An Assessment On The Effects Of Various Factors To The Efficiency Of Workers In A Pipe Manufacturing Company

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Abstract. Concrete pipes are one of the most common building materials used all over the world in the field of construction & civil engineering. This paper tackles about the labor's efficiency in the concrete pipes manufacturing. Efficiency also affects the worker's productivity since it is a high factor to be considered especially in masonry which is why masonry contractors gather detailed data on their workers’ productivity and as well as factors that may affect productivity. The group used ANOVA analysis to analyze the relationship based on employees’ age, length of service, employee satisfaction index, and acquired technical skills. The significance of this study will be beneficial to both the company and the masonry contractors and can optimize the availability of workers to improve its efficiency.

1. Introduction
The most difficult issue in construction industry in the most recent decade is the manner by which to enhance the productivity efficiency [1]. Productivity remains a fascinating subject and an overwhelming issue in the development part, encouraging cost reserve funds and proficient use of assets [2]. Profitability is a standout amongst the most essential issues in both created and creating nations which is a key factor in construction industry [3]. The created nations know about the significance of financial development and social welfare. The creating nations which confront joblessness issues, swelling and asset shortage look to use assets and in such an approach to accomplish financial development and enhance nationals’ lives. Efficiency is an issue of specific significance to ventures found [4].

Numerous investigations have been led that evaluate the execution of the construction industry, basically from a work efficiency perspective [5 -8]. Despite the fact that the aftereffects of efficiency contemplates on various ventures are frequently looked at, a large scale level examination can just evaluate the conceivable explanations behind varieties that is faced in the construction industry. Building material preparations for project is also significant in determining the productivity of the industry [8].

Concrete pipes are one of the most common building materials used all over the world in the field of construction & civil engineering [9]. Every year, the global production of concrete can be estimated to 6 billion cubic meters [9]. This is equal to approximately one cubic meter for every person on this planet [10]. Steel-reinforced concrete pipes are being used for road culvert, drainage systems, and
sewer pipe applications [10]. Concrete pipes are recognized for its quality of manufacturing, consistent strength, availability in designs and sizes to serve most installations, being easy to place, and providing a reliable and durable system, particularly under load [11].

D.A.P. Pipes Manufacturing (D.A.P. acronym came from the name of the President, David A. Pau) has been existing for more than 20 years. They currently boast their facilities coupled with skilled and trained employees. D.A.P Pipes Manufacturing offers Ordinary, Class II and Class IV cement pipes with sizes ranging from 6” to 72” diameter. Due to time constraint and limited given data by the company, the researchers limit their study to ordinary cement pipes with an inside diameter of 15” (375 mm). The size of 15” is also one of the most profitable sizes they manufactured.

Based on the researcher’s plant visit, the group noticed that in the pipe molding process there are 3 groups with different characteristics. While on the metal frame making, 3 workers are assigned on this process. Based on the companies given data, each team produces at least 500 pipes per month for the size 15” inside diameter. The workers are given 8 hours each day to produce concrete pipes. The current situation in the company depends on the skills and strategy of the workers. Through this given problem, the group would like to make a time and motion study to set standard time on the processes and to identify the maximum capacity of the workers they can produced each day. In general, the study aims to assess and analyze the relationship between the age of workers and their efficiency as well as their length of service.

2. Methodology

2.1. Research Design
The research design consists of the research purpose and the strategy for the results of study. The researchers used a comparative approach in the study. Comparative approach was used in determining the productivity of workers of the same production department but of different length of stay in the company.

2.2. Qualitative approach
The research will be composed of the descriptive way of explaining the theories, results, and other findings of the study. The result for the hypotheses such as approving, and disapproving is part of the approach. Other factors that will be considered in the qualitative approach are the behavior and personality of the workers.

2.3. Quantitative approach
The research will mostly contain quantitative data that concerns the accuracy, frequency, and measurements. These quantitative data will be used in determining the required and acceptable strategy to improve the problem. Some quantitative data are the time obtained from the time and motion study and the length (years) of stay of workers in the company.

2.4. Subject and Study Site
The researchers focused the study on DAP Concrete Pipe Manufacturing company solely. The specific department which the researchers focused on is the workers from the production department. The key respondents were segmented from the newly hired workers and regular workers.

2.5. Data Gathering Procedure
The researchers acquired the necessary information by conducting interviews with the people who are knowledgeable about the current production system of DAP Pipes Manufacturing Company. The people involved include the owner of the company, manager, supervisor, and the workers. The company in coordination with the plant manager handling the processing of reinforced concrete pipes allowed the researchers to conduct their study and received data needed with the agreement that it will be solely for academic purposes. Thus, the data of metal framing making was analyzed. The reading
were taken based on three workers for each task. The readings were comprised of 19 sets. Next these data were further analysed using Anova analysis. As for pipe molding, the reading were taken based on groups for 20 sets. data were further analysed using Anova analysis to test the hypothesis set.

3. Result and Discussion
Table 1 shows the result metal frame making that was done among three workers for 19 sets readings. The anova analysis for single factor was done to evaluate the statistical output of the metal frame making among the three workers. Table 2 and Table 3 shows the anova summary and results. The hypothesis were set as follow, the H0: \( \mu_A = \mu_B = \mu_C \), H1: at least two are not equal. H0: The mean production times of one metal frame for worker's A, B, & C are equal. H1: The mean production times of one metal frame for worker's A, B, & C are not equal. Also, H0: The length of service of the workers has no effect on the production time of metal frames. H1: The length of service of the workers has an effect on the production time of metal frames. Thus, from the result of the analysis, \( \alpha = 0.10 \), C.R \( f > 2.40 \), test stat \( f = 13.75 \), P-value = 0.000015, this it can be concluded that Since P-value < \( \alpha \), reject H0.

| Table 1. Metal Frame Making |
|-----------------------------|
| Metal Frame Making          |
| Worker (Minutes) | Worker (Minutes) | Worker (Minutes) |
|------------------|------------------|------------------|
| 2.33             | 2.05             | 2.17             |
| 2.31             | 2.27             | 2.49             |
| 2.33             | 2.01             | 2.28             |
| 2.58             | 2.10             | 2.58             |
| 2.37             | 2.16             | 2.37             |
| 2.22             | 2.18             | 2.22             |
| 2.26             | 1.92             | 2.27             |
| 2.32             | 2.18             | 2.01             |
| 2.37             | 2.35             | 2.24             |
| 2.16             | 2.11             | 2.04             |
| 2.34             | 2.09             | 2.55             |
| 2.43             | 2.07             | 2.38             |
| 2.60             | 2.02             | 2.26             |
| 2.32             | 2.18             | 1.98             |
| 2.24             | 2.06             | 2.62             |
| 2.33             | 1.99             | 2.24             |
| 2.37             | 1.94             | 2.12             |
| 2.59             | 2.13             | 1.98             |
| 2.08             | 1.88             | 2.24             |

| Table 2. Anova single factor summary for Metal Frame Making |
|-------------------------------------------------------------|
| Groups | Count | Sum       | Average | Variance |
|--------|-------|-----------|---------|----------|
| Worker A | 19    | 44.54383  | 2.344412| 0.01851  |
| Worker B | 19    | 39.69783  | 2.08936 | 0.013938 |
| Worker C | 19    | 43.05383  | 2.265991| 0.038299 |
Table 3. Anova for Metal Frame Making

| Source of variation | SS    | df | MS     | F      | p-value | F-critical |
|---------------------|-------|----|--------|--------|---------|------------|
| Between Groups      | 0.648536 | 2  | 0.324268 | 13.75049 | 1.49017E-5 | 2.4033619981 |
| Within Group        | 1.273443 | 54 | 0.023582 |        |         |            |
| Total               | 1.921979 | 56 |         |        |         |            |

Table 4 shows the result pipe Molding that was done among three workers for 20 sets readings. The anova analysis for single factor was done to evaluate the statistical output of the pipe molding among the groups. Table 5 and Table 6 shows the anova summary and results for pipe molding. The hypothesis were set as follow, H0: \( \mu_1 = \mu_2 = \mu_3 \), H1: at least two are not equal, where H0: The mean production times of one pipe for group's 1, 2, & 3 are equal, H1: The mean production times of one pipe for group's 1, 2, & 3 are not equal, H0: The groups of workers has no effect on the production time of pipes and H1: The groups of workers has an effect on the production time of pipes. Thus, from the result of the analysis, \( \alpha = 0.10 \), C.R \( f > 3.16 \), test stat \( f = 7.02 \), P-value = 0.0019, this it can be concluded that since P-value < \( \alpha \), reject H0.

Table 4. Pipe Molding

| PIPES | Worker A (Minutes) | Worker B (Minutes) | Worker C (Minutes) |
|-------|--------------------|--------------------|--------------------|
| 2.31  | 2.84               | 2.41               |
| 2.29  | 2.21               | 2.47               |
| 2.45  | 2.65               | 2.74               |
| 2.39  | 2.27               | 2.27               |
| 2.22  | 2.93               | 2.35               |
| 2.39  | 2.55               | 2.20               |
| 2.20  | 2.32               | 2.39               |
| 2.47  | 2.34               | 2.31               |
| 2.26  | 2.22               | 2.22               |
| 2.19  | 2.41               | 2.30               |
| 2.20  | 2.35               | 2.62               |
| 2.36  | 2.71               | 2.54               |
| 2.20  | 2.21               | 2.25               |
| 2.19  | 2.45               | 2.48               |
| 2.21  | 2.53               | 2.31               |
| 2.21  | 2.66               | 2.40               |
| 2.34  | 2.29               | 2.35               |
| 2.47  | 2.58               | 2.59               |
| 2.24  | 2.59               | 2.58               |
| 2.23  | 3.05               | 2.94               |
Table 5. Anova single factor summary for Pipe Moulding

| Groups  | Count | Sum    | Average | Variance |
|---------|-------|--------|---------|----------|
| Worker A | 20    | 45.81467 | 2.290733 | 0.009813 |
| Worker B | 20    | 50.16617 | 2.508308 | 0.059713 |
| Worker C | 20    | 48.72372 | 2.436186 | 0.035437 |

Table 6. Anova for Pipe Moulding

| Source of variation | SS       | df | MS       | F          | p-value    | F-critical |
|---------------------|----------|----|----------|-------------|------------|------------|
| Between Groups      | 0.491313 | 2  | 0.245657 | 7.021181    | 0.001880129| 2.398157   |
| Within Group        | 1.994312 | 57 | 0.034988 |             |            |            |
| Total               | 2.485625 | 59 |          |             |            |            |

4. Conclusion
After conducting the study and discussing the analysis of the results, the research suggests that the several factors including age, job type, and length of service do not affect the efficiency of the workers in the manufacturing area of the company. On the other hand, to verify the results, the researchers utilized the ANOVA single factor to compare that there is really an effect caused by workers on the efficiency. The data gathered were taken by timing one cycle of the process for the workers. Therefore, the workers have an effect on the efficiency of the manufacturing plant. Since their efficiency varies, it means that the workers may have something that drives them to have a greater efficiency. The researchers looked in to the analysis of the learning curve for workers by knowing their acquired technical skills. In the pipe-making process, specifically on the pipe molding area, the experience of the workers has an effect on their labor efficiency. Also, the delegation of 2 workers for the pipe molding area proves to be more efficient than having only 1 worker.

Based on the conclusions of the research, various worker factors contribute to the efficiency of their labor. Therefore, the researchers recommend that the company implement a mix-aged group of workers to increase the overall efficiency of the workers. Since the skill-set of the workers also vary, the researchers also recommend that the company implement training programs for their workers, depending on the skills that they need to acquire. The workers can also have a rotation of job tasks so that the workers can also have equal skill-sets which is a factor when considering their labor efficiency.

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