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The Comparison of Statistical Quality Control Results on Reinforced Concrete Buildings in Myanmar

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ABSTRACT

Yangon, the former capital city of Myanmar, gradually increases high-rise buildings. But, Myanmar, our country, is one of the countries which still weakened at the quality management system of construction projects. Few construction companies in Myanmar hold the certificates of ISO standards and also there are few people who understand that how much quality is very important for the construction industry. Actually, quality is very important for all stages of construction projects to save time and money of the whole projects. In this situation, two construction projects in Myanmar which are constructed under different construction companies have been chosen to apply the statistical quality control methods to know which areas are needed to emphasis to get the better quality performances of construction projects in Myanmar. This finding can be useful to solve some quality problems of construction projects and by using these statistical quality control methods, quality weak points can be analyzed and reduced to get the better quality performances of the construction project.

KEYWORDS: *Quality management system, ISO standards, Statistical quality control methods, Quality weak points, Quality performances*

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I. INTRODUCTION

Myanmar has been experiencing huge problems in construction industry such as poor safety, imperfect working environment and insufficient quality management. If there were lack of quality management system in construction projects, loss of business, liability, productivity and increasing costs can be faced as a consequences of poor quality. Nowadays, some construction companies and engineers in Myanmar start emphasizing on effective quality management system for construction projects. In Myanmar, checklists are the most useful tools for quality control and many construction projects used construction quality control checklists in construction stage. In this situation, construction quality checklists are used as a basic step to get the statistical quality control data for continuous quality improvement. Moreover, total quality management emphasizes on customer-driven quality standards, managerial leadership and continuous improvement and statistics contains as one portion of the total quality management which can calculate the variations of the process and the products. So, this research is intended to be the one which can fill the gap of quality management system of construction projects in Myanmar.

II. LITERATURE REVIEW

Statistical quality control contributes the accountabilities and it is an essential ingredient in quality effort. The decisions about what needs to be improved, the possible methods to improve it, and the steps to take after getting results from the charts are all made by humans and based on wisdom and experience. Statistics is the application of numeric data to improve decision-making and the study of numeric data consolidates operationally defining variables. There are two types of statistical quality control methods. These are enumerative studies and analytic studies. Enumerative studies are statistical investigations that lead to action on static populations and analytic studies are statistical investigations that lead to actions on the cause-and-effect systems of a process. Both statistical studies can occur type I and type II errors. Type I error appears when the action is taken on a process when it should have been left alone and type II error can be found that it is fail to take action on a process when the action is appropriate. The statistical quality control method X-bar, R-bar, P-bar chart and C-chart are calculated by the respective equations and the table of control chart constants is used to calculate these equations. In these methods, x-bar chart measures the central tendency of the process and the range, R chart measures the dispersion or variance of the process. P-bar chart shows the proportion of nonconforming units on the Y-axis and C-charts are measured by the number of nonconformities per item or group of items and changes over time.

III. DATA SOURCES

The research was done totally in Yangon City (16°48' North, 96°09' East), the former capital city of Myanmar, because it is the most populated and commercial city of our country. Yangon has 4 districts (East, West, Southern and Northern Districts) and it comprises altogether thirty-three townships. Nowadays, many construction projects and high-rise buildings are constructed in Yangon. Among them, two numbers of eighth and half storey reinforced concrete buildings are selected to apply statistical quality control methods and compare their results. Project engineers, site engineers and quality control engineers have been targeted to obtain the data of checklists of construction process. These construction projects are constructed under different companies and situated at different townships.

IV. RESULTS AND DISCUSSION

To get the statistical quality control results, construction checklists are prepared according to the International Building Code and Myanmar National Building Code. These have been divided by 6 main fields and 13 subgroups. They are human resource management, inspection and testing results, health management, safety management, environmental management, risk management, equipment and material and construction process. Table 1 shows the fields and sub-divisions of construction checklists. There are three main parts of construction processes checklists which had been divided by substructure, superstructure and materials.

Each part has different procedures and stages. For substructure, there are 19 numbers of total checklists sheets and all had code numbers which have been named according to the ISO 9001:2015 documented control procedures. There are 225 checkpoints for substructure and 2710 total checkpoints are produced for superstructure. Checklists for Materials contain checklist for brick, checklist for rebar and checklist for concrete. Checklists for Construction process involved three stages which are before, during and after. All checklists had been used from mobilization stage and ended at 8.5 storey reinforced concreting work. Project engineer, Site engineer and quality control engineer checked step by step of construction processes by using prepared checklists and total time limitation of the whole construction projects are over one year.

Table 1 Fields and sub-divisions of construction checklists

No	Fields	Sub Groups	Remarks
001	Administrative	HR Management	
002	Inspection and Testing	Testing Results	
003	*Health , Safety and Environmental (HSE) and Risk Management	Health Management	
004		Safety Management	
005		Environmental Management	only Working Environment
006		Risk Management	
007	*Equipment	According to Daily QC Report	
008	*Material	Brick	
009		Rebar	
010		Ready-Mix Concrete	
011	*Construction Process	Before	
012		During	
013		After	

Table.2 Sample code numbers of construction checklists

No	Checklist's Name	Code No.
Substructure		
1	Checklist for surveying, mobilization, ground and Camp Site Condition in Construction	Sub-001
2	Checklist for Surveying ans Excavation Work	Sub-002
3	Checklist for Backfilling Work	Sub-003
4	Checklist for Retaining Wall (Pre)	Sub-004-01
5	Checklist for Retaining Wall (During)	Sub-004-02
6	Checklist for Retaining Wall (After)	Sub-004-03
7	Checklist for Rebar/Steel Work (Pre)	Sub-005-01
8	Checklist for Rebar/Steel Work (During)	Sub-005-02
9	Checklist for Rebar/Steel Work (After)	Sub-005-03
10	Checklist for Formwork (Before)	Sub-006-01
11	Checklist for Formwork (During)	Sub-006-02
12	Checklist for Formwork (After)	Sub-006-03
13	Checklist for Concreting Work (Pre)	Sub-007-01
14	Checklist for Concreting Work (During)	Sub-007-02
15	Checklist for Concreting Work (After)	Sub-007-03
16	Checklist for Equipment	Sub-008
17	Checklist for Material (Brick)	Sub-009-01
18	Checklist for Material (Rebar)	Sub-009-02
19	Checklist for Material (Ready-Mix Concrete)	Sub-009-03

Table 2 expresses the code numbers of substructure of construction buildings and these can be changed and defined as according to the company's quality manual and documented control procedures. Figure 1 and 2 show the results of X-bar charts of 8.5th storey RC buildings at North Dagon and North Okkalapa Townships which had been built by local contractors. Data analysis Results are different according to their experiences, accountabilities and decision making. All data had been calculated by the respective equations of statistical quality control method X-bar, R-bar, P-bar chart and C-chart. In X-bar charts, the X bar chart of Bahtoo has central tendency and there are no out of control limits during the construction stage. For Figure 2, number 3 and 10 are out of control limits. It means that health management and inspection of ready mix concrete fields are needed to inspect more to get the better quality improvement of this construction project. By comparing this X bar charts, Project 1 which had been constructed at Bahtoo Road has more stability than the Project 2 at North Okkalapa township. In X-bar charts, administrative fields are upper control limits because both quality control engineers and supervisors took administrative roles and responsibilities. All checklists are same for both site engineers and quality control engineers in construction projects. Although checklists are same, engineers of construction sites are different. These are constructed under different companies.

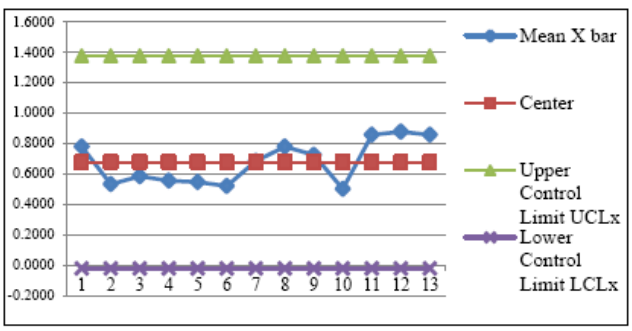

Fig. 1 X-bar Chart for 8.5 th storey building Bahtoo Road, North DagonTp.

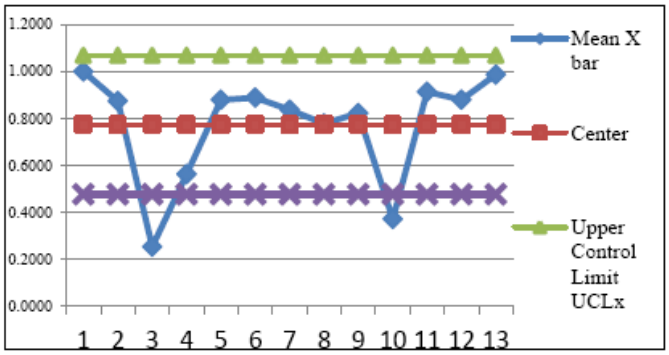

Fig.2 X-bar Chart for 8.5 th storey building Thandar Road, North OkkalapaTp.

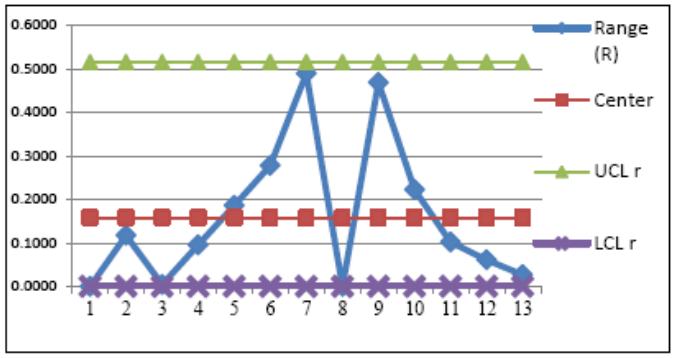

Fig.4 R-bar Chart for 8.5 th storey building Thandar Road, North OkkalapaTp.

Figure 3 and 4 explains the R bar charts which had been checked by site engineer and external quality control engineer of projects. They show the dispersion or variance of the process. The control limits for this chart type are defined as the estimate of the long-term process and it means establishing during control-chart setup. If the lower control limit is less than or equal to zero, process observations only need be plotted against the upper control limit. Historically, the R charts have been the most commonly used control charts for the process variation because they are the simplest to calculate. R charts are also used to monitor the variation of a process and if a point is outside these established control limits, it indicates that the variation of the process is out-of-control. The observations of proportion nonconforming below a positive lower control limit mean they are more frequently evidence of improperly calibrated test and inspection equipment or inadequately trained inspectors than of sustained quality improvement. In these figures, the variations of both projects are restless between numbers 4 and 13. The most distinct parts are number 5,6,7,8 and 9.These mean that fields of environmental management, risk management, equipment management and material management are still needed to inspect for better performances.

For material, the result of checking rebar is upper control limit in both construction projects because both site engineers and project engineers checked the quality of rebar material in vision and others are within control limits in every stage as these are still needed to check in some construction checkpoints. The results of R-bar charts for these buildings are within control limits. It means that although there were some variances in the process, these cannot be affected to the whole process hugely. According to figures 3 and 4, the inspection results of quality control engineers and site engineers are quite different in these fluctuated fields.

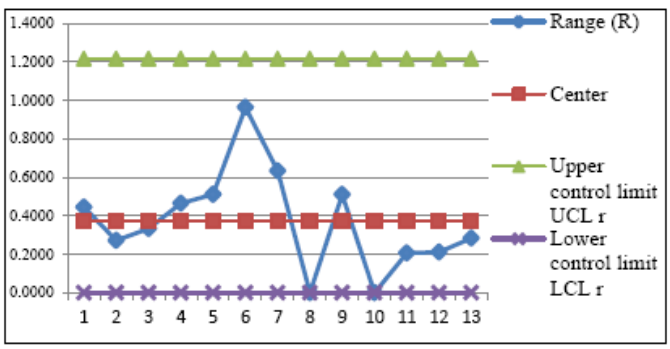

Fig.3 R-bar Chart for 8.5 th storey building Bahtoo Road, North DagonTp.

Although they used the same construction checklists, the inspection results are quite different and so top management should be aware their results because the results are come out from the checklists of site engineers and external quality control engineers. Engineers in both of companies are still weakened to obey roles and responsibilities of their respective fields because some results are opposite in YES and NO answers. For examples, the answers are quite different at the question of checking the preparations for unforeseen weather condition for concrete pouring. Site engineer answered YES for this question and then quality control engineer found that it is not true. In this way, the process's variations are restless in these figures.

Figure 5 and 6 explain the P bar charts, which had been checked by site engineer, and external quality control engineer of each construction project. P-bar chart shows the proportion of nonconforming units of each subgroup from number 1 to 13 on the Y-axis. In the P bar charts, safety management is suspected whenever the control chart indicates an out-of-control process. In the figures, both of the construction projects faced out of control in safety management. Many defects means it is not inspected are found in the construction checklists. Therefore, safety management is one of the areas that should be emphasis in quality management system of these construction projects. The checkpoint of construction process (after) is also the important area because all people in the construction project don't emphasis on that filed effectively. Construction processes (before and during) are upper control limits and some points exceed expected conditions and so it can be assumed that engineers are skillful and inspected regularly on these respective fields.

Figure 7 and 8 explain the C bar charts of the projects. C-charts are measured by the number of nonconformities per item or group of items and changes over time. If a point is outside these established control limits, it indicates that the number of nonconformities for a unit of the process is out-of-control. For safety management, it is the same as P bar chart structures and workers are still needed to emphasis on wearing personal protective equipment (PPE) during their working time. According to the weather conditions, most of general workers refuse to obey wearing personal protective equipment when they are working. Emergency response plan still has been left to prepare during superstructure work. In figures 7 and 8, control limits have been established for the C charts and these limits may be used to monitor the number of nonconformities (defects) of the process going forward. Data analysis results of site engineer and external quality control engineer are quite different at the variations

points of 2, 3 4 and 5.It means that site engineers are not much interested in the field of quality control management and don't take full responsibilities in their respective roles because yes is the common answer in their respective checklists. An initial series of units is used to estimate the average number of nonconformities of a process and the estimated value is used to produce control limits for the number of nonconformities. If points are out-of-control during the initial phase, the problems should be determined and the best solutions should be figure out for them.

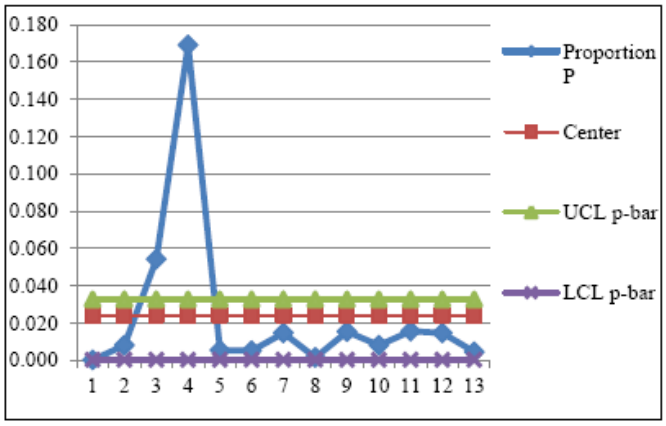

Fig.5 P bar chart for 8.5 th storey building Bahtoo Road, North DagonTp

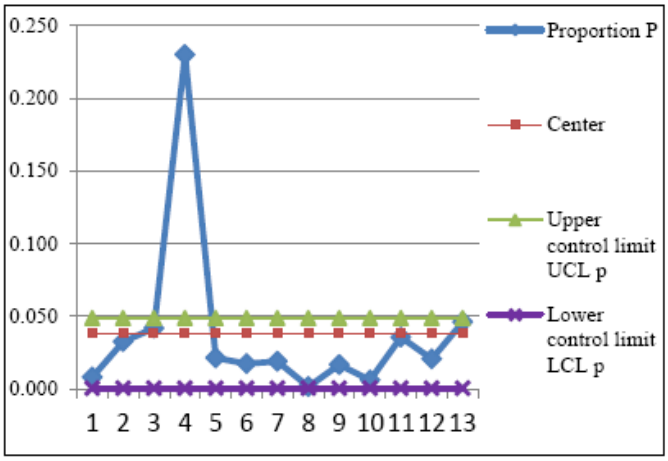

Fig.6 P bar chart for 8.5 th storey building Thandar Road, North OkkalapaTp.

In data analysis results, sub groups no.004, safety management, is out of control in both construction projects although they are constructed under different companies. It means that construction projects are weakened at the safety management and top management should be aware of on that field to safe from accidents and incidents and also get continuous improvements of quality management system. Safe work method, statement (SWMS) and cleanliness are needed to put in surveying and excavation work. Emergency response plan is also needed to prepare and should be used. Lack of quality control and quality assurance, skilled labor shortage, absence of material quality control, without site inspections and loss of good communication are the fundamental problems in construction sites. In total quality management, these can cause the design or structural failure, absence of applying construction method and techniques, loss of quality schedule and management and reduce customer satisfaction. There is still need to study building codes and construction techniques in constructions. Moreover, quality controls of materials in constructions are also considered. In some cases, there was found the answer of YES although it is quite different in the actual conditions. For overall percentage of defects, it has been found that the superstructure of Bahtoo construction project increased 2.46% of defects than the substructure and defects are mostly found in the area of inspection and testing, health, safety and environmental management.

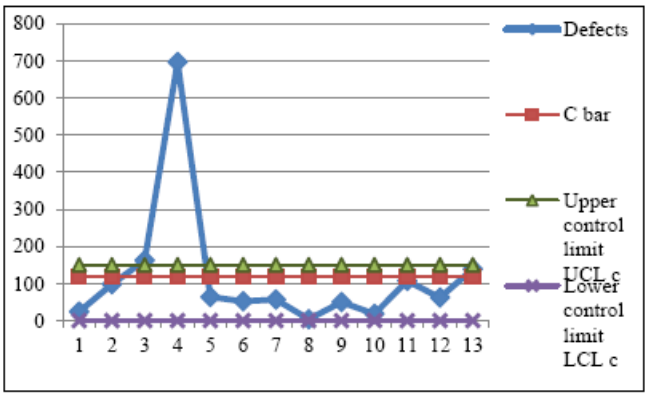

Fig.7 C bar chart for 8.5 th storey building Bahtoo Road, North DagonTp

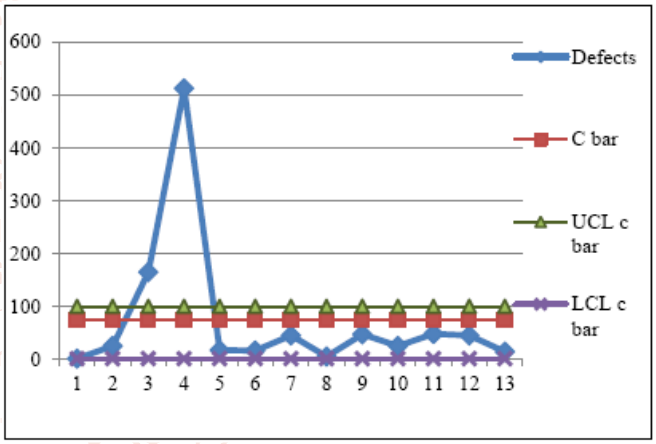

Fig.8 C bar chart for 8.5 th storey building Thandar Road, North OkkalapaTp

V. DISCUSSION AND CONCLUSION

According to the analysis of statistical quality control results, figure 1 and 2 display the central tendency of the process. In the figures, data analysis results of X bar chart of substructure and superstructure are fluctuated between number 3 and 11. It means that the process is not consistent with fields and sub-divisions of the construction project and a lot of sub groups are out of control limits such as HSE management, equipment management, material management and construction process (before). So, the management team of the projects need to emphasis on these fields to get the better quality performance in central tendency. Figure 3 and 4 show the results of R-bar charts of the buildings and they expressed that the answers of the checklists of site engineer and quality control engineer are quite different at these sub groups and top management necessary to conduct their roles and responsibilities to minimize the variance of the process. Although equipment management is upper control limit in both construction projects, it is still needed to inspect in both and defects are greater than other sub groups. There are assumed that calibration tests, apply code of practice and standards, available of competent person, documents and records are weakened in construction projects and top management should be aware on that areas if they want to get better

results of equipment management. In Myanmar, planning of documents in equipment management such as mobilization and demobilization plan, equipment inspection and testing schedule and equipment master list are rarely used in most construction projects. So, many construction projects face problems concern with it and it leads to occur delaying of time, schedule and cost overrun. According to the results of external quality control engineer, health management, safety management and construction process (after) are other important areas to checked regularly. On job training and daily tool box meeting need to be given to labors to get the continuous improvement of the project. First-aid kit, health care system and emergency response plan should be prepared for better quality performance. Inspection and testing is also the other weak point for the construction process and it can widely affect the quality of construction materials and the whole process. In some cases, complexity of roles and responsibilities matrix is found among site engineer, project manager and quantity surveyor. For construction process, both project engineer and site engineer used construction checklists and results are satisfied in both substructure and superstructure.

By using these statistical quality control methods, quality weak points can be analyzed and reduced to get the better quality performance of the construction project. These methods can measure the central tendency of the process, the dispersion or variance of the process and the proportion of nonconforming units of the process of the projects. Myanmar, our country is still developing country and effective quality management system of construction project is essential not to lose business, liability, productivity and costs of the construction. Although it can get the better results of quality, it is very important to check the inspection checklists daily and answers must be accurate to run statistical quality control methods. In some cases, role matrix complexity has been found between site engineers and quality control engineers. Calculations of external and internal failure costs such as quality costs, including prevention, appraisal and failure costs are highly recommended for the future investigations.

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