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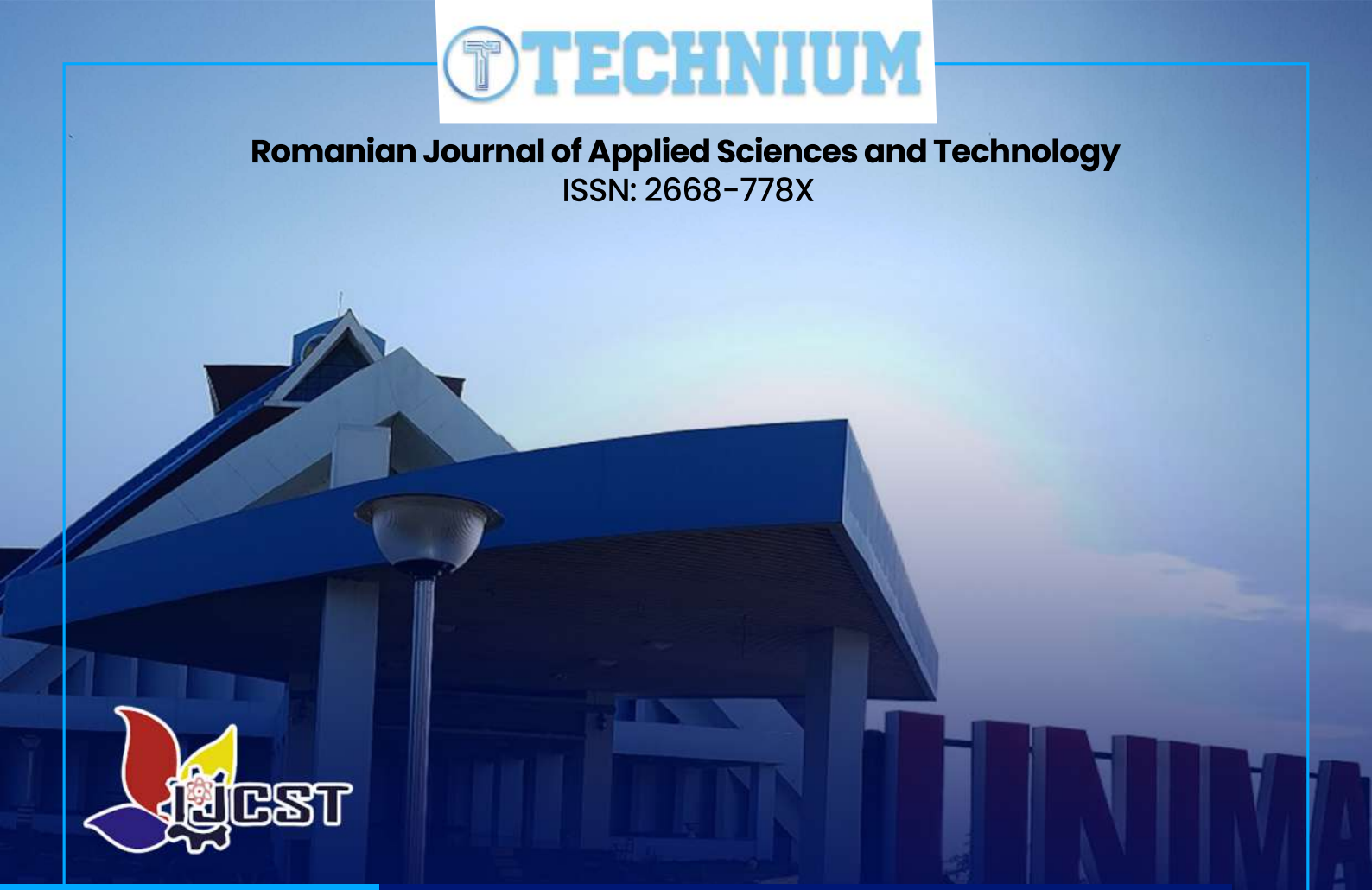

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Study of Statistical Quality Control (SQC) Methods in Analyzing Quality Control of Paving Block Products at PT. X

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Abstract. PT. X is a manufacturing company that produces building materials. PT. X is still often faced with several problems including the frequent occurrence of defective products, especially in paving block products as one of its main products. The defects that often occur include products that are easily crushed, cracked, asymmetrical, not dry and also broken in some parts. The defects that occur affect the quality of the resulting product. The purpose of this study was to determine the most dominant percentage of defects to allow further treatment. The method used in this research is Statistical Quality Control (SQC). The SQC method uses several tools including check sheets, stratification, histograms, paretto diagrams, scatter diagrams, control charts, and cause and effect diagrams. Based on the results of the SQC study, the most dominant defects were easily crushed paving with a percentage of 38.34%, cracked paving with a percentage of 28.86%, broken paving in some parts with a percentage of 13.83%, asymmetrical paving with a percentage of 10.92%, and non-dry paving with a percentage of 8.05%.

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1 Introduction

Today's market competition forces companies to produce quality products [1]. Good quality products can be produced through good quality processes as well [2]. By improving the production process, manufacturing lead time will automatically be reduced to optimal numbers [3]. As a result, the costs that must be associated with the manufacturing process will also reduced [4].

In the era of industrialization 4.0, all products and services offered by companies must follow what the market wants [5]. So, the quality of the products and services which produced is determined by the market. Quality itself is the level or measure of conformity of a product to its users, in a narrow sense quality can be interpreted as the degree of conformity of a product to a predetermined standard based on consumer desires [6], [7]. While quality control is an engineering and management activity, by comparing objects with specifications or requirements, then taking appropriate action if there is a difference between actual product quality and quality standards. The process is said to be of high quality if it can produce products that meet the quality standards or expectation [8], [9].

A product defect can occur if the quality of the product produced does not meet the standards [10] so that quality control is necessary, which is an important activity in management to improve or maintain the quality of a product and minimize the number of defective products. According to [11] one way to maintain product quality is to reduce the number of defects that occur in products and improve them on an ongoing basis.

PT. X is a manufacturing company located in Pasuruan Regency and has been established since 2008. PT. X is engaged in the building materials or concrete industry with products such as paving blocks, bricks, lightweight bricks, ready mix, and precast concrete. The resulting products are used as raw materials for building construction such as houses, buildings, road surfaces, road dividers, and many more. The company in its production process uses machines such as readymix batching plant machines, stone crushers, hydraulic paving block machines, and some heavy equipment such as forklifts, loaders and excavators.

Problems that occur at PT. This X is the frequent occurrence of defects in the paving produced. This indirectly affects customer satisfaction. Therefore, the research will be carried out mapping product defects that occur in each process carried out at PT. X. So that the percentage of defects that most often occurs can be known. The method used in mapping the types of defects that occur in paving production is a statistical quality control method (SQC). The SQC method itself is a quality control method that uses several of the seven tools to map defects that occur.

SQC itself is a very effective method in quality control and has been widely used in previous studies such as analysis of quality control process of making snacks in SMEs [12], quality control in steel deformed bar process [13], defect analysis on pipe production [14]–[16].

2 Research Method

2.1 Data Collection

Data collection method used in this study is through direct observation and interviews with related parties. The data collected includes paving production data from January to December 2022, data on defective products during that period, data on the types of defects that occur in each process.

2.2 Variable Identification

In this research, it is necessary to identify the research variables. Identification of research variables was carried out to determine the variables to be measured based on data from the company. dependent variable is a variable that is influenced by the behavior of the independent variable. In this study, the dependent variable is quality control with Statistical Quality Control (SQC). The independent variable is the variable that causes changes in the dependent variable or is the main factor of the problem under study [17], [18]. The independent variables in this study are as follows:

- Data on the amount of production of paving block products used from January 2022 to December 2022.
- Data on the number of defects from paving block products used from January 2022 to December 2022
- Data on the types of product defects which include: Paving crumbles easily, Paving is not symmetrical, Paving is cracked, Paving is not dry, and Paving is broken in certain parts.

2.3 Data Analysis

Statistical quality control is method used by company to control the product or service quality through process control [19], [20]. Statistical quality control is a system developed to maintain the same standard of product quality at a minimum cost level. The steps and use of Statistical Quality Control according to [21]:

- Process monitoring using control chart
- Comparison between actual process and standard

Data collection and processing is the initial stage for carrying out analysis activities before providing suggestions for improvements to the industry which is carried out by analyzing stages through check sheets, flow charts, control charts, pareto analysis, and cause and effect diagrams.

3 Data Processing

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To determine the quality of a product, it is necessary to study the manufacturing process so that the product can compete in the market. Therefore, it is essential to conduct a quality analysis of defective products produced during production. In this study, we used the paving block's production quantity and number of defects from January 2022 to December 2022 at PT. X.

3.1 Production Data

Data collection was conducted from January 2022 until the required data was fulfilled. Paving block production from January 2022 to December 2022 is shown in Table 1.

Table 1. Production of Brick Paving Block K250

No	Month	Production Quantity (Pcs)	Defect Products (Pcs)
1	January	39709	3261
2	February	42534	3161
3	March	42906	3264
4	April	39117	3113
5	May	35132	2670
6	June	37733	2987
7	July	48035	3637
8	August	55861	4407
9	September	48295	3551
10	October	50304	3810
11	November	45618	3556
12	December	39554	3359
Total		524798	40776

(Source: Company Data, 2022)

3.2 Defect Products

Defect products are defined as the number of products that do not meet the company's quality standards. We used the defective products from January 2022 to December 2022 as shown in Table 2.

Table 2. Defect Products of Brick Paving Block K250

Month	Easily Crushed	Asym-metric	Cracked	Non-dry	Broken
Jan	1243	348	942	269	459
Feb	1232	330	933	230	436
Mar	1242	342	993	243	444
Apr	1232	332	894	229	426
May	1096	270	751	189	364
Jun	1209	296	880	200	402
Jul	1398	412	1009	310	508
Aug	1634	548	1242	383	600
Sept	1342	423	1008	289	489
Oct	1441	419	1052	374	524
Nov	1268	369	1133	296	490
Dec	1295	363	932	272	497
Total	15632	4452	11769	3284	5639

(Source: Company Data, 2022)

Table 3. Defect Types of Brick Paving Blocks

Figure	Category and Root Cause Analysis
	Easily Crushed The ratio of raw materials was not equal so the resulting raw materials were not suitable causing the printed paving to crushed easily.
	Asymmetric The dough from the forming process is too fluid for workers to place the dough into the molds.
	Cracked It dried unevenly and the dough didn`t fit properly so the produced paving would crack.

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	Non-dry The amount of hardener was below specification and there was also the problem with drying.
	Broken Negligence in storage processing and negligence in drying during loading and unloading.

(Source: Company Data, 2022)

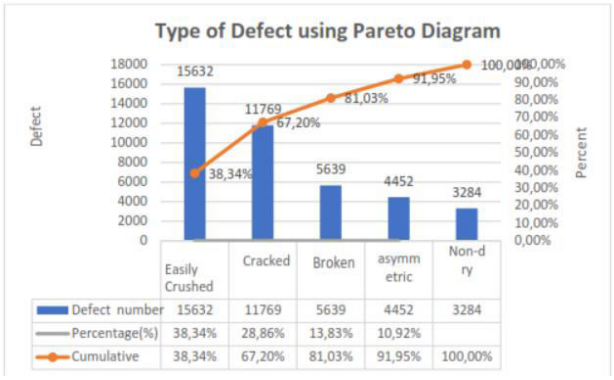

Figure 1. Pareto Diagram

Scatter Plot for each type of defect

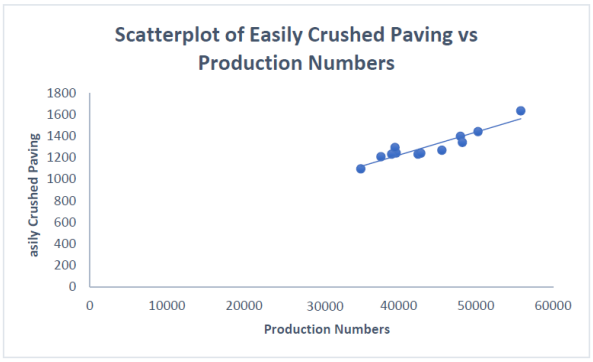

Figure 2. Scatterplot Diagram of Easily-Crushed Deffect

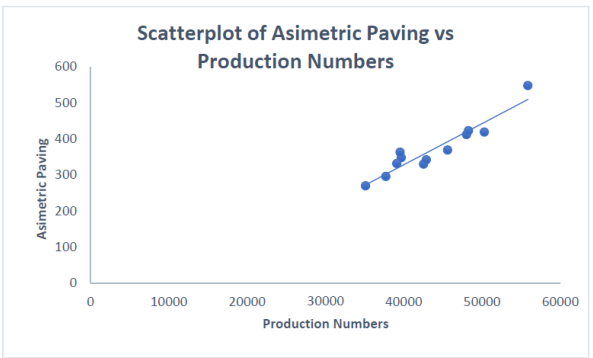

Figure 3. Scatterplot Diagram of Asymetric Deffect

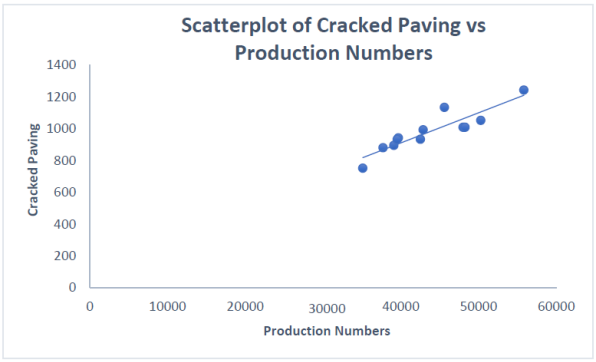

Figure 4. Scatterplot Diagram of Cracked Deffect

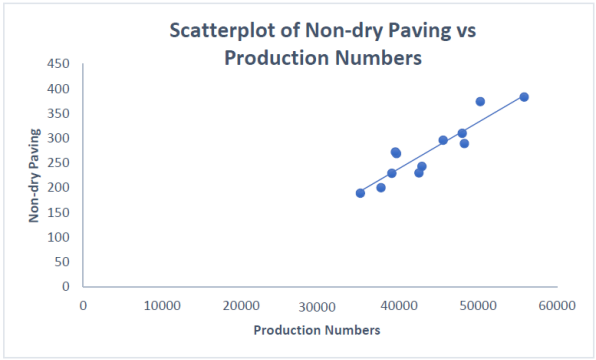

Figure 5. Scatterplot Diagram of Non-dry Deffect

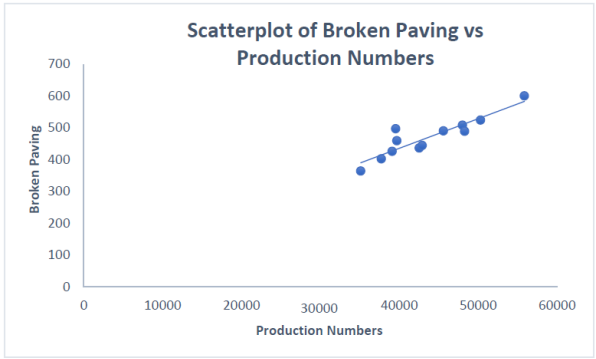

Figure 6. Scatterplot Diagram of Broken Deffect

Control Chart

Used as an indication whether the number of defects that occur in the product is still within reasonable limits or not so that an analysis of product defects can be carried out is the use of a control chart or control chart. In this study using an attribute control chart, namely control chart p. Where describes the part that was rejected because it did not match the desired specifications from the amount of production.

1. Easily crushed

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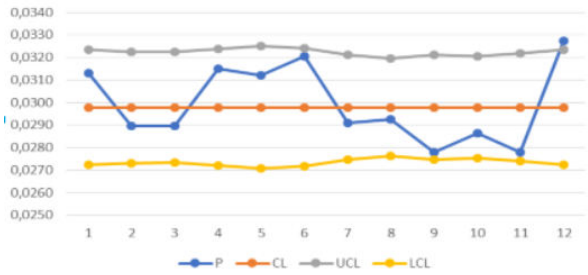

Figure 7. P-Chart for Easily crushed

2. Cracked

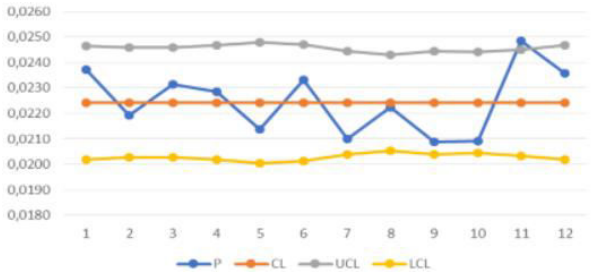

Figure 8. P-Chart for Cracked

3. Broken

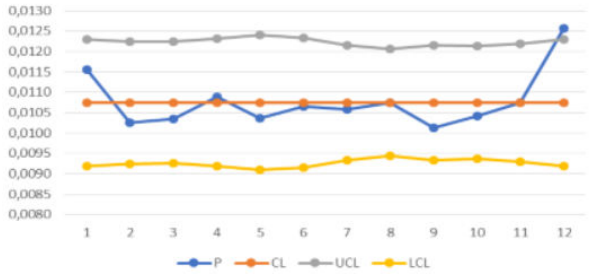

Figure 9. P-Chart for Broken

4. Asymetric

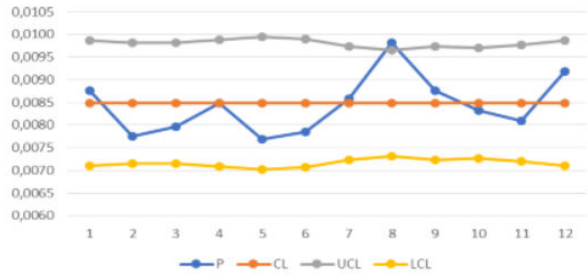

Figure 10. P-Chart for Asymetric

5. Non-dry

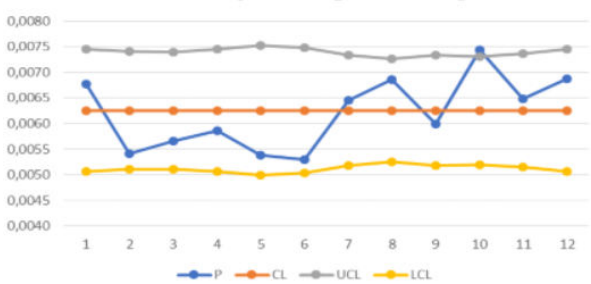

Figure 11. P-Chart for Non-dry

4 Result and Discussion

Based on the calculation, we could see the checksheet of production quantity and defects of block paving block K250 every month from January 2022 to December 2022. Histograms after grouping the checksheet by interval revealed that the order of defect type was 15,632 pieces of easily crushed paving, then 11,769 cracked pavings, then 5,639 broken pavings, then 4,452 asymmetrical paving, and last, non-dry paving as much as 3,284 pieces.

After knowing the order of the defect types from highest to lowest, then a Pareto chart was formed to find out the main issues or those that need to be prioritized. Based on the Pareto chart results, it could be seen that the main issue of defects in the brick paving block product K250 that needs to be prioritized was the first easily crushed paving, followed by cracked paving, chipped paving, asymmetrical paving, and non-dry paving.

In the scatter plot, the five figures had a positive correlation pattern (having a positive relationship) meaning that an increase in the X variable is followed by an increase in the Y variable which shows a close positive relationship. This shows that the number of defects and the amount of production influence each other, which means that an increase in the amount of production is also followed by an increase in the number of defects or vice versa. In the control chart of the five defects, it could be seen that the number of defects was still within all control limits, which means that the number of defects was still in control.

In the fishbone diagram, we have analyzed several causative factors that could lead to product failures. First of all, the causes of easily crushed paving were including poor stone ash content, too coarse sand, the ratio of mixing raw materials not equal, irregular maintenance or machine cleaning, insufficient hydraulic pressure of the paving block machine during the printing process, and dirty or worn out paving block molded pallet. Furthermore, cracked paving could be caused by the mixing result of dough or raw materials being too dry, employees being too rough when stacking and drying paving blocks, mixing less than the required time, insufficient paving storage area, and malfunctioning mixer machines. Broken paving could be caused by the negligence of employees who were not careful in the loading and unloading process

with heavy equipment, storage areas with uneven ground surfaces, and the wrong way of preparing paving block pallets. Furthermore, asymmetrical paving could be caused by too much water in raw material mixing, low operator supervision during the paving block production process, operators not being careful when putting the dough into the molds, and paving mats that were worn out. And lastly, incomplete dried paving could be caused by the amount of hardener given being below the specification and the insufficient drying area during bad weather.

Based on observations and interviews at the company, the factors causing paving block defects were non-optimal conditions in terms of humans, machines, materials, methods, and the environment in the production process at the production site. Therefore, it is necessary to strengthen the supervision of workers, machines, methods, and materials during the production process to minimize defects in paving block products.

5 Conclusion

Based on the results of data processing of brick paving block product K250 in January - December 2022, the dominant defects were obtained, namely easily crushed paving 15632 pcs or 2.98% of the total production, followed by cracked paving 11769 pcs or 2.24% of the total production, broken paving 5639 pcs or 1.07% of the total production, asymmetrical paving 4452 pcs or 0.85% of total production, and non-dry paving 3285.

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