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# An Analysis of Concrete Test Weight with Different Water Cement Factors Using Histogram in Quality Management

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**Abstract.** Concrete is a product with the composition of binding medium in which there is an aggregate pigments or particles. The binder is formed by cement and water mixture. Cater cement factor affects the compressive strength result. In producing concrete, a quality control is needed to obtain performance or process variation. In order to obtain the quality, statistical analysis using histogram method in the form tables and graphs is needed. From the measurement analysis results of 30 concrete test objects with different cement water factors getting uneven and unpredictable distribution results. The greater the cement water factor, the more dispersed the distribution of the cement will be but the weight of the concrete will decrease.

## 1. Introduction

Concrete is naturally a material that is a basic form of modern social life and is a composite material consisting of coarse and fine aggregates mixed with water and cement as binder and filler between the aggregates [1]. The weight of concrete test object is also strongly influenced by water/cement ratio [2]. To get the performance or variation process, it is necessary to have a quality control. Quality management is aspects of the overall management function that implements and carries out the quality of a company / organization, in order to meet customer needs and time requirements with a economical and economical budget, a project manager must enter & conduct quality management training [3]. The measurement process for concrete quality can be obtained from concrete testing, namely compressive strength, weight, volume and specific gravity [4]. For measuring the difference in the concrete mixture process, histogram method was employed. Histogram is a tool or method for making data summary to be easily analyzed [5]. The presentation of the bar diagram is depicted with cells that have the same area of data between cell 1 and the other with no distance, because the data includes continuous data that continues so that the one with the next one must coincide [6]. In the manufacture of concrete there are several things that need to be considered in concrete quality control with variations in concrete production, namely variations in cement water factors [7].

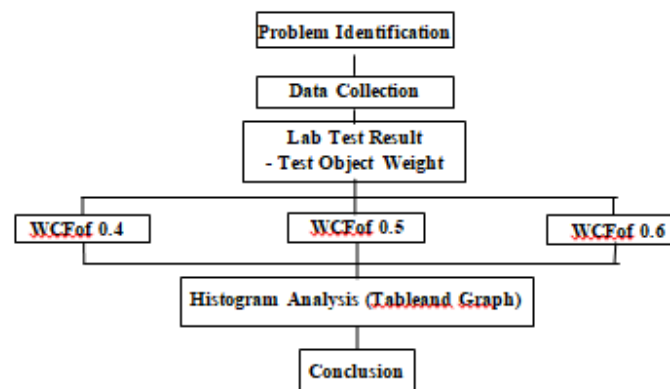


## 2. Literature Review

Quality control techniques so that data is easily analyzed is using a histogram method that has the benefits of: obtaining process stability, performance or process variation, testing, evaluating, developing and monitoring process improvement [8]. Quality control techniques to ease data analysis process was by using histogram method with the benefits including: obtaining the process stability, performance or process variation, testing, evaluating, developing and monitoring process improvement [9]. Concrete is a complicated composite material, can be made easily even by those who have no understanding of concrete technology, but this misconception of simplicity often results in problems with products, including the reputation of concrete as building material [10]. The weight of concrete is also a very decisive factor since the measurement of concrete test results are obtained from compressive strength, weight, and volume. The water cement ratio is the ratio of the weight of water to the weight of cement used in a concrete mix. A lower ratio leads to higher strength and durability, but may make the mix difficult to work with the use of plasticizers or super plasticizers [11].

## 3. Method

The data source used in the histogram analysis was test/measurement results of concrete test object from the laboratory as many as 30 specimens with Water Cement Factor (WCF) of 0.4, 0.5 and 0.6 at 28-day-old concrete.



**Figure 1.** Flow Diagram

The several steps required to construct histogram beginning with computing the range (R) of data [12] :

Step 1 : compute the range (R) of the data.  $R = X_{\max} - X_{\min}$

Step 2 : Compute the appropriate number of classes (k):  $K = \sqrt{n}$ , round up a k to of 6 classes.

Step 3 : Compute the appropriate class width (h):  $h = R/k$

Step 4 : Determine the unit of measurement (m): 1,00

Step 5 : Finalize the class width (h) by rounding up to the next highest to measure, So highest  $h = 20$

Step 6 : Compute the lower boundary of the first class (L1).  $L1 = (X_{\min} - m/2)$

Step 7 : Determine the lower boundary of the remaining of the classes:

$$L2 = L1 + h$$

$$L3 = L2 + h$$

$$L4 = L3 + h$$

$$L5 = L4 + h$$

$$L6 = L5 + h$$

$$L7 = L6 + h$$

Step 8 : Using the class intervals, a frequency table is constructed shown. Note the upper boundary for L7 is also shown.

Step 9 : Making diagram number of traffic fines paid and fine paid.

#### 4. Result and Discussion

This research results on the measurement of test object weight and histogram analysis are presented in the form of table and graph.

##### 4.1 The weight of concrete test object with WCF of 0.4

**Table 1.** The weight results of 28-day concrete test object.

2.9	3.25	2.9	2.975	2.98	3.22
3.1	2.95	2.95	3.15	3.21	2.95
2.95	3.2	2.915	3.22	3.22	3.2
3.22	3.225	3.22	3.22	3.21	3.2
3.15	3.1	3.2	3.21	2.96	2.95

Computation:

A. Computing the total :

$$X = 93.105$$

Computing the mean :

$$X' = x/n = 93.105/30 = 3.10$$

B. Computing the range (R) of the data :

$$R = X_{\max} - X_{\min}$$

$$R' = 3.225 - 2.90 = 0.325$$

C. Computing the approximate class number of classes (k)

$$K = \sqrt{n} = \sqrt{30} = 5.48 = 6$$

D. Computing the approximate class width :

$$H = R/K = 0.325 / 6 = 0.054 = 0.1$$

E.  $M = 0.01$

F. Finalizing the class width (h) by rounding up to the next highest of measure :

$$h = 0.1$$

G. Computing the lower boundary of the first class :

$$L1 = X_{\min} - (m/2) = 2.90 - (0.01/2) = 2.895$$

H. Determining the lower boundaries of the remaining :

$$L2 = L1 + h = 2.895 + 0.1 = 2.995$$

$$L3 = L2 + h = 3.095 + 0.1 = 3.195$$

$$L4 = L3 + h = 3.295 + 0.1 = 3.395$$

$$L5 = L4 + h = 3.495 + 0.1 = 3.595$$

$$L6 = L5 + h = 3.695 + 0.1 = 3.795$$

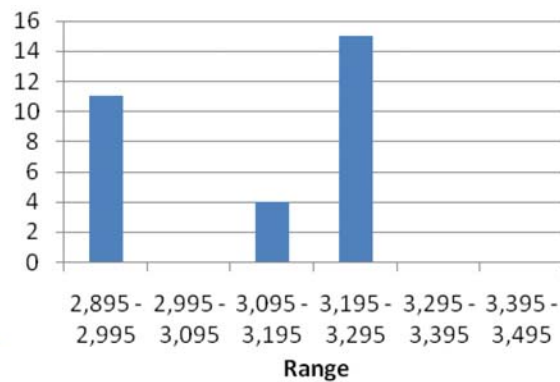
$$L7 = L6 + h = 3.895 + 0.1 = 3.995$$

I. Using the class intervals, a frequency table is constructed as shown.

The upper boundary note for L7 is also shown.

**Table 2.** 0.4 WCF Histogram

Class	Tally	Frequency
2.895 - 2.995		11
2.995 - 3.095		0
3.095 - 3.195		4
3.195 - 3.295		13
3.295 - 3.395		0
3.395 - 3.495		0



**Figure 2.** The Graph of 0.4 WCF Histogram

Based on histogram analysis, the weight spread of concrete test subject was uneven and 3 ranges were not fulfilled.

4.2 The weight of concrete test subject with 0.5 WCF

**Table 3.** The weight results of 28-day concrete test object.

2.9	3.25	2.9	2.975	2.975	3.15
3.1	2.95	2.95	3.15	3.21	2.95
2.95	3.2	2.92	3.22	3.22	3.22
3.22	3.225	3.22	3.22	3.1	3.22
3.15	3.1	3.2	3.21	2.92	2.92

Computation:

A. Computing the total:

$$X = 92.885$$

Computing the mean:

$$X' = x/n = 92.885 / 30 = 3.09$$

B. Computing the range (R) of the data:

$$R = X \text{ max} - X \text{ min}$$

$$R' = 3.22 - 2.90 = 0.32$$

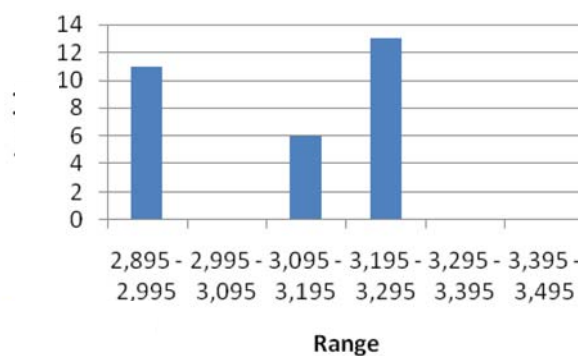
C. Computing the approximate class number of classes (k)

$$K = \sqrt{n} = \sqrt{30} = 5.48 = 6$$

- D. Computing the approximate class width:  
 $H = R/K = 0.32 / 6 = 0.053 = 0.1$
- E.  $M = 0.01$
- F. Finalizing the class width (h) by rounding up to the next highest of measure:  
 $h = 0.1$
- G. Computing the lower boundary of the first class:  
 $L1 = Xmin - (m/2) = 2.90 - (0.01/2) = 2.895$
- H. Determining the lower boundaries of the remaining:  
 $L2 = L1 + h = 2.895 + 0.1 = 2.995$   
 $L3 = L2 + h = 3.895 + 0.1 = 3.095$   
 $L4 = L3 + h = 4.895 + 0.1 = 3.195$   
 $L5 = L4 + h = 5.895 + 0.1 = 3.295$   
 $L6 = L5 + h = 6.895 + 0.1 = 3.395$   
 $L7 = L6 + h = 7.895 + 0.1 = 3.495$
- I. Using the class intervals, a frequency table is constructed as shown.  
 The upper boundary note for L7 is also shows.

**Table 4.** 0.5 WCF Histogram

Class	Tally	Frequency
2.895 - 2.995	 	11
2.995 - 3.095		0
3.095 - 3.195		6
3.195 - 3.295	 	13
3.295 - 3.395		0
3.395 - 3.495		0



**Figure 3.** The Graph of 0.5 WCF

Based on histogram analysis, the weight spread of concrete test subject was uneven and 3 ranges were not fulfilled.

#### 4.3 The weight of concrete test subject with 0.6 WCF

**Table 5.** The weight results of 28-day concrete test object

2.56	3.2	2.21	3.2	2.9	2.9
2.92	2.2	2.92	3.3	3.5	3.2
3.27	2.56	3.27	3.38	3.2	3.38
3.23	3.3	3.23	3.5	3.2	2.9
3.2	2.79	3.38	3.9	2.95	3.2

Computation:

A. Computing the total:

$$X = 92.85$$

Computing the mean:

$$X' = x/n = 92.85 / 30 = 3.09$$

B. Computing the range (R) of the data:

$$R = X_{\max} - X_{\min}$$

$$R = 3.90 - 2.79 = 1.11$$

C. Computing the approximate class number of classes (k)

$$K = \sqrt{n} = \sqrt{30} = 5.48 = 6$$

D. Computing the approximate class width:

$$H = R/K = 1.11 / 6 = 0.185 = 0.1$$

E.  $M = 0.01$

F. Finalizing the class width (h) by rounding up to the next highest of measure:

$$h = 0.1$$

G. Computing the lower boundary of the first class:

$$L1 = X_{\min} - (m/2) = 2.79 - (0.01/2) = 2.785$$

H. Determining the lower boundaries of the remaining:

$$L2 = L1 + h = 2.785 + 0.1 = 2.885$$

$$L3 = L2 + h = 2.885 + 0.1 = 2.985$$

$$L4 = L3 + h = 2.985 + 0.1 = 3.085$$

$$L5 = L4 + h = 3.085 + 0.1 = 3.185$$

$$L6 = L5 + h = 3.185 + 0.1 = 3.285$$

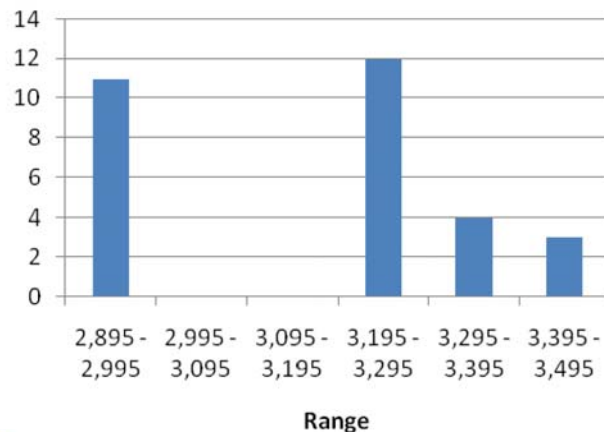
$$L7 = L6 + h = 3.285 + 0.1 = 3.385$$

I. Using the class intervals, a frequency table is constructed as shown.

The upper boundary note for L7 is also shown.

**Table 6.** 0.6 WCF Histogram

Class	Tally	Frequency
2.895 - 2.995	 	11
2.995 - 3.095		0
3.095 - 3.195		0
3.195 - 3.295	 	12
3.295 - 3.395		4
3.395 - 3.495		3



**Figure 4.** The Graph of 0.6 WCF

Based on histogram analysis, the weight spread of concrete test subject was uneven and 2 ranges were not fulfilled

## 5. Conclusion

From table 1,2,3 and images of histograms 2,3,4 on specimens with FAS (0,4) FAS (0,5) and FAS (0,6), the results are uneven distribution. Indicates that the process is unstable and unpredictable with almost the same graphical form. Then the greater the FAS, the more spread the test specimen (FAS = 0.6).

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