

## Application of Statistical Quality Control Tools In Concrete Road Construction

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**Abstract**-In this paper a statistical quality control tools such as control charts, acceptance sampling are utilized for the concrete road construction in Mumbai region. Specifically, authors utilized control charts such as  $\bar{x}$  chart and R-chart while constructing the concrete road for the sake of monitoring the quality during construction and also developed acceptance plan for the accomplished part of road to restore quality of concrete road which is constructed and also they evolved an acceptance sampling plan for the incoming material such as paver block based on their acceptance criteria. From the analysis, it is found that there is lack of consistency during the construction and also process went out of control during construction.

**Keywords**-Quality Assurance, Control Charts, Acceptance Sampling.

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### I. INTRODUCTION

Quality control deals with the Process through which we measure the actual performance of that process and then it compares with standard or goal and measure the deviation and act on the deviation.”

Statistical quality control is the set of statistical tools used in the quality control. It can be divided in the three categories.

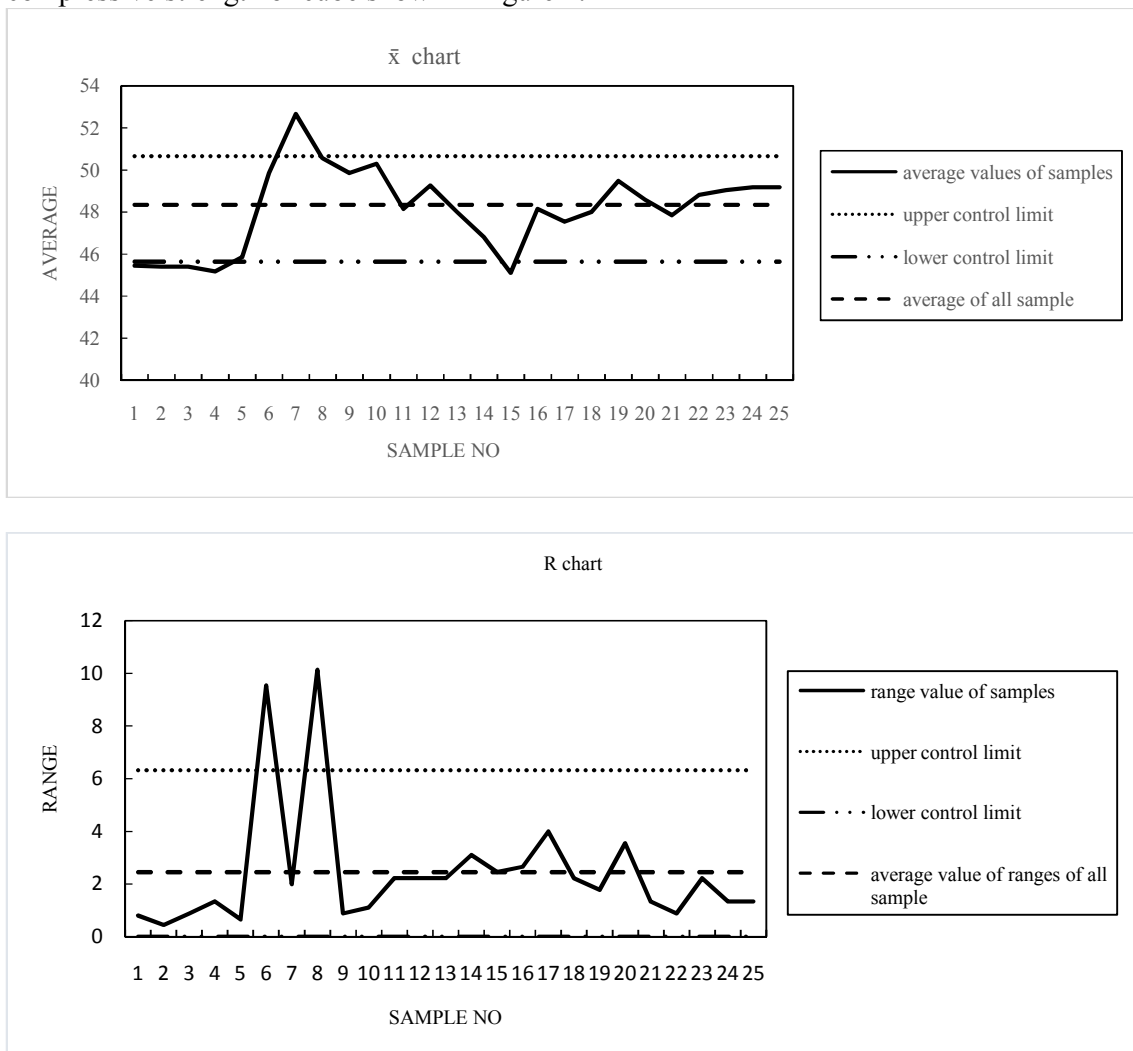
- i) Descriptive statistic-: A statistic which describe quality characteristics such as central tendency, variability of observed data by using mean, standard deviation, range.
- ii) Statistical process control-: In this process, a sample from the process are drawn and decide whether the process is producing products with characteristics that lie within the specified range. It also helps to identify consistency in the process. This is achieved by using various control charts.
- iii) Acceptance Sampling-: In this sampling a sample from lot which is representative of lot is randomly selected in order to take decision for accepting or rejecting the lot.

Most of the researchers utilized statistical quality control tools for various project. Khaled and Walid evolved control charts such as control charts for individual and moving range chart for finding out the cost overrun of the project. David Kosnik applied a statistical process control framework to support structural health monitoring of the Grace Church building in Charleston. Luh and Machine told that choice of proper quality acceptance sampling methods depends upon the characteristics of construction process and author also mentioned various acceptance sampling methods. All the researchers found that statistical quality control tools prove an efficient tool for controlling the quality of work.

This paper deals with an application of statistical quality control tools in the concrete road construction in Navi Mumbai region. There are different statistical quality control tools which can be used in assuring the quality of the work. There are two types of control charts i) control charts for variables and ii) control charts for attributes. Control charts for variables such as  $\bar{x}$ , R chart, moving range chart etc. help to identify common type of the variation in the process and also define the control limits for the process so one can easily identify when the process go out of control from the chart by entering the value of variables such as compressive strength of cube, density of the core etc. acceptance sampling which is the one of the major part of the statistical quality control tools help whether to accept or reject work based on their acceptance criteria.

## II. IMPLEMENTATION OF CONTROL CHARTS DURING THE CONSTRUCTION OF ROAD

For this analysis data are collected from Murbad diversion road located in Mumbai region. As per the specification of road, nine cubes from each transit mixture should be tested during the construction of the road for respective 7, 14 & 28 days compressive strengths. The authors took 28 days compressive strength of cubes and such 25 samples for respective chainages are taken during the construction of road for the analysis and developed  $\bar{x}$  and R chart for the 28 days compressive strength of cube shown in figure 1.



*Figure 1.  $\bar{x}$  and R charts for compressive strength of cube*

From the above analysis it is found that there is lack of consistency while constructing the road and also at some location process went out of control. As these control limits are not specification limit so the samples which are above or below control limit may or may not be accepted. Contractor can monitor the construction process by utilising control charts so this will avoid future rework or scrap work and also reduce the cost related to rework.

### III. ACCEPTANCE PLAN FOR ACCOMPLISHED WORK

As per specification of the road, for every 150 m<sup>3</sup> of completed work of road one core should take for the sake of computing quality of road after the construction. For this plan, compressive strength of twenty core samples have been taken for the analysis. In this analysis quality indices are calculated by using following equations (1) and (2). From these indices and sample no a lot percentage defectives P<sub>U</sub> and P<sub>L</sub> are calculated. As in this plan only lower specification limit is specified so P<sub>L</sub> is calculated. Also a Moving Range chart is developed as shown in figure 2 for compressive strength of core in order to show variances or deviation in the process.

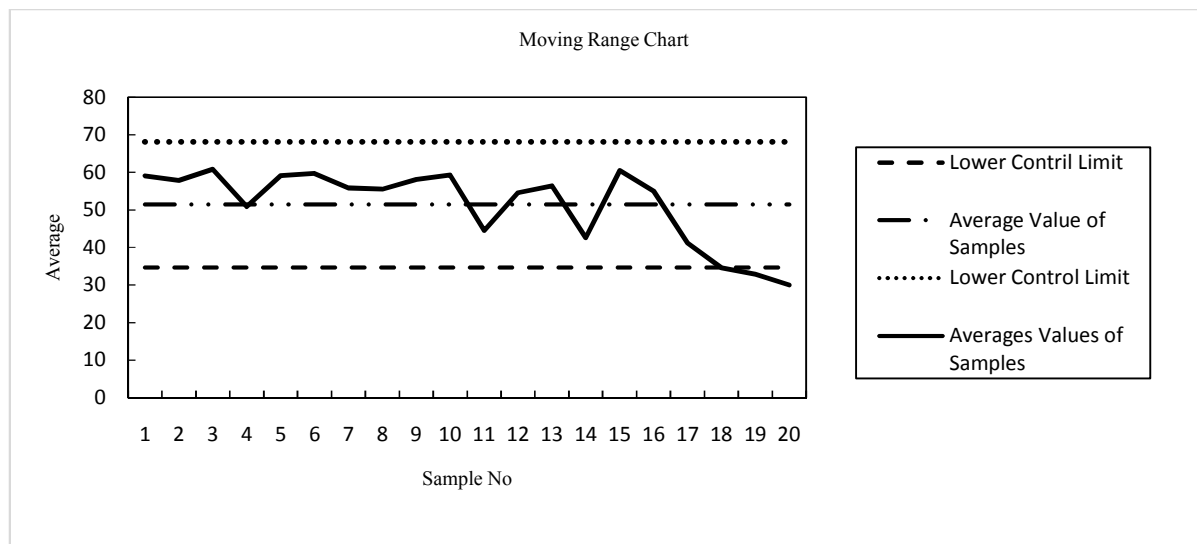
Calculations

$$Q_L = \frac{(\bar{X} - L)}{S} \tag{1}$$

$$Q_U = \frac{(U - \bar{X})}{S} \tag{2}$$

- Where,  $\bar{x}$  = Mean of the Sample
- S = Standard Deviation of the Sample
- U = Upper Specification Limit
- L = Lower Specification Limit

As  $Q_L = 1.0197$  form calculation of samples,  
 So based on  $Q_L$  and sample no, value of  $P_L = 15.83$ .



**Figure 2. Moving Range Chart for Compressive strength of Core**

Above graph shows deviation in the process. As per the standards charts, values of compressive strength should be near to the mean value but in above graph some values are near to mean and some are away from mean and some values are below the lower control limit.

Based on  $P_L$  value a decision should be made whether to accept the work or reject, as this value compares with their acceptance criteria and check whether this value falls within the specified range.

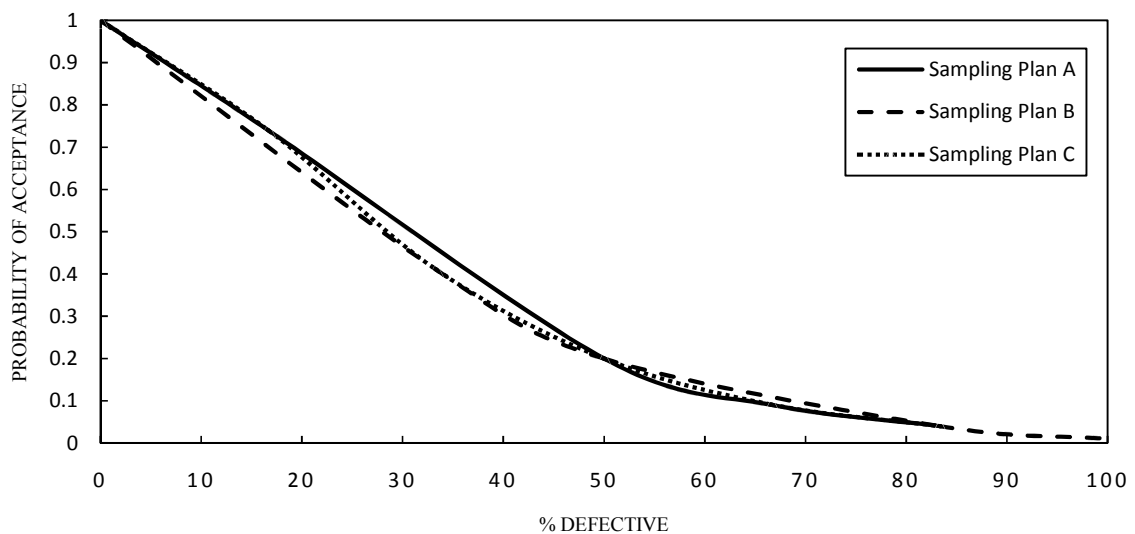
#### IV. ACCEPTANCE SAMPLING PLAN FOR PAVER BLOCK

As per specification of road six paver block should be tested for every unloading and a decision should be made whether to accept or reject lot. A detailed accepting sampling plans are developed based on their acceptance criteria. The calculation of one of the acceptance sampling plan is shown below in table 1 and operating characteristics curves for each sampling plan are shown in figure 2.

$N$ = Total no of paver block in a lot,  $n$ = total no. of paver block actually tested from lot,  $c$ = Acceptance number,  $X$  = no of defectives in tested paver block, Probability of Acceptance calculated from the Poisson probability.

**Table 1. Calculation of Acceptance Plan**

N	n	C	No of Defectives	% Defectives	Probability of Acceptance
5000	6	1	0	0	1
5000	6	1	1	16.67	0.74
5000	6	1	3	50	0.2
5000	6	1	4	66.67	0.09
5000	6	1	5	83.33	0.04



**Figure 3. Operating Characteristics Curve for Acceptance Sampling Plans.**

#### V. CONCLUDING REMARK

To maintain the quality in construction of road there should be a strong procedure for monitoring the quality of work. For this statistical quality control tools prove an efficient tools for maintaining quality of the work. By using control charts such as  $\bar{x}$  and R chart Contractor can

monitor quality of road which is being constructed and also by using acceptance sampling the Engineer or quality controller can make a decision whether completed work should be accepted or rejected. If these tools are used in the specification of road, then there will be a strong procedure to monitor the quality of work and also this will be helpful to the Contractor and Engineer to maintain the quality of work and this will avoid future rework and cost related to it.

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