responsible for its marketing through outright sales, leasing or letting as appropriate.

Knowledge Management and the Construction Industry

Knowledge management has become an increasingly important issue due to rapid changes in markets conditions, competition and technological developments which have led to changes in work and the way work is organized. Knowledge management is considered vital for the survival of organization. It is asserted that knowledge is fast overtaking capital and labour as the key economic resource in advanced economies (Edvinsson, 2000). Knowledge management is particularly important for the construction industry, for at least three main reasons.

Firstly, the construction industry is widely perceived as an industry with low productivity and poor performance despite its importance in the national economy. Hence, there is a need for KM to improve the existing processes and management of construction companies (Preece, Moodley and Hyde, 2000). Secondly, the project-based nature of the industry has made it particularly important to record and transfer lessons from one project to another (Rezgui, 2001). Thirdly, construction companies today face various challenges and new solutions are necessary to meet the growing demand for new types of buildings and structures (Mior, and Abdul-Rashid, 2001).

It is widely accepted that the current market dynamics and the trends towards specialized and customer-oriented services in the construction industry demand a more efficient and effective application of knowledge within corporate as well as project organizations (Egbu, Sturgesand and Bates, 1999; Snyman, and Kruger, 2004; Moodley, Preece, and Kyprianou, 2001)). A number of researchers have acknowledged the limitations of current approaches to managing information and knowledge relating to and arising from a construction project (Preece, et al 2000; Mior, and Abdul-Rashid, 2001; Egbu et al., 1999; Snyman, and Kruger, 2004; Rezgui, 2001). Preece, et al (2000) states that the lessons learnt in SA construction projects are not organized well and are buried in details. This makes it difficult to compile and disseminate useful knowledge to other projects. The fragmentation of the construction industry has also been identified as a critical barrier to achieving efficient communication among parties (and individuals) within a project team working together on construction projects (Mior, and Abdul-Rashid, 2001; Egbu et al., 1999; Latham, 1994; Rezgui, 2001).

Reviewing the literature on knowledge management in construction reveals that knowledge can be captured, created, stored, used, protected and essentially managed, not unlike any other economic commodities (Geoff and Bart, 1994). Thus it can be put together as bits, bytes, and packages for ease of transfer through the use if ICT (Andawei, 2001). The initiative, explicit and factual nature of knowledge makes it amenable to ICT manipulation. However upon closer inspection it is not clear in what sense knowledge is different from information. Information represents data arranged in a meaningful pattern; where intellectual input has been added to raw data, data in turn represents raw numbers, images words and sounds which are derived from observation or measurements.

Although information is required for the creation of knowledge but knowledge makes information meaningful and guides to what data to be collected, thus the dynamic nature of knowledge (Kazi, Hannus and Charoenngam, 1999)

Role of ICT in Knowledge Management

Lei Chi and Goce (2010) observed that Information Technology (IT) has long been recognized as critical for successful knowledge management. This is probably a legacy of the growth in knowledge based systems (KBS) in the 80s and early 90s, and has led to much of the early work on knowledge management focusing on the delivery of technological solutions. While it is now recognized that good knowledge management does not result from the implementation of information systems, the role of IT as a key enabler remains undiminished (Egbu, Botterill and Bates, 2001). Laudon and Laudon (1998) classify information systems for knowledge management into four main categories:

- Those for creating knowledge (knowledge work systems): these support the activities of highly skilled knowledge workers and professionals as they create new knowledge and try to integrate it into firms;
- Those for distributing knowledge (office automation systems): these help disseminate and co-ordinate the flow of information in an organization;
- Those for sharing knowledge (group collaboration systems): these support the creation and sharing of knowledge among people working in groups; and
- Those for capturing and codifying knowledge (artificial intelligence system): these provide organizations and managers with codified knowledge that can be reused by others in the organization.

Barriers to Knowledge Management in the Construction Industry

The typical construction organization does not encourage the culture of sharing knowledge. Wates Group, a medium sized UK building company, stated it took four and a half years before staff accepted the concept of sharing knowledge (Barlow and Jashapara, 1998). Primarily, the cultures of the organizations need to be addressed if KM is to be of benefit.

Each organization has its individual culture and only they can say what initiatives need to be set up to encourage a culture change. There are many other barriers to the successful implementation of KM within a construction enterprise. These according to Kazi, Hannus and Charoenngam (1999) include:

Lack of Time

Sharing knowledge demands additional effort. This effort may be minimized by work practices and the introduction of better knowledge sharing tools. Construction projects are always working to tight deadlines. Anything that detracts from the main business is seen as of diminished importance.

Trying to solve large problems

The various stages involves in KM are complex. It is easy to envisage the utopian world of delivering knowledge to different members of the project team as and when required for different stages of the construction process. However, in reality, for a company embarking on Knowledge Management, Richard (2011) believed that it is best to undertake very small projects that are self-contained with little input from external parties.

Converting Knowledge

One major obstacle is how organizations capture knowledge on projects that cuts across organizational boundaries. The industry is full of individuals, skilled trade workers and professionals who have years of experience of doing specific tasks (Oliver and Martin, 2008). Converting their tacit knowledge to explicit knowledge for the benefit of others is a problem, which is difficult to conduct within a reasonable period and at an acceptable cost.

Large number of SMEs

The UK construction industry consists of a large proportion of small to medium-sized enterprise (SMEs). These organizations have more pressing concerns than KM and in many cases do not see the need nor do they have the commitment and resources to undertake KM.

Multi-Disciplinary Teams

Some project team members may belong to different divisions or even different companies. Managing knowledge with such a team within a limited time period is difficult. Each team member will be working towards the agenda set by their employer. The benefits of KM may be seen as limited to the life of the individual project unless in long-term partnering type relationships.

Unique Projects

Despite efforts to encourage the UK construction industry to view itself as a manufacturing enterprise, it still regards each project as a one-off. This reinforces the view that KM on individual projects will be wasted as the next project may be quite different.

Lack of Learning

Because of the view of the industry producing unique projects, there has also been a failure to learn from past mistakes. In many circles, the UK construction industry is regarded as a national (rather than international) industry and there is an unwillingness to learn from internal and external sources.

Lengthy Time Period

KM is a long-term goal without any short cuts. If it is to bring long-term benefit to the organization, it will take a considerable period to have systems up and running with sufficient time to be validated and for benefits to percolate to the organization's performance.

Loss of faith

With KM systems available, employees may be tempted into thinking the data required is always easily accessible. In fact, it will take considerable time to get a spread of working KM systems. This may lead to employees losing faith in the system because it does not deliver immediate benefits in their own individual areas.

IT Support

Many of the existing systems rely on IT for delivery. Construction offices may be port cabins in isolated environments with inadequate infrastructure. The IT support, a key element in KM systems, must be present to deliver the knowledge required. Based on current working practices and the barriers to KM, a discussion of the IT support required within the construction sector now follows.

Requirements of a Knowledge Management System

For any IT system to be classified as a Knowledge Management system according to Andawei (2001), it must fulfil a number of requirements:

1. It must support the full KM lifecycle – from knowledge creation through distribution and management to retirement – and not just a subset thereof.
2. There should be appropriate mechanisms for validation and authentication of the knowledge encapsulated in the system.
3. The system should be able to seamlessly integrate with existing legacy IT systems within a real or virtual organization.
4. Flexibility and ease of use are essential components of the system, as they are crucial for ensuring its acceptability and utilization.
5. The knowledge contained within the system must be well maintained and up-to-date. This is essential for building up user confidence in the system and ensuring that decisions are based on the latest information available.
6. The system must be designed in accordance with an organization's goals, culture and business processes. End-user involvement in the design and implementation of the system is crucial in this regard.

KNOWLEDGE MANAGEMENT, INTELLECTUAL CAPITAL AND INNOVATION

Innovation is a complex phenomenon. Despite diverse perspectives, many researchers are in agreement on the importance of innovation as a pre-requisite for competitive advantage.

Innovations come from many different sources and exist in many different forms. In order to create an environment conducive to innovation, it could be argued that there needs to be an effective management of this complex process (Stephen, 2009). Thus, increased attention is focused on KM and IC management as a possible pre-requisite to successful innovation. In the last decade there has been a shift in management focus from traditional accountancy practices where financial capital is paramount, to growing realization that intangible assets are of greater significance in our knowledge-based economy (Egbu et al. 2000, Egbu et al 2001). However, the Gottlieb Duttweiler Foundation found that only 20% of knowledge available to an organization is actually used (Barlow and Jashapara, 1998).

Knowledge can be a valuable resource for competitive advantage and harnessing its value is one of the pre-eminent challenges of management. Identifying and exploiting knowledge assets, or intellectual capital (IC), has been vastly documented. There are different types of knowledge in an organization from the tacit knowledge of individuals, which is unarticulated and intuitive, to explicit knowledge that is codified and easily transmitted (Nonaka and Takeuchi, 1995). Further distinctions have been made by academics and practitioners involved in the IC debate. Three components of IC have been identified comprising human, structural and customer capital (Edvinsson, 2000). Clearly, structural capital describes the internal structure of an organization, such as its strategies, core competencies and culture, which is always context specific. Customer capital encompasses the external intangible assets of an organization. External forces play a part in determining the market position and strength of an organization. Customers are the principal determinants of this position Barlow and Jashapara, 1998)

However, it is asserted that the human capital in an organization is the most important intangible asset, especially in terms of innovation (Edvinsson, 2000; Andawei, 2001). The unique tacit knowledge of individuals is of immense value to the organization as a whole, and is the “wellspring of innovation” (Andawei, 2001). Identification of the different types of knowledge available to an organization is the first step to understanding how to manage them.

Therefore, KM is intrinsically linked to IC as revealed by Sharimllah , Siong and Hishamuddin (2009). There are many definitions of KM. However, an operational definition has been developed for the purposes of this research. KM is about the processes by which knowledge is created, captured, stored, shared, transferred, implemented, exploited and measured to meet the needs of an organization. These processes lead to the establishment of a knowledge-based organization. A thorough review of the relevant literature and discussions with targeted researchers in the field would suggest that the development of successful knowledge management programmes involve due cognizance of many factors. They involve 'hard' (e.g. technology) and 'soft' (e.g. people, culture, leadership) issues.

RESEARCH METHODOLOGY

This research was designed to use survey to prepare a mental plan for solving the problem in systematic manner. It involved assessing the public opinion through the collection of detailed data of the existing circumstances on knowledge management sharing, transfer, sources, and problems and using the data collected to justify the current conditions in order to make improvement in the construction industry. The focus of interest of this study were the knowledge workers in the construction industry such as the Civil Engineers, Quantity Surveyors, Estate Valuers, Architects, Technicians and Builders in Nigeria. Structured questionnaires were self-administered to 65 construction professionals in the industry and 50 of them representing about 77% of the overall total number of questionnaires were suitable for analysis. The questionnaires were directed to all knowledge workers involved in the construction industry as they are expected to know how to respond to the questions being asked and identify most of the facts that will lead to reliable conclusions. Questions were asked in order to ascertain the ways they manage knowledge, the aspect of the construction industry that will improve as a result of improvement in knowledge sharing and transfer among construction industry. It is based on these responses and findings that conclusions were drawn using frequency and mean item score statistical tools.

RESULTS AND DISCUSSION

In order to assess the characteristics of respondents for the study, the following data were collected: respondents' profession; highest academic qualification; professional qualification of respondents; and the years of experience.

Table 1: Summary of characteristics of respondents

Characteristics	Frequency	Percent
Respondents Profession		
Quantity Surveyor	13	26
Architect	20	40
Estate Surveyors	8	16
Civil Engineers	6	12
Builders	3	6
Total	50	100
Respondents' Qualification		
HND	22	44
B.Tech	18	36
M. Tech	9	18
PhD	1	2
Total	50	100
Professional qualification		
Graduate	37	74
Corporate	13	26
Total	50	100
Years of Experience		
0-5	31	62
6-10	12	24
11-15	3	6
16-20	2	4
21 & Above	2	4
Total	50	100

Table 1 shows the characteristics of the respondents used for the study, as shown in the table, 40% of the questionnaire was administered among the architects and 26% among the Quantity surveyors. Among the respondents 37% were graduates in their various professions. Thus, with the information provided in the Table 1, the data provided by the respondents can be relied upon for the purpose of the analysis.

Table 2: Awareness of Knowledge Management

Awareness of knowledge management.	Frequency	Percent
Yes	50	100
No	0	0
Total	50	100

As shown in table 2, all the respondents used in this study have heard of knowledge management at one time or the other. For the data used to be relevant the respondents must have heard of knowledge management before or have it in place in their organizations.

Table 3: Extent of awareness of Knowledge Management

Awareness Level	Frequency	Percent
Very low	2	4
Low	7	14
Undecided	3	6
High	28	56
Very high	10	20
Total	50	100

Table 3 revealed that some of the respondents have a low level of awareness of knowledge management while about 76% are aware on a high or very high level. This implies that knowledge management is still a new and under-explored area in the Nigerian construction industry as well as among construction professionals.

Table 4: Knowledge sharing among construction workers

Professionals	Mean	Rank
Builders	4.19	1
Quantity surveyors	3.98	2
Technicians	3.96	3
Architects	3.94	4
Top managers	3.94	4
Civil engineers	3.93	6
Middle managers	3.91	7
Estate surveyors	3.86	8
Low managers	3.79	9

It could be observed in table 4 that the respondents ranked the builders as professionals that share knowledge the most with them with a mean score of 4, Quantity Surveyors and technicians were ranked second and third respectively implies that they are the most that share knowledge with other professionals in the industry. The Top Managers also rank the 4th position which tied with the Architect showing that these set of respondents also share and transfer knowledge with construction professionals on a high rate.

Table 5: Sources of Knowledge Available to the Respondents in Their Organizations

Sources of Knowledge	Mean	Rank
Colleague's experience	4.14	1
Books	4.10	2
Interaction with outside party	3.98	3
Supervision	3.84	4
Phone	3.82	5
Peer tutoring	3.69	6
Lesson learned	3.68	7
Emails	3.58	8
Journals	3.58	9
Report	3.55	10
Internet	3.54	11
Seminars	3.47	12
Conference and events	3.39	13
Training on regular basis	3.31	14
Library	3.28	15
Reward	3.19	16
Regular meetings &training	3.16	17
Research	3.16	18
Internal course	3.14	19
External course	3.04	20
Databases	2.96	21

Table 5 show that the respondents believe that learning from their colleagues' experience is the highest source of knowledge available to them within their organizations with a mean score of 4.14. The use of Databases is the lowest source of knowledge available to them with a mean score of 2.96 and it could be deduced from this that the level of knowledge sharing and transfer among the colleagues is high.

Table 6: Problems of Knowledge Management in Construction Organizations

KM militating factors	Mean	Rank
Funding	4.09	1
Lack of time and understanding of KM	4.04	2
Lack of proper technical expertise	4.02	3
Lack of adequate and up to date data	3.96	4
Lack of successful KM model in the construction industry	3.89	5
Lack of effective communication among construction professionals	3.86	6
Difficulty in capital valuing intellectual	3.86	6
Lack of cooperation among Construction professionals	3.82	8
Misunderstanding KM with information management	3.80	9
Government policies	3.67	10
Difficulty generalizing & storing knowledge	3.65	11
Unwillingness to change current operating system	3.64	12
Difficulty in capturing knowledge	3.49	13
Unwillingness of employee to share knowledge	3.41	14
Difficulty locating knowledge	3.33	15

From table 6, the problem of fund poses the highest hindrance to the adoption of knowledge management to construction organizations and this is followed by lack of time and understanding of knowledge management among professionals. Difficulty in locating knowledge and unwillingness of employee to share knowledge were ranked 14th and 15th respectively.

Table 7: Benefits Derived from the Adoption of Knowledge Management

Benefits of KM	Mean	Rank
Improvement in job analysis and specification	4.96	1
Improvement in communication skills	4.21	2
Training benefits of new employee	4.16	3
Improvement in productivity	4.13	4
Increased customer satisfaction	4.12	5
Enhance professionalism	4.06	6
Increase employee’s morale creativity and ingenuity	4.02	7
Maintain competitiveness	3.98	8
Improvement in leadership control	3.94	9
Raise company professional Image	3.88	10
Increase Innovation	3.78	11
Rapid and effective in enterprise wide Problem solving	3.77	12

Market research	3.60	13

As shown in table 7, the respondents believe that all the stated areas of construction work will improve but with the most improvement seen in job analysis and specification with a mean score of 4.96 and the least to be in market research though it is all the areas that will improve if knowledge management is in place in any organisation.

Table 8: Factors Affecting Success of KM in the Construction Industry

Factors	Mean		Rank
Active participation of employee	4.22		1
Top Management Support	4.18		2
Application of IT	4.12		3
Creating Knowledge sharing space	4.00		4

Table 8 shows that the respondents ranked active participation of employee as the most important factor for Knowledge Management success followed by top management support. Creating Knowledge is the least important factor just below application of information technology.

DISCUSSION OF RESULTS

Awareness level of knowledge among Construction Professionals

The result have shown that all the respondents have heard of knowledge management at one time or the other as it is only those that have had the understanding of the topic that are eligible to respond to the questionnaire, so as to have a true and reliable output. The extent to which each one have heard of it differs but more than average of the respondents claimed to have average knowledge of knowledge management. However, knowledge management first established itself as a distinct area of management science in the early 1990s (Botha, 2004). Being a new area, one can say that the awareness level is improving, though it can be better. Knowledge management is considered vital for the survival of organization. It is asserted that knowledge is fast overtaking capital and labour as the key economic resource in advanced economies (Edvinsson, 2000). The project-based nature of the industry has made it particularly important to record and transfer lessons from one project to another (Rezgui, 2001).

Sources of Knowledge Available In the Construction Industry

The analysis revealed that learning from respondent's colleagues experience is the highest source of knowledge available to them within their organizations, while books, interaction with outside party, the use of phones followed respectively, and the use of Databases as the lowest source of knowledge available to them.

A research carried out by Kazi, Hannus and Charoenngam (1999) revealed that knowledge for construction professionals can be sourced through the following ways; personal experience, colleagues' experiences, internal courses, external courses, interaction with outside party research and development departments, company libraries, and other sources includes; internet, journals books etc. but this study revealed that personal experience and colleagues experience is very important, internal and external courses is moderately important, interaction with outside party as important, company libraries and internet/journals as least important, while others as not important. based on this data it was agreed that the listed sources for knowledge management is based on human, meaning that the staff needed to acquire through personal experience, linkages with others and interactions. Thus colleague's experience is still a very vital source that is readily available to the construction professionals as they rely much on interaction among themselves. Ricky and Eric (2010) also believed that personal knowledge management should be enhanced.

Areas that will improve with the adoption and application of KM

The result has shown that all the stated areas of construction work will improve but with the most improvement seen in job analysis and specification with a mean score of 4.96 and the least to be in market research with a mean score of 3.6. This is in agreement with a survey of Malaysian contractors, on the level of knowledge management application in the construction organization and areas of construction management that can be improved by its application (Mohamed, Abdul-Rahman, Otham, Yahya and Zakaria, 2001). The study revealed that knowledge management application is at a below par level and that the level of knowledge among middle and front-line workers needed improvement especially in the areas of communication and technical skills.

The analysis on the feedback showed that job knowledge and skills are important in making good and reliable decisions. Budgetary control, contract management, material planning and control, manpower planning and control, and negotiating with other involved parties were identified as important areas that knowledge management can help to improve. The study also revealed that KM can improve individual performance in response to Dong-Gil and Alan (2011).

Factors Affecting the Success of KM in the Construction Industry

The application of IT as a factor to the success knowledge management in the construction industry is only average, as most of the construction workers still confuse information management with knowledge management, and do not have an in-depth understanding of Knowledge Management.

However, Information Technology (IT) has long been recognized as critical for successful knowledge management. This is probably a legacy of the growth in knowledge based systems (KBS) in the eighties and early nineties, and has led to much of the early work on knowledge management focusing on the delivery of technological solutions. It is now recognized that good knowledge management does not result from the implementation of information systems alone (Andawei, 2001).

CONCLUSION

According to construction professionals, colleagues' experience is the ready source of knowledge that is available to them in Nigeria as they rely mostly on what their colleagues share with them. The study concluded that Architects are the construction professionals that share and transfer knowledge the most with other professionals in the industry. It was also revealed that all elements of the construction industry will improve with effective Knowledge Management. The result also revealed that the problem hindering the adoption of Knowledge management the most in the construction industry is funding while the least is difficulty in locating knowledge. It revealed that top management support, employee active participation, application of IT and creation of knowledge sharing space are factors that contribute to the success of knowledge management in the industry.

Based on the findings of this study, it was recommended that there is a need for construction professionals to embrace the use of ICT since the application of ICT to knowledge management would make their jobs easier and facilitate good and instant result. More so, the government and other construction professionals should inject fund into knowledge management aspect of the construction industry so that the benefits that are derived from this area can be harnessed.

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TOWARDS A SYSTEMIC CONSTRUCTION INDUSTRY DEVELOPMENT: A RESEARCH AGENDA FOR A FRAGMENTED INDUSTRY IN AFRICA

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Abstract
In spite of the several attempts by African countries to address their infrastructure needs, and despite the enormous investments injected into infrastructural development, much has not been achieved. The central problem is that researches and development issues in the industry have not taken into consideration its fragmented nature and how this impacts on the efforts being put in place. Relying on the survey of literature review, this paper proposes a research agenda for the construction industries in Africa and other developing countries in which a concerted effort based on systemic approach should be used to address the problem. It is conceived that the research and development objective of the industry in Africa could be better achieved if it is considered as a system of fragmented components. This will provide a framework in which the General Systems Theory which will enable the application of laws and theories from other disciplines in the industry's research and hence its development. The expected results is that improvements and developments programmes shall be focused on individual component parts whose interactions, if properly managed, will result in the development of the whole. In the process better and realistic results of infrastructural developmental agenda will be achieved.

Keywords: Infrastructure, construction, fragmented, system, system thinking.

INTRODUCTION

In spite of the relatively high investment in infrastructure in developing countries, the World Development report (1994) highlights the less corresponding impact these have had on the people in these countries. Hence, the report indicated that the infrastructure's future challenges should be dealt with by tackling inefficiency and waste –both in investment and delivering services. The report indicated that the poor performance of those managing the delivery and maintenance of these infrastructures provides strong reasons for doing things differently.

In the developing countries the problems confronting the construction industry are even bigger, compounded by lack of adequate resource and institutions to address them. Considering the investments levels of the construction industry and the development needs of most developing countries, the time is overdue for these matters to be given prominence. Indeed, Agenda 21 for sustainable construction in developing countries puts construction at the centre of how the future is to be shaped, and the sustainability of this future (Du Plessis, 2002 pi). In particular, developing countries were well advised to avoid the development mistakes of the developed world and to take steps to intervene on behalf of sustainability today than to wait and change things after they have occurred (Du Plessis, 2002 p1). These, together with the threat on the environment, have led to the call by various countries to work towards improvements in, and the development and sustainability of, the construction industry. Where, sustainable development has been defined as the “development that meets the needs of the present without compromising the ability of the future generations to meet their needs” (The Brundtland, 1987). Against this background, several countries at various levels of socio-economic development have recognised the need and importance of taking measures to improve the performance of their construction industry in other to meet the aspirations of its developmental goals (Ofori, 2000). This is in line with the agreements reached and reported by the CIB Task Group 29 (1999). According to Ofori (2000), the report agreed that “construction industry development is a deliberate process to improve the capacity and effectiveness of the construction industry in order to meet the demand for building and civil engineering products, and to support sustained national economic and social development objectives (CIB, 1999)”. At that meeting, the report continued, it was agreed that construction industry development promotes: (a) increased value for money to industry clients as well as environmental responsibility in the delivery process (b) the viability and competitiveness of domestic construction enterprises. This has become necessary because of the poor performance of the construction industry due to problems and challenges including those having to do with its structure characterised by fragmentation, institutional weakness and resource shortages (Ofori, 2000; Beatham et al., 2004; Latham, 1994; Egan, 1998).

However, this quest has met with several challenges which have prevented the development of the industry of any country to reach the desired goal. This state of affairs is epitomised in the several performance deficiencies on project execution namely: delays, cost overruns, disputes and poor quality of work among others. Discontent with the state of their construction industries, governments in developed countries are supporting various initiatives for improvements (Ofori, 2000). Following the Latham (1994) and Egan (1998) Reports, for example, the UK construction industry in particular has resorted to using several performance measures to address improvement concerns of the various aspect of the industry (Beatham et al., 2004). According to Ofori (2000) several other countries have also made some deliberate attempts to improve their construction industry. They have formed dedicated agencies to administer the continuous improvement of the industry. Examples of these are: Malaysia (Construction Industry Development Board), Sri Lanka (The Institute of Construction Training and Development), Tanzania (National Construction Council of Tanzania), and Singapore (Building Construction Authority). Ofori added others who have made long-term plans towards this end as: Hong Kong (21st Century Steering Committee), Australia (Australia Construction and Steering Committee, 1997) and Southern African Countries (Formation of construction industry development agencies to co-ordinate efforts and pool resources where necessary).

TOWARDS A BALANCED DEVELOPMENT

Discussing the concept of revaluing construction, Kumaraswany et al. (2007) focus on the need for a “balanced development” of the construction industry. Balanced development, they explained, refers to the need for striking an appropriate balance both within and between the development of the various “stakeholders, construction personnel, public institutions and private companies, the construction industry and the country itself”. Among the benefits to be achieved relate to “accelerating knowledge flows, which include one-way transfers and two-way exchanges of both ‘hard’ and ‘soft’ knowledge components between or among joint venture partners, consultants, contractors and sub-contractors, and other participants in construction projects. In their submission, Kumaraswamy et al. (2007) note the following difficulties:

- There are difficulties in identifying desirable developmental goals, agreeing on them among the stakeholders, and then achieving the right balance.

- There are also difficulties in agreeing on the appropriate courses of action for achieving the developmental goals as well as the assignment of responsibilities for them.
- The fragmentation of the industry also makes it difficult for companies to share information and knowledge (Robert et al, 2006).
- The construction industries generally comprise small and medium companies that cannot easily invest in research and development (R&D) or in sophisticated information management systems (Robert et al, 2006).

In particular, they conclude that "smoother knowledge flows would help to accelerate the mutual understanding of the diverse stakeholders and thereby facilitate the required holistic perspective for better management of the construction industry towards balanced development along all the fronts highlighted above (Kumaraswamy, 2006). This would contribute towards the revaluing of the construction industry in developing countries." However, coupled with it "one-of-a-kind production, site production and temporary product organisation (Koskela, 2002)", we see an industry which has complex problems to overcome to achieve these objectives for development.

THE PROBLEM STATEMENT

An industry with the foregoing difficulties and challenges needs to redefine its approaches towards research and development. The acknowledgement of the underpinning peculiar features appears to have been overemphasised to the detriment of what really needs to be done with this knowledge as we attempt to bring about improvements and development.

In the main, researches and efforts aimed at developing the industry have not considered it as a system –a complex system for that matter –with variety of interrelated and interacting parts. Hence most of the interventions aimed at improving the industry and addressing the developmental problems have attempted to address it either en bloc or dealt with the parts in isolation. This limits our understanding of the construction industry. With regard to the quest by nations to develop their construction industry, this could explain why efforts have not yielded the desired results so far.

AIM AND SPECIFIC OBJECTIVES

The aim of this paper is to propose a conceptual framework by which construction industries of developing countries could be developed holistically using a systemic approach. It is the position of this paper that the objective of improvements and developments in a typical construction industry would be better achieved if the industry is considered as a system and to address its problems using System Thinking. To this end the specific objective of the paper is to achieve the following:

- To discuss the need to consider the construction industry of a country as a system of identifiable components
- To show that it is possible for research in the construction industry could be done within the domain of system thinking for holistic
- To suggest this paradigm as a major research agenda for the construction industry everywhere

It is the contention of this paper that a critical study and monitoring of the interactions between these parts and their attributes will provide the basis of identifying improvement areas which will in turn shape development goals of the industry of a country. Consequently, the performance of the construction industry of any country will be the aggregation of the performance of its components. Thus, the improvements in the construction industry of any country as measured by its performance at any time should be represented by the aggregation of the improvement of its components; and finally, the overall development of the construction industry of any country at any time should be represented by the aggregation of the developments of its components.

THE CONSTRUCTION INDUSTRY AS A SYSTEM

Hall and Fagen (1956 pp. 18-28) define a system as: “a set of objects together with relationships between the objects and between their attributes”. Objects are parts or components of a system and they are unlimited in variety. Attributes are properties of objects. In the construction industry for example, clients, practitioners, contractors, projects and so on constitutes the objects of a components; whiles such attributes as can be used to describe the “objects” in the industry as success factors, indicators, growth.

The last key word in the definition is “relationships”. This is what “ties the system together”. It is in fact these relationships that make the notion of the “system” useful. The relationships that exist in the components parts of a construction system are indispensable for its success and growth.

The essence of a system is that it is a “complex whole” (the concise oxford dictionary, 1976, p.1174) “of a group of interrelated, interdependent, or interacting elements forming a collective unity” (Collins English dictionary, 1979, P.1475). It is this idea of complex wholeness and collective unity that makes system thinking a relevant philosophy for the construction industry –existing as fragments and aiming to develop as a whole. Using contrasts to explain further, Fuenmayor (1991) identifies two possible types of nonsystems by way of inference from the definitions above:

1. Indivisible entities (e.g. sub-atomic particles which are not constituted by a plurality of elements). These are atomic concepts without a direct phenomenal correlate.
2. Sets of elements that do not form a “collective unity”.
3. Using system thinking, the construction industry of any country as a system can be represented at three levels as shown below:

- **System Level**: the system itself i.e. the construction industry as a social system.
- **Subsystem level (objects)**: all that belong to the system, each component and assembly e.g. projects, firms, personnel etc.
- **Super-system level:** everything that does not belong to the system but interacts with the system, or produce influence upon functioning of the system e.g. the natural, social, economic, political and competitive environment. Hence, using the “systems approach” to address the needs of the construction industry is simply to see the industry as a system.

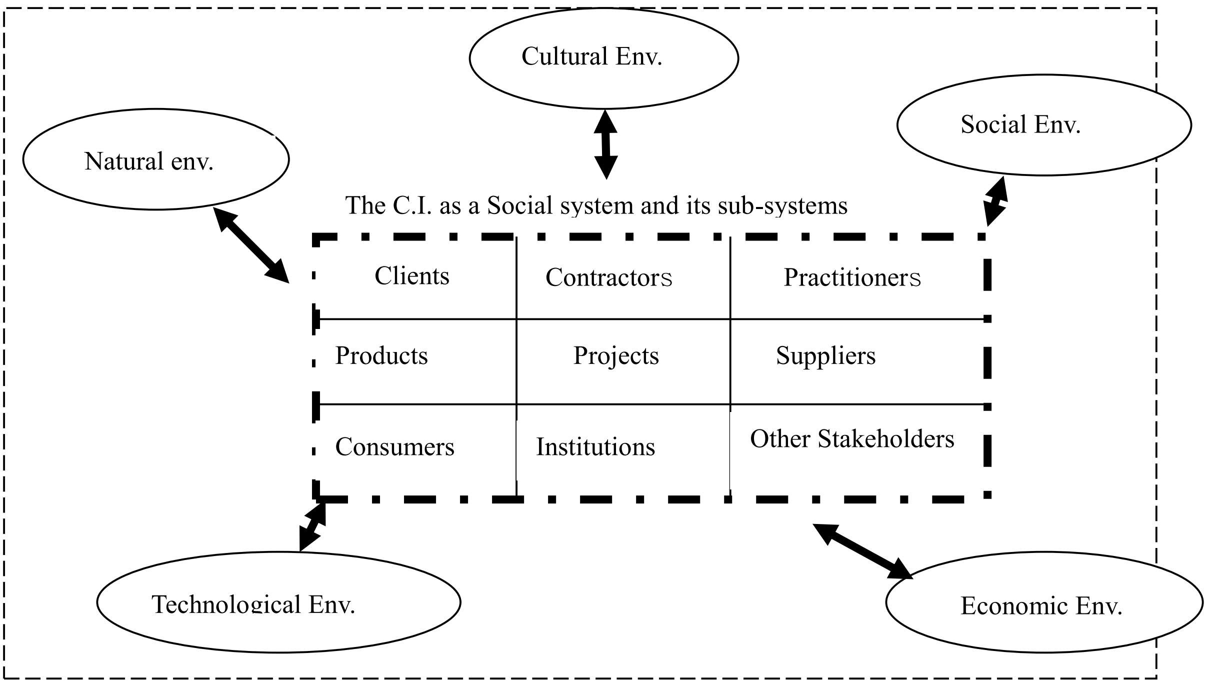
In this regard, the construction industry is a composite (social) system of distinguishable parts in that it deals with the society (people and shelter) and the environment (economic, technological, and natural). It is characterised as one which comprises many interacting parts such that a change affecting any one part usually, has the potential of affecting the other in an unpredictable manner. It is also a pluralistic (Jackson and Keys, 1984) industry because groups (components or constituents) within the system have diverging interests and aspirations. It is therefore important that studies into the mechanisms within the industry should be carried out with this system concept in mind.

According to Capra (1982; 2003), systems thinking is the most appropriate paradigm for rethinking socio-economic development, arguing that it will help us avoid the shortcomings of tackling environmental challenges at the global level.

Delineating the Key Components of a Construction Industry

The primary action to undertake towards a systemic approach to develop the construction industry will be to identify the key components. Following from Kumaraswamy et al. (2007), thus, the quest for a balanced and sustainable development should be rooted in the delineating and the analysis of such identifiable entities as the stakeholders, construction personnel, public institutions and private companies,(the identifiable components –the sub-system) the construction industry (the system) and the country itself (talking about the super-system) all benefiting from Knowledge flow –both external (among components), and internal (within the same organisation), emanating from the study of their attributes as well as the relationships that ties them together. Figure 1 is the author's view of a representation of the construction industry and some of its key components identifying them as systems and subsystems within a super-system.

The global, regional and related country environment as the super-system



THE GENERAL SYSTEMS THEORY

Fig. 1 The Construction Industry as a social system with its key components with its sub-systems; the super-system comprises the social, economic, natural, technological and cultural environments and the interactions of these system components.

Properties and Characteristics of Systems

Forrester (1971) posits that a thorough understanding of a social system is absolutely necessary for its improvements and development through realistic changes. Lack of this understanding has been the cause of consistent failure on the part of policy makers to achieve their aims of trying to effect changes. This paper uses Jenkins's (1969) six properties of a system and Forrester's (1971) three characteristics of a social system to relate to the construction industry.

Properties of Systems

Using a chemical plant as a basis of analysis, Jenkins (1969) outlines six properties of a system in general:

1. "A system is a complex grouping of human beings and machines." This is also for the construction industry as a system and each of the components as sub-systems.
2. "Systems may be broken down into sub-systems, the amount of sub-system detail depending on the problem to be studied." As illustrated in Figure 2, the construction industry as system can be broken down to as many sub-systems as are identifiable. However, this property of a system informs researchers that the number of sub-systems should be limited by the problem and scope of the research. For example, a research on project execution efficiency in the construction industry will limit the sub-systems principally to projects, consultants and clients and to a smaller extent, the other closely related stakeholders.
3. 'The outputs from a given sub-system provide the inputs for other sub-systems. Thus the performance of a given sub-system interacts with the performance of other sub-systems and hence cannot be studied in isolation." The reality of this in the construction industry is the essence of calling for a systemic approach to research and developments in the industry.

How can one study the performance of projects without thinking about its interaction and hence its relationship with the performance and inputs from consultants, clients, suppliers, and also those of the external environments?

4. “The system being studied will usually form part of a hierarchy of such systems. The systems at the top are very important and exert considerable influence on the system lower down.” A typical system within the construction industry must always be seen as forming part of hierarchy defined by which of them have the power to initiate activities and control it, etc. In other considerations, the construction industry within a country (considering it external environments) should be seen as part of a hierarchy of systems comprising manufacturing, agricultural, mining, oil etc. as other related and interacting industries.
5. “To function at all, a system must have an objective, but this is influenced by the wider systems of which it forms part. Usually, systems have multiple objectives which are in conflict with one another, so that an overall objective is required which effects a compromise between these conflicting objectives.” All industries as systems must have objectives. All sub-systems within each industry must also have their objectives. At the national level, the objective of the construction industry in a country must be set. The relationship of this objective and that of other industries within the country needs to be considered. How do the overall results of this conflicting objectives impact on the overall objective of a country as the master system? What is the objective of a typical project being executed? What is the level of agreement and conflict between the project as sub-systems and those of other sub-system during its life cycle? How do these conflicting objectives impact on the objective of the industry over time “t”.
6. “To function at maximum efficiency, a system must be designed in such a way that it is capable of achieving its overall objective in the best way possible.” This brings to the fore the need for identification of the industry’s objective to improve performance, to grow, to develop and be sustainable. This will result, expectedly, in the need to re-engineer the construction industry as a system in the country to ensure that it achieves its developmental goals. This is the thesis of this paper.

Characteristics of a Social System

Forrester (1971) also identified three characteristics of a social system which, in applying to the construction industry development agenda, challenges researchers and policy makers to be extremely critical in providing intervention for developments.

1. "Social systems are inherently insensitive to most policy changes that people select in an effort to alter the behaviour of the system". He posits that "a social system tends to draw our attention to the very points to which an attempt to intervene will fail".
2. "Social systems seem to have a few sensitive influence points through which the behaviour of the system can be changed. These influence points are not in the location where most people expect.
3. As a Social system there is usually a fundamental conflict between the short-term and the long-term consequences of a policy change. "A policy which produces improvement in the short-term, within five to ten years, is usually one which degrades the system in the long run, beyond ten years". Likewise those policies which produce improvements in the long-run may initially depress the behaviour of the system. The visible and more compelling nature of the short-term as against the long-term makes this very treacherous. It speaks loudly for immediate attention; however such short-term improvement measures "can eventually burden a system with long-run depressants so severe that even heroic short-term measures no longer suffice".

GENERAL SYSTEMS THEORY AND ITS RELEVANCE TO CONSTRUCTION INDUSTRY RESEARCH

The Need for a General Systems Theory

At the outset, by formulating a research aim to uncover the fundamental characteristics of systems of various kinds, we were making the unquestioned assumption that the world contained such systems (Checkland, 2000). And, generally, a concept is as good as its theoretical base. The manifesto for a systems approach to analysing the construction industry should, thus, be rooted in the general systems theory. According to Boulding (1956) General Systems Theory is a name which has come to describe a level of theoretical model-building which lies somewhere between highly generalised construction of pure mathematics and the specific theories of the specialised disciplines.

Boulding (1956) notes that each discipline corresponds to a certain segment of the empirical world with theories that are developed to have particular applicability to its own empirical segment. The quest for a General Systems Theory is, thus, instigated by the fact that modern science, characterised by specialisation, has become so fragmented that there appears to be a perception which has encapsulated scientist of different fields in their "private universe" and "it is difficult to get a word from one cocoon to the other (Bertallanffy, 1956)". A deeper analysis, however, points to the contrary.

According to Bertallanffy (1956), "similar viewpoints and conceptions have appeared in very diverse fields" and that similar problems are predominant in other scientific fields. For example, problems of organisation, of wholeness, of dynamic interactions, are topical in "physics, chemistry, physical chemistry, and technology". It has become necessary, thus, that a body of systematic theoretical construct which will discuss the general relationships of the empirical world be established. Collins Cobuild Advanced Learner's Dictionary (2006 P.1470) defines a system as "a network of things that are linked together so that people or things can travel from one place to another or communicate". This is the quest for a General Systems Theory. Betallanffy (1956) summarised the aim of General Systems Theory as:

1. There is general tendency towards integration in the various sciences, natural and social
2. Such integration seems to be centred in a general theory of systems
3. Such theory may be an important means for aiming at exact theory in the non-physical fields of science
4. Developing unifying principles running "vertically" through the universe of the individual sciences, this theory brings us nearer to the goal of the unity of science
5. This can lead to a much-needed integration in scientific education."

According to Boulding (1956) such a theory does not seek to establish a single, self-contained "general theory of practically everything" which will replace all the theories of particular disciplines. The vision is about the development of a "spectrum" of theories –a system of systems which may perform the function of a "gestalt" in theoretical construction.

Such a theory will accommodate the existing models, principles, and laws that apply to generalised systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relations of "forces" between them. It is a quest for universal principles applying to systems in general (Bertallanffy, 1956).

A Lesson from the Concept of Sustainability

To illustrate the feasibility of the General Systems Theory as per its applicability, the concept of sustainable development comes to mind. With its definition hinging on the three pillars of economic, social and environmental considerations, this concept has gained wider application across several disciplines. Several developed countries have made it a requirement for approval of most research and developmental projects in all disciplines. These three pillars have become pillars in all disciplines. Such is the expectation of the proponents of General Systems Theory.

SYSTEMS APPROACH TO CONSTRUCTION INDUSTRY RESEARCH AND DEVELOPMENT

Checkland (1989) defines systems approach as 'an approach to a problem, which takes a broad view, which tries to take all the aspects into account, which concentrates on interactions between the different parts of the problem'. Figure 2 shows the author's view on how the various components should be perceived within a typical industry of a country. This arrangement shows how the various types of components are identified according to their levels within the system and visualising the components as standing in interaction within the industry as a system, figure attempts to illustrate the author's view of what encapsulates the research agenda for a fragmented industry which functions as a system. This is represented along the lines of the 'solar' system. Conceptually, however, there is an expected difference in that it is a distortable system of systems because the forces of interaction are not expected to be equal or constant. The changes that occur in society will constantly affect it. However, in the same way that social theories are identified and perceived as existing over time, it is also expected that these impacts are determinable.

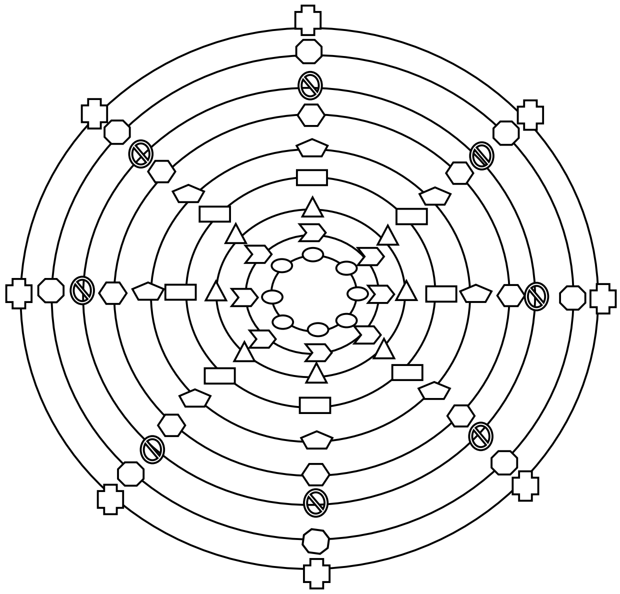


Fig. 2 Components in the construction Industry of a country.

(Note similar components rotating along their 'orbit' in the 'solar' system", as it were, and standing in determinable interaction and relationships within themselves as similar components, and those of other components. Projects are at the centre of the system).

It is conceived as a matter of course that, research in the industry, if it is pursued based on Figure 2, provides the following objectives:

1. The identification of the nature, impact and direction of the interactions (forces) and relationships of similar components along the same "orbit" close or remote; and between those of other components close and remote as the need may be, within a well defined period.
2. The identification of the nature, impact and direction of the external environmental interactions and relationships (the super-system) on each of the components (as well as a group of similar or different components) and vice versa, within a geographical location and within a well defined time frame.
3. The prediction of these interactions and relationships as identified above based on prevailing circumstances and available data.
4. The application of all the above to the sub-systems (each of the components) as a system of systems.

The aim of accomplishing the above research objectives is what brings about the ultimate need of employing all the relevant existing models, principles, and laws that apply to generalised systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relations of “forces” between them as proposed by Bertallanfy (1956) and supported by Boulding (1956). In addition, it is envisioned that existing and applicable models, principles and laws from other disciplines into a related system could instigate the discovery of new forces or impacts that has hitherto not been discovered. That is the way forward. This is the agenda for research in the construction industry. The orbits are not limiting and will follow the theory of the ‘expanding universe’ as and when new “planets” are discovered (new project related disciplines are brought to bear).

METHODOLOGIES FOR SYSTEMS RESEARCH IN THE CONSTRUCTION INDUSTRY

Applying System Thinking to construction industry research and dvelopment, it is paramount that we fall on the existing methodologies that are capable of addressing the research objectives and questions in systems. Researches using the General System Theory embrace methodologies applicable in other fields –which are themselves linked up as a system. Particularly, methodologies in Management Science dominate these methodologies; examples are Soft System Methodology (SSM) (Checkland, 2000), System of Systems Methodologies (SOSM) (Jackson and Keys, 1984; Jackson, 1987), Total System Intervention (Flood and Jackson, 1991), Diversity Management and Triple-Loop Learning (Flood and Romm ,1996). Other methodologies include: Decision Tree and Influence Diagrammes, Strategic Choice Approach, Scenario planning, Robustness Analysis, Metagaming, Hypergames, Cognitive Mapping , Repertory Grid Technique, Delphi Methods etc., as well as Such organizational Research Methods as Linear Programming, Queuing Theory, Game Theory, Simulation and Markov Process .

In all these, Mingers and Brocklesby (1996), acknowledge the growing interest in utilizing more than one methodology and method possibly from different paradigms within the same inquiry.

Such combinations are required in researches in the system domain, which are characterized with high complexity and multidimensional problems. The overall purpose is to maximize flexibility and responsiveness during interventions (Heyer, 2004).

CONCLUSION

This paper purports to instigate paradigm shift in the way researchers in the construction industry in Africa have understood the industry's research question. It proposes a higher level consideration where the interrelationship and interactions between the fragmented components of the industry will be used as a basis of understanding the industry behaviour. It joins the numerous researchers' acknowledgement that the industry is a fragmented one and goes further to ask the question: 'and so what do we do to grow it together?' Approaching research and development within the construction industry with System Thinking will yield the desired realistic and holistic improvements in its performance and its sustainable development. The real problems militating against the development of the industry will be identified through multi-lenses and clarified at its elemental or component levels; identifying how each component impacts on the nearest or remotest components within the industry. A better understanding and knowledge of the construction industry situation will be achieved. Such knowledge of the industry is crucial for addressing its multi-faceted problems including those of inefficiencies, ineffectiveness and wastes.

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