Applications of Statistical Quality Control Tools in Construction Industry a Quality Approach

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***Abstract*: It has been the aim of engineers to strive at higher and higher accuracy, but absolute accuracy is unattainable. Every process and its output are subject to variation.. Statistics acts as a practical tool in this direction. Statistics refers to the collection, organization, analysis interpretation and presentation of data. SQC involves analysis of characteristics of a output by inference from sampling the output .The analysis make to ensure that process remains in control. In SQC, the actual physical measurements are first secured by means of inspection. Control chart are used to separate out the assignable cause of quality variation. Random samples of work in progress are taken at random and inspected. A large data regarding different test conducted on different types of material are taken and process under SQC and control chart ,also the MATLAB software which provides the output in form of table chart containing the average X, the range R, standard deviation, Variance etc and also gives the X-chart and R-chart**

***Keywords*: SQC techniques, X-chart, R-chart, MATLAB software.**

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1 INTRODUCTION

SQC employs statistical methods to manage the quality of goods and services. In 1924, Walter A. Shewhart of the Bell Telephone Laboratories laid the foundation for statistical quality control.

Since then, the area of SQC has been enriched by the work of numerous statisticians, quality philosophers, and researchers. The prominent contributors include H.F. Dodge, H.G. Roming, Edwards Deming, Joseph M. Juran, Kaoru Ishikawa, and Philip Crosby, just to name a few. The chronological account of statistical methods and statistical thinking to quality control is provided in the section that follows. Next, the debate of whether the statistical quality control has evolved or been evolving as evolutionary or revolutionary research program is presented.Control chart is intended to monitor process stability and variability. The graph includes a Centre Line, an Upper Control Limit and a Lower Control Limit. Control chart is one of the most important SQC methods in quality control and improvement. A huge data regarding the various tests conducted on concrete while the work in progress was collected. Furthermore, that those data was unbiased and a religious adherence to random selection of samples was usually necessary to insure that lack of bias. To accomplish that, a specially designed sampling plan using random number tables was used for developement for statistical parameters.

2 METHODOLOGY

The method to carry out the statistical quality control work will be as follows-

1) The test performance data was collected by a construction company which is a contracting firm specialized in RCC work of building.
2) From individual sites the data was collected in form of stock register entries for cement, river sand, and coarse aggregates received on site, the test record register for the raw materials, the quality check list before concreting, pour card before concreting and pour card after concreting, quality tests in form of N.D.T. to test the quality of concrete, the quality standards as per set by the consultants as per IS Code for concrete.
3) The data was collected from three different sites in progress simultaneously by the same having the topographical and environmental variations may be there.
4) The data collected was carefully studied and segregated as per statistical quality check requirement and was arranged in tabular table method form (frequency distribution method) and was carefully analyzed.
5) The computer program was prepared in MATLAB in which the various control charts are easily displayed selecting the suitable acceptance sampling number and the data in form of variance and 3σ values.
6) The standard deviation and the variance were calculated by tabular form method.
7) The result was tabulated and plotted on X-chart and R-charts graphs for each individual site for the same construction company and comparative statement was prepared by selecting suitable acceptance sampling number.

2.1 Mathematical Model:

The mean, **X** is a measure of central tendency of a group of measurements.

Mathematically:

$$\mathbf{X}' = \sum \boldsymbol{Xi}/\boldsymbol{n}$$

$\boldsymbol{Xi}$ = Individual observations and

$\boldsymbol{n}$ = Number of observations in a group.

The standard deviation σ (sigma) is a measure of the dispersion of the measurements from their mean. The mathematical definition is:

$$\boldsymbol{\sigma} = \sqrt{\frac{\sum(\boldsymbol{Xi}-\boldsymbol{X}\prime)^2}{\boldsymbol{n}-1}}$$ where, $\boldsymbol{X_i}$, $\boldsymbol{X}$ and $\boldsymbol{n}$ as above.

The variance ($\boldsymbol{V}$), is the square of the standard deviation, mathematically,

$$\boldsymbol{V} = \boldsymbol{\sigma}^2$$

The standard error ($\boldsymbol{\sigma'_x}$) is the standard deviation of mean of several samples and is estimated by:

$$\boldsymbol{\sigma'_x} = \boldsymbol{\sigma}/\sqrt{\boldsymbol{n}}$$

2.2 Testing Of Materials

The Procedure of various tests conducted on materials is as follows

2.2.1Compressive strength of cement

The Compression Test is a laboratory test to determine the characteristic strength of the cement but the making of test cubes is sometimes carried out by the supervisor on site. This cube test result is very important to the acceptance of cement, since it demonstrates the strength of the design mix.
The compressive strength is studied by determining the compressive strength of cement sand mortar.

Figure 1 Commpressive Testing Machine

2.2.2 AGGREGATE CRUSHING VALUE

The apparatus used is cylindrical measure and plunger, Compression testing machine, IS Sieves of sizes – 12.5mm, 10mm and 2.36mm.) The weight of aggregates is measured (Weight 'A'). The sample is then sieved through a 2.36mm IS Sieve and the fraction passing through the sieve is weighed (Weight 'B'). Aggregate crushing value = (B/A) x 100%.

2.3 ATHSHREE II AT KHARADI PUNE

MATERIAL - RIVER SAND
TEST CONDUCTED - SILT CONTENT TEST
NO OF TRUCKS CONSUMED -470 TRUCK CAPACITY - 3 BRASS
SAMPLES TAKEN PER TRUCK-5
THE QUALITY STD AS PER IS - 7 %

Table 2.3.1 Material-River Sand(Silt Content Test)

TRUCK NO	SAMPLES TAKEN					AVG X	RANGE R	σ	$v = \sigma^2$
	1	2	3	4	5				
1	6.85	6.75	6.65	6.66	6.64	6.71	0.21	0.0802	0.0064
2	6.68	6.66	7.11	7.12	7.13	6.94	0.47	0.2206	0.0487
3	7.31	7.32	7.35	6.95	6.98	7.18	0.40	0.1779	0.0317

TEST CONDUCTED - CRUSHING STRENGTH

NO OF TRUCKS CONSUMED - 520
SAMPLES TAKEN PER TRUCK - 5
THE QUALITY STD AS PER IS - 40 %
THE QUALITY STD AS PER IS - 40 %

Table 2.3.2 Material-River Sand(Crushing Strenght Test)

TRUCK NO	SAMPLES TAKEN					AVG X	RANGE R	σ	$v = \sigma^2$
	1	2	3	4	5				
1	38.25	40.00	38.50	38.25	39.00	38.80	1.75	0.6595	0.4350
2	39.00	38.75	39.25	39.50	39.00	39.10	0.75	0.2550	0.0650
3	36.00	36.50	37.00	39.00	38.15	37.33	3.00	1.0980	1.2056
4	35.00	38.00	35.65	36.55	36.15	36.27	3.00	1.0083	1.0166
5	38.00	39.00	38.75	39.15	40.00	38.98	2.00	0.6454	0.4166

3 CONTROL CHARTS

Control of any repetitive process such as production of Portland cement concrete or bituminous hot mix is of prime importance. A control chart is a statistical tool, which gives a visual indication of the state of control of any production process. It is an instrument to be used in specification, production and inspection and

3.1 Objectives of Control Charts –

1) X-charts and R-charts are used in combination for the control process.X-charts shows the variation in the averages of samples.R-chart shows the variation s in the ranges of samples.
2) The control charts are used to determine whether a given process can meet the existing specifications without a fundamental change in the production process. when so used, brings these three phases of industry into an interdependent whole.

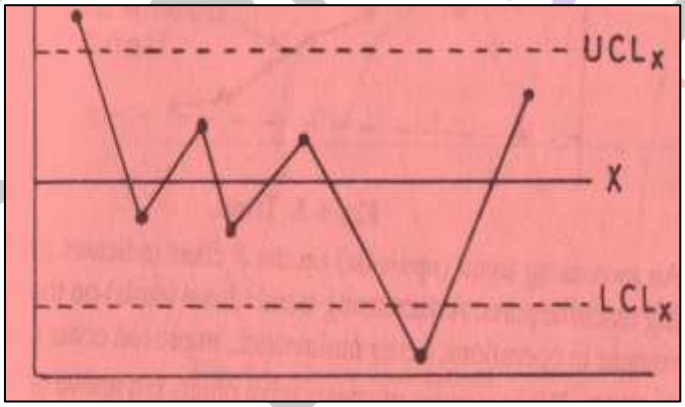

FIGURE 7.1: Control Charts (X-Chart)

3.2 Types of control charts

Variables or measurement charts – 1) X-charts; 2) R-charts; 3) σ-charts

Attribute charts – 1) p-charts; 2) n-p-charts; 3) C-charts; 4) U-charts

4 About MATLAB and SIMULINK

4.1 What Is MATLAB?

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include:

•Math and computation

•Algorithm development

•Modeling, simulation, and prototyping

•Data analysis, exploration, and visualization

•Application development, including graphical user interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar noninteractive language such as C or FORTRAN.

R-CHART DISPLAY:

Figure 9.5: R-chart for compressive test of cement

X-CHART DISPLAY:

Figure 9.6: X-chart for compressive test of cement

IV. RESULTS

COMPARISON BETWEEN THREE SITES WORK

As all the charts are having extreme variation patterns which indicates the following causes –

1) Change in material properties
2) Change in machineries
3) Change in operation work due to labour replacement

Overall result including above matters and study of the X-charts and R-charts are as follows:

COMPARATIVE RESULT EXTRACTED FROM THREE SITE CHART

SR. NO.	NAME OF SITE	PARTICULARS					REMARKS
		QUALITY OF CEMENT	QUALITY OF RIVER SAND	QUALITY OF AGGREGATE	QUALITY OF CONCRETE		
					MACHINERY	WORKMANSHIP	
1	ATHSHREE - II AT KHARADI	B	C	B	D	D	PROCESS NOT IN CONTROL
2	SAPTAGIRI AT BANER	B	C	C	E	E	PROCESS NOT IN CONTROL
3	ATHSHREE - III AT WAARJE MALWADI	B	B	B	C	C	PROCESS IN CONTROL

GRADES	EXCELLENT	A
	GOOD	B
	MEDIUM	C
	POOR	D
	WORST	E

ACCEPTANCE PLAN - 3 FAILED TEST RESULTS PER LOT OF 30 TEST RESULTS ARE PERMISSIBLE

CONCLUSION

The best of specifications can not fully accomplish their objectives unless they are uniformly interpreted and enforced. However, uniformity in interpretation and enforcement can only be achieved through proper knowledge of what is involved in statistically adopted specifications. Adoption of statistically derived acceptance plans for materials or job compliance will undoubtedly present multitude of factors, some large as to involve administrative decisions and other small enough to be tackled by field personnel.

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