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KNOWLEDGE AND USAGE OF THE SEVEN BASIC QUALITY CONTROL TOOLS BY PRODUCERS OF PRECAST CONCRETE PRODUCTS IN GHANA

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ABSTRACT

For very small organisations, the root cause of quality problems may be obvious, but once it gets beyond small businesses, most decision points and problem root causes will remain vague until valid data are studied and analysed. It is for such cases that quality management tools play an important role in helping improve the quality of products and processes. This research seeks to explore the level of knowledge and usage of the seven basic quality control tools by producers of precast concrete products in Ghana. A survey of 42 producers of precast concrete products in the cities of Accra and Tema was conducted to elicit the desired data. The data was basically analysed using gap and quadrant analyses. The study revealed very limited levels of both knowledge and usage of the said tools by these organisations even though their perception of quality was very good. Again, the survey identified some practical measures to help improve the quality of the operations of these organisations. Chief among these measures is training and education of the work force on the use of the seven basic quality control tools. Even though the findings are limited to data from only two cities, they tend to support earlier findings from similar studies, thus providing useful lessons for manufacturers of such products.

Keywords: Quality management, quality control tools, precast concrete products, Ghana

1. INTRODUCTION

Quality control (QC) is essentially the practice of control activities in order to achieve quality goals. However, several writers suggest more detailed definitions for quality control. In fact, they deal with this term as a system that consists of interrelated components so as to fulfil a particular objective(s). Most of these control components, basically, revolve around the components of Plan-Do-Check-Act (PDCA) management cycle (Ozeki and Asaka, 1990).

In the era of competitive markets and globalization, quality concepts and philosophies have emerged as strategic issues at all organizational levels and in all industries.

International quality standards and excellence models such as ISO 9000 standards, the European Foundation for Quality Management (EFQM) model, Deming Prize and the King Abdul-Aziz Quality Award model require organizations' quality systems to be built on processes, rather than requirements, departments or functions. Consequently, proper process identification and management are becoming more relevant and critical challenges for quality professionals, process engineers and business leaders. World class organizations use total quality management (TQM) tools to identify, analyse and assess qualitative and quantitative data that are relevant to their processes with the aim of continuous improvement in their operations (Dias and Saraiva, 2004). One of the simplest and most effective set of tools employed by manufacturers for problem solving and quality improvement, is the set of basic quality tools known as the magnificent seven (Nankana, 2005; Dias, and Saraiva, 2004). Japanese quality guru, Engineering Professor Kaoru Ishikawa who is the inventor of the seven basic quality tools has long indicated that 95% of quality related problems in any organization can be resolved using these tools. This important statement has been proven in the field by different organizations and researchers including Delgado-Hernandez and Aspinwall (2005) and Ortega and Bisgaard (2000).

In the last two decades, quality has been considered one of the most important and competitive factors amongst construction related organisations (Al-Ani and Al-Adhmawi, 2011; Ying, 2010). Even though quality can be defined in different ways by different writers, it is simply defined as the ability of the features of a project to meet the requirements needed by the final user (Ayandibu, 2010). Thorpe and Summer (1990) argue that quality is defined in different ways depending on the context in which it is needed and is defined by some writers as ‘the best or value for money’, whilst others refer to it as ‘the fitness for a purpose’.

Ghana, as many other developing countries is in her developmental phase which requires an increase and improvement in infrastructure as a means to generating economic growth. With an increasing effort to meet the over 1.8 million housing deficit in Ghana, coupled with road construction, social amenities among other constructions, there is the need to ensure adequate supply of good quality construction materials including precast concrete products which are on very high demand in the country’s construction industry given its several merits. The idea of prefabrication of building elements in factory conditions brings with it certain inherent advantages over purely site-based construction (Taylor, 1999). Precast concrete manufacturing has an intrinsic environmental advantage compared with constructing similar products at a job site. It also presents one with a greater degree of control leading to higher quality products compared to its on-site equivalent. The very existence of a precast concrete industry and the numerous successful building projects achieved using precast concrete, for the whole or just a part, is ample proof that the technique is practical and economical (Elliott, 2002).

Adopting a contingency viewpoint, it can be said that though quality management is key to the production of precast concrete products, very little or no studies have been conducted in Ghana to examine the subject. Again, relatively limited research has been devoted to exploring the level of knowledge and usage of the seven basic quality control tools that influence the success of quality management in developing countries and how TQM can be successfully implemented in such countries. This study thus seeks to fill this research gap by exploring the level of knowledge and usage of the seven basic quality control tools by manufacturers of precast concrete products in Ghana.

2. LITERATURE REVIEW

The seven basic quality control tools are simple statistical tools used for problem solving and are considered as the most important tools that are able to solve up to 95% of problems (Dias, and Saraiva, 2004; Montgomery 1991; Galgano, 1994). They are referred to as basic due to their suitability for use by even people with little formal training in statistics and the fact that they can be used to solve the vast majority of quality-related issues (Rao et al., 1996). These tools include check sheet, control chart, histogram, cause and effect diagram, Pareto chart, flow chart, and scatter diagram.

Check sheets are like tally sheets/cards used to collect data in real time at the location where the data is generated. The data can be quantitative or qualitative (Schultz 2006). In terms of quality control check sheets can be used to check the shape of the probability distribution of a process, quantify defects by type, quantify defects by location, quantify defects by cause and or keep track of the completion of steps in a multistep procedure (in other words, as a checklist)

Histograms are a graphical representation of the distribution of data. It is a representation of tabulated frequencies, shown as adjacent rectangles, erected over discrete intervals, with an area equal to the frequency of the observations in the interval. The height of a rectangle is also equal to the frequency density of the interval, i.e., the frequency divided by the width of the interval. Histograms are used to plot the density of data, and often for density estimation; estimating the probability density function of the underlying variable (Nankana, 2005; Dias and Saraiva, 2004).

Cause and effect diagrams also known as the Ishikawa diagram are casual diagrams that show the causes of a specific event (Nankana, 2005). Common uses of the Ishikawa diagram are product design and quality defect prevention by identifying potential factors causing an overall effect. Each cause or reason for imperfection is a source of variation. Causes are usually grouped into major categories to identify these sources of variation. The categories typically will include people, methods and machines.

Control Charts are process behaviour charts used to determine if a manufacturing or business process is in a state of statistical control (Dias and Saraiva, 2004). If analysis of the control chart indicates that the process is currently under control (i.e., is stable, with variation only coming from sources common to the process), then no corrections or changes to process control parameters are needed or desired (Nankana, 2005).

Pareto charts contains both bars and line graphs, where individual values are represented in descending order by bars, and the cumulative total is represented by the line. The purpose of the Pareto chart is to highlight the most important among a (typically large) set of factors. In quality control, it often represents the most common sources of defects, the highest occurring type of defect, or the most frequent reasons for customer complaints. The Pareto analysis is based on Pareto's '80-20' rule (Kolarik, 1995; Tang et al., 2005).

Flow charts or process flow charts graphically show the inputs, actions, and output of a given system. The purpose of a flow chart is to help people to understand the process (Dias and Saraiva, 2004). A flow chart illustrates the activities performed and the flow of resources and information in the process. Typically, four to seven sub-processes are shown in a flowchart. By including only basic information, high level flowcharts can readily show an entire process and its key sub processes. A detailed flow chart provides a wealth of information about activities at each step in a sub process (Dias and Saraiva, 2004).

It shows the sequence of the work and includes most or all of the steps, including rework steps that may be needed to overcome problems in the process. A quality improvement team can increase the detail to show the individuals performing each activity or the time required to complete each activity. If necessary, the link between various points in the sub process and other high level flow charts of the process can also be shown.

Scatter diagrams or scatter plots are used when a variable exists below the control of the experimenter (Nankana, 2005; Dias and Saraiva, 2004). If a parameter exists that is systematically incremented and/or decremented by the other, it is called the independent variable and is customarily plotted along the horizontal axis. The measured or dependent variable is customarily plotted along the vertical axis. If no dependent variable exists, either type of variable can be plotted on either axis where a scatter plot will illustrate only the degree of correlation (not causation) between two variables. The cool scatter plot can suggest various kinds of correlations between variables with a certain confidence interval. If the pattern of dots slopes from lower left to upper right, it suggests a positive correlation between the variables being studied. If the pattern of dots slopes from upper left to lower right, it suggests a negative correlation. A line of best fit can be drawn in order to study the correlation between the variables. An equation for the correlation between the variables can be determined by established best-fit procedures. For a linear correlation, the best-fit procedure is known as linear regression and is guaranteed to generate a correct solution in a finite time. A scatter plot is also very useful when one wishes to see how two comparable data sets agree with each other Dias and Saraiva, 2004). One of the most powerful aspects of a scatter plot, however, is its ability to show nonlinear relationships between variables.

3. RESEARCH METHODOLOGY

A structured questionnaire involving both open and closed ended questions was designed to elicit the views of respondents regarding the seven basic quality control tools. The questionnaire was designed in four sections - Section A, B, C and D) Section 'A' sought to explore the background of respondents, and included issues of legal status of manufacturers, nature of business, age, turnover, and type of pre-fab products produced. Sections B and C contained questions, which were mainly closed-ended and sought to inquire about respondents level of knowledge and usage of the seven basic quality control tools. Section 'D' covered practical measures to improve quality control.

Respondents were selected through a snowball sampling technique largely due to the unavailability of a register (with the addresses) of these manufacturers. Fifty (50), producers of precast concrete products in the cities of Accra and Tema (two of the cities with the most population of precast concrete product manufacturers in Ghana) were contacted for the study with forty-two (42) providing data for the analysis.

A quantitative approach to data analysis was employed. The Statistical Package for the Social Science (SPSS) version 19.0 for Windows was used to analyse the data. For the seven basic quality control tools, the respondents were asked to indicate their level of knowledge and level of usage on a four-point Likert scale (1= 'not at all,' 2= 'limited' , 3= 'working knowledge' and 4= 'very good knowledge') and (1= 'not at all', 2= 'seldom', 3= 'frequent' and 4= 'all the time') respectively.

The study employed the use of gap and quadrant analyses to determine if there were any significant differences in the mean scores for the level of knowledge and level of usage of the seven basic quality control tools. Having explored the level of knowledge and level of usage of the seven basic quality control tools, the importance (I)-evidence (E) gaps analysis was performed. The tools were ranked according to their importance (I)-evidence (E) gap obtained from percentage coefficient of variance (i.e. standard deviation divided by mean multiplied by 100). This approach is modelled along the concept of Importance-performance analysis (IPA) which is a strategic approach to measure users' satisfaction and functionally identify the strengths and the areas of improvement in a particular service (Ainin and Hisham, 2008). With IPA one first ascertains the importance that users assign to the most relevant attributes of a service and subsequently evaluate the performance of each service, thereby obtaining a (Cartesian) graph with four quadrants. This graph allows an intuitive assessment of its operation and the implementation of appropriate recommendations for brand management (Ainin and Hisham, 2008). In this context the level of knowledge and evidence of use quadrant plot allows one an intuitive assessment of important quality control tools for much training and advocacy is required. IPA has been applied in various fields (Ainin and Hisham, 2008; Matzler et al., 2003.)

4. FINDINGS AND DISCUSSION

4.1 Profiles of Respondents /Organisations

Quality control managers (12.2%) and production managers (46.3%) were in the majority with regards to the respondents. Other respondents included commercial managers, quantity surveyors, site engineers, factory managers, and project managers. 65.8% of these respondents had over 5 years work experience in the precast concrete product manufacturing industry. In terms of the average annual turnover of the organisations, 3 respondents representing 7.3% indicated an average annual turnover of below US$5,000.00, 46.3% indicated between US$5,000.00 and US$10,000.00 with the rest having an average annual turnover of above US$10,000.00. However, only 16 of the 42 organisations studied had a properly setup quality control unit / department with an average annual budget of between US$3,000.00 and US$7,000.00.

4.2 Level of knowledge and usage of the seven basic quality control tools

Results from the analysis of data on the level of knowledge and level as usage of the seven basic quality control tools as well as the gap analysis conduction on data obtained is summarized in Table 1.

Table1. Level of knowledge and usage of the seven basic quality control tools.

Code	Quality Control Tools	Mean Score		Std. Deviation		Gap (%)		K-U Gap (%)	Rank
		K	U	K	U	K	U		
K-U 1	Check sheet	3.19	3.19	.890	.917	28	29	-1	7th
K-U 2	Flow chart	2.95	2.44	.805	.940	27	39	-12	3rd
K-U 3	Histogram	2.93	2.29	.859	1.006	29	44	-15	2nd
K-U 4	Control charts	2.29	1.86	1.100	1.061	48	57	-9	4th
K-U 5	Pareto chart	2.15	1.55	1.064	1.021	50	66	-16	1st
K-U 6	Scatter diagram	2.07	1.46	1.184	.793	57	54	3	6th
K-U 7	Cause and effect diagram	2.00	1.45	1.054	.827	53	57	-4	5th

Given the rating scale for responses on level of knowledge of the tools, the results in Table 1 indicate that ‘Check sheet’, ‘Flow chart’ and ‘Histogram’ with a mean score of 3.19, 2.95 and 2.93 respectively were the only tools that the respondents had a working knowledge of. Respondents only had a very limited level of knowledge with regards to the rest of the six quality control tools. As can be expected ‘Check sheet’ again with mean score of 3.19 was the only quality control tool that enjoyed frequent usage in the quality control operations of these manufacturers. ‘Flow chart’, ‘Histogram’, ‘Control charts’ and ‘Pareto chart’ with mean scores of 2.44,2.29, 1.86 and 1.55 respectively showed some seldom usage whiles the rest were not used at all by the respondents.

To give a truer picture of the level of knowledge and usage of the seven basic quality control tools, a gap analysis between knowledge and usage was performed. The gaps obtained for the respective tools are shown in Table 1. These results are based on percentage coefficient of variation (i.e. standard deviation divided by mean multiplied by 100). From the results it is clear that there are significant gaps (ranging from -16% to +3%) existing in the levels of knowledge and usage of the seven basic quality control tools in the production of precast concrete products in Ghana. The largest gap was observed with ‘Pareto chart’ (-16% gap; ranked 1st), followed by ‘Histogram’ (-15% gap; ranked 2nd), and ‘Flow chart’ (-12%; ranked 3rd).

The results from the gap analysis clearly points to a situation that leads to the conclusion that producers of precast concrete products are not making the most use of the seven basic quality control tools in their operations largely due to very limited knowledge regarding these tools. This situation should serve as a source of concern to the precast concrete production industry and the construction industry in Ghana at large given the importance of quality control, and for that matter, the merits of using these tools to help achieve quality of processes and products.

A Knowledge–Usage Quadrant analysis was conducted in order to integrate the ratings of the current knowledge levels and current usage levels (See Figure 1). This helped to identify areas in which education and training is most needed to positively impact on the present situation depicted by the results from the field work. It can be seen from Figure 1 that only 1 out of the 7 basic quality tools was rated above average in terms of knowledge and above average in terms of usage evidence. The remaining 6 were rated below average in both level of knowledge and level of usage evidence ratings. On the basis of this, immediate interventions are required to improve the level of knowledge and inevitably the level of usage of these 6 of the seven basic quality control tools whilst the continuous use of 'Check sheet' should be encouraged.

Knowledge rating	Above Average	Quality control tools to maintain or deemphasize	Quality tools to Maintain for continuous improvement K-U 1
	Below Average	Quality tools to De-emphasize	Quality tools requiring Immediate attention K-U 2, K-U 3, K-U 4, K-U 5, K-U 6, K-U7
		Below Average	Above Average
		Usage Rating	

Figure 1. Knowledge – Usage Quadrant.

5. CONCLUSION AND RECOMMENDATION

Several studies have in one way or the other stressed the fact that the seven basic quality tools, when properly utilised, have major capacity to improve the manufacturing and services industries across the globe. With these tools, manufacturers, and service providers can monitor, control, and improve their processes in order to achieve breakthrough improvements and business results. Their use is likely to lead to improved productivity, effective detecting and preventing of errors in operations, preventing of unnecessary process adjustments, providing diagnostic information, and also information regarding process capability to meet customer requirements.

Most precast concrete product manufacturers in the two cities studied are in no doubt as to the importance of quality control in their operations, but clearly lack adequate knowledge with regards to arguably the best tools to accomplish this. Most of these firms do not use the seven basic quality control tools in their operations largely due to the lack of adequate knowledge about these tools. The study identified 'Check sheet' 'Flow chart' and 'Histogram' as the only basic quality control tools which enjoyed some appreciable level of usage in their operations. This perhaps is not surprising given that basic real time data collected with these tools in a way directly indicates their level of productivity and hence profitability. Even with respect to a 'Check sheet', proper training on it use for quality control could serve many other very useful purposes such as to determine probability distribution of a process, to quantify defects by type, to quantify defects by location, to quantify defects by cause, and or keep track of the completion of steps in a multistep procedure.

The results from this study even though not based on any inferential statistic provides industry stakeholders with useful information regarding where to target interventions to greatly improve quality control. The authors appreciate that the use of inferential statistic would be valuable especially in explaining the observations recorded. However the scope of this paper is limited to describing the state of knowledge and usage of these tools in the targeted industry. Aside the need for having a clear policy regarding quality control, regular inspections and audits, regular meetings between key stake holders i.e. design team, production team, and users, training and education of especially frontline workers regarding the use of the seven basic quality control tools will go a long way to improve quality control in this industry. Even though the findings are limited to data from the two cities of Accra and Tema, they tend to support earlier findings from similar studies, thus providing useful lessons for manufacturers of precast concrete products.

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