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Failure Analysis of Paving Block Production Using Failure Mode and Effects Analysis Method at UD. Baja Mulia

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Abstract
UD. Baja Mulia is a paving block manufacturing company that continues to experience product failures during its production process, with a daily failure rate ranging from 5% to 15%, exceeding the company's defect tolerance limit of 2%. This study aims to analyze the failure risk in the paving block production process using the *Failure Mode and Effects Analysis* (FMEA) method and to develop improvement proposals using the Kaizen method through the 5W1H approach. A quantitative descriptive approach was employed, and data were collected through observation, interviews, and documentation. The analysis results indicate that grivis failure has the highest *Risk Priority Number* (RPN) value of 343, making it the primary priority for improvement. The causes of failure are associated with human, method, material, machine, and environmental factors. The proposed improvements focus on arranging paving blocks on wooden pallets to prevent contact between products, providing *on-the-job training* for new operators, and implementing mixture testing as a standard inspection procedure before the molding process. These improvement proposals are expected to reduce the risk of grivis failure in the paving block production process.
Keywords: *paving block, failure mode and effect analysis, kaizen, product failure*

Abstrak
UD. Baja Mulia merupakan perusahaan yang memproduksi paving block, namun dalam proses produksinya masih ditemukan kegagalan produk dengan persentase 5–15% per hari, melebihi batas toleransi cacat perusahaan sebesar 2%. Penelitian ini bertujuan menganalisis tingkat risiko kegagalan pada proses produksi paving block menggunakan metode *Failure Mode and Effects Analysis* (FMEA) serta menyusun usulan perbaikan menggunakan metode Kaizen melalui pendekatan 5W1H. Penelitian menggunakan pendekatan deskriptif kuantitatif dengan teknik pengumpulan data berupa observasi, wawancara, dan dokumentasi. Hasil analisis menunjukkan bahwa kegagalan grivis memiliki nilai *Risk Priority Number* (RPN) tertinggi, yaitu sebesar 343, sehingga menjadi prioritas utama untuk dilakukan perbaikan. Penyebab kegagalan berasal dari faktor manusia, metode, material, mesin, dan lingkungan. Usulan perbaikan difokuskan pada penyusunan paving block menggunakan pallet kayu agar produk tidak saling bersentuhan, pemberian *on-the-job training* kepada operator baru, serta penerapan uji adonan sebagai standar pemeriksaan sebelum proses pencetakan. Penerapan usulan tersebut diharapkan dapat mengurangi risiko kegagalan grivis pada proses produksi paving block.
Kata Kunci: *paving block, failure mode and effect analysis, kaizen, produk gagal*

1. Introduction

Paving blocks are a construction material widely used in sidewalks, parks, yards, and parking areas. Paving block quality is influenced by the raw materials, production process, material composition, and environmental factors [1]. Therefore, quality control is a crucial aspect of the production process to ensure products meet established standards and reduce product failures [2].

UD. Baja Mulia is a paving block manufacturing company in Lhokseumawe. The production process is still manual and involves three workers. Daily production capacity ranges from 500–1,500 units. Observations indicate several types of product failures, including cracks, chipping, chipping, and breakage. The company sets a failure tolerance limit of 2% of total daily production, but production data from January–March 2026 shows a failure rate of 5–15% per day. This situation indicates that the production process is not optimal and has the potential to lead to raw material waste, additional production time, decreased product quality, and reduced company profits. To address these issues, a method is needed that can identify the causes of failure and determine repair priorities.

Quality is the level of excellence of a product in meeting consumer needs and expectations according to established standards [3]. Implementing good quality control can reduce product variation, minimize failures, and increase company efficiency and profits [4]. Therefore, quality control is a crucial aspect in ensuring that products meet established quality standards [5]. In the paving block industry, product quality is influenced by raw materials, production processes, material composition, and work methods [6]. Paving blocks that meet quality standards must have a perfect shape, be free of cracks or defects on their surfaces, and have corners and edges that are resistant to damage [7].

One method widely used to analyze failure risks in the production process is Failure Mode and Effects Analysis (FMEA) [8]. This method is used to identify potential failures, analyze their impact, and determine repair priorities based on the Risk Priority Number (RPN) value [9]. The assessment in FMEA is based on three main parameters: severity, occurrence, and detection, which are used to evaluate the severity, likelihood of occurrence, and the system's ability to detect failures [10].

The Risk Priority Number (RPN) is a measure of relative risk obtained by multiplying severity, occurrence, and detection. The RPN value is used to determine improvement priorities for each failure mode, thus forming the basis for decision-making regarding risk control and mitigation measures [11]. Failure Mode and Effects Analysis (FMEA) is a systematic method used to identify potential failures, analyze their impact, and prioritize improvements based on risk level. The main stages in FMEA include process review, failure mode identification, failure impact analysis, severity, occurrence, and detection assessment, RPN calculation, failure prioritization, and development of corrective actions [12].

In failure analysis, a fishbone diagram is used to identify the root cause of a problem based on various factors affecting the process [11]. Meanwhile, a Pareto diagram is used to determine the most dominant type of failure, facilitating improvement prioritization [4] Kaizen is a philosophy of continuous improvement that focuses on increasing quality and efficiency through small, incremental, and continuous changes [13]. Kaizen is widely applied in the manufacturing and service industries because it can improve organizational performance without requiring large additional resources [14]. One of the approaches commonly used in Kaizen is the 5W1H method, which consists of six basic questions: what, why, where, when, who, and how. This method is used to identify the cause of the problem, determine the responsible party, determine the location and time of implementation, and systematically compile corrective action steps [15].

2. Material and Methods

Study design

This study employed a quantitative descriptive approach to analyze product failures in the paving block production process at UD. Baja Mulia, Lhokseumawe, Indonesia. The research focused on identifying failure modes, evaluating their risk levels, and proposing improvement actions.

Data collection

The study used both primary and secondary data. Primary data were obtained through direct observation of the paving block production process, interviews with the business owner and production workers, and documentation of production activities and product failures. Secondary data consisted of production records, defect data, books, scientific journals, and other literature related to quality control, FMEA, and Kaizen.

FMEA analysis

Failure analysis was conducted using the *Failure Mode and Effects Analysis* (FMEA) method. The analysis involved identifying product failure types, determining *Critical to Quality* (CTQ) characteristics, analyzing the dominant failure types using Pareto diagrams, identifying root causes through fishbone diagrams, assessing *severity*, *occurrence*, and *detection*, calculating the *Risk Priority Number* (RPN), and determining improvement priorities based on the highest RPN values.

Kaizen improvement

Improvement proposals were developed using the Kaizen method through the 5W1H approach. The failure mode with the highest RPN value was selected as the priority for improvement, and corrective actions were formulated based on the questions *what, why, where, when, who,* and *how* to develop systematic and continuous improvement actions.

3. Results and Discussion

Based on observations conducted during the paving block production process at UD. Baja Mulia, four dominant failure types were identified: cracks, grivis, breakage, and chipping. These failure types indicate product quality deficiencies that may result in raw material waste, increased production time, and reduced production efficiency. The number of each failure type recorded during the January–March 2026 observation period is presented in **Table 1**.

Table 1. Jenis dan Jumlah *Failure Paving Block* Bulan Januari – Maret 2026

No	Potensial CTQ	Amount (units)			Total
		January	February	March	
1	Grivis	562	666	638	1.866
2	Breakage	319	371	345	1.035
3	Chipping	242	295	279	816
4	Breakage	106	132	111	349
Total *failure*		**1.229**	**1.464**	**1.373**	**4.066**

Source: Data Processing

Pareto Diagram

Based on the Pareto chart shown in **Figure 1**, grivis was identified as the most dominant failure type, with 1,866 units (46%), followed by cracks with 1,035 units (25%), chipping with 816 units (20%), and breakage with 349 units (9%). Cumulatively, grivis, cracks, and chipping accounted for 91% of the total failures. These results indicate that most quality problems originated from a small number of dominant failure types, which is consistent with the Pareto principle (80/20), where the majority of defects are caused by a limited number of key factors. Therefore, grivis, cracks, and chipping were selected as the priority failure types for further analysis, while breakage was not considered a primary priority due to its relatively small contribution to the total failures.

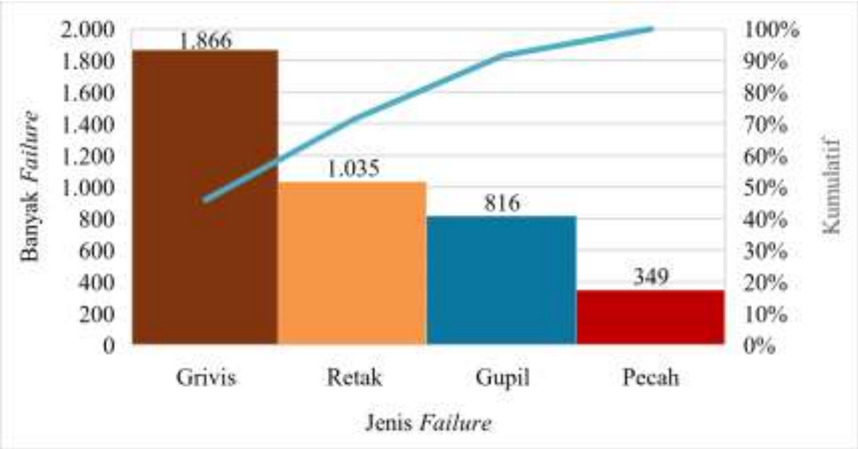

Fig 1. Pareto Diagram
Source: Data Processing

Failure Mode and Effects Analysis

The RPN calculation is used to determine which part of the paving block manufacturing process is most likely to produce failures. The RPN calculation is based on the multiplication of severity, occurrence, and detection (S x O x D). The RPN calculation for each failure type is shown in **Table 2**. After obtaining the *Risk Priority Number* (RPN) values, the failure modes were ranked from the highest to the lowest RPN value, and the percentage contribution of each RPN was calculated. The recapitulation of the RPN values is presented in **Table 3**.

Table 2. Determine severity, occurrence, detection, and RPN

No	Process function	Failure Mode	Effect of Failure	S	Cause of Failure	O	Process Control	D	RPN
1	Preparation of materials	Grivis	a) The paving block surface is uneven, b) The density of the paving block surface is reduced c) It cannot be marketed	7	- Poor quality of materials	7	- Make visual observations	4	196
2	Making paving block dough	Grivis	a) The paving block surface is uneven, b) The density of the paving block surface is reduced c) It cannot be marketed	7	- Lack of operator experience The raw material mixing process is not optimal	7	- Visual inspection of dough homogeneity.	6	294
2	Making paving block dough	Cracks	a) The strength and durability of the product decreases, potentially causing damage during use. b) It cannot be marketed.	7	- Lack of operator experience - Inadequate water composition - Suboptimal dough mixing process	6	- Water measurement based on operator habit/experience. - Visual inspection of dough homogeneity.	6	252
3	Mencetak adonan *paving block*	Grivis	a) Permukaan *paving block* tidak rata, b) Kepadatan permukaan *paving block* menurun c) Tidak dapat dipasarkan	7	- The arrangement of paving blocks is not appropriate	7	- Make adjustments to the product placement	7	343
3	Printing paving block dough	Chipping	a) Product dimensions become imperfect b) Risk of further damage to the gupil section increases c) Cannot be marketed	6	- Operator carelessness - Operator inexperience - Mold wear resulting in inaccuracy - Pressing insufficiently tight	6	- Perform tool repairs. - Pressing is performed according to the operator's strength. - Visual inspection during the mold removal process.	4	144
4	Drying and curing	Cracks	a) The strength and durability of the product decreases, potentially causing damage during use. b) It cannot be marketed.	7	- Storage area unprotected - Stacked and high stacking - Insufficient curing frequency - Unstable ambient temperature	6	- Direct observation of weather conditions and environmental temperature.	6	252

Source: Data Processing

Table 3. Recapitulation of RPN values

Rank	Failure Mode	Process	Risk Priority Number (RPN)	Critical Category	Percentage RPN (%)
1	Grivis	Printing paving block dough	343	High	23,2%
2	Grivis	Making dough	294	High	19,9%
3	Cracks	Making dough	252	High	17%
4	Cracks	Drying and curing	252	High	17%
5	Grivis	Preparation of raw materials	196	Medium	13,2%
6	Chipping	Printing paving block dough	144	Medium	9,7%
Total			**1.481**		**100%**

Source: Data Processing

Based on the *Risk Priority Number* (RPN) analysis, four failure modes were identified as critical and prioritized for improvement. The highest RPN value was recorded for grivis during the molding process (343), followed by grivis during the mixing process (294), and cracks during the mixing process and the drying and curing stages (252). These results indicate that the identified failure modes pose higher risks than the other failure modes and therefore require priority corrective actions.

Based on the FMEA results, grivis had the highest *Risk Priority Number* (RPN) value and was therefore identified as the top priority for improvement. Accordingly, improvement proposals were developed using the Kaizen method through the 5W1H approach based on the factors causing grivis. The proposed improvement actions are presented in **Table 4**.

Table 4. Proposed Repair of Grivis Failure with 5W + 1H Analysis

Factors	*What*	*Why*	*Where*	*When*	*Who*	*How*
The arrangement of paving blocks is not appropriate	Arrange paving blocks using lifting boards (wooden pallets) so that each product has space and does not touch each other during the drying and storage process.	Because the arrangement of paving blocks that are close together causes the products to rub against each other, thus increasing the risk of failure, especially grivis.	In the printing area .	This is done after the paving blocks are removed from the mold and during the drying process until the product is ready to be moved to the storage area.	Production operator	Provide lifting platforms (wooden pallets) capable of holding paving blocks individually on each level. Operators arrange paving blocks according to the pallet's capacity, spacing them apart to prevent them from touching during the drying and storage process.
The material mixing process is not optimal	Apply dough test as a standard for checking the mixture before the molding process.	Because the mixture cannot maintain the shape of a small ball, it shows that the consistency and bonding between particles is not optimal, thus increasing the risk of grain failure.	Material mixing area	It is done every time a batch of mixture is finished being mixed before being poured into the mold.	Production operator	Take a handful of the mixture and shape it into a small ball. The mixture is ready to be molded if the ball doesn't crumble easily, doesn't crack, and only leaves your hands slightly damp. If the mixture doesn't meet these criteria, continue mixing and gradually add water until the mixture meets the molding readiness criteria.
Lack of operator experience	Provide training and mentoring (on-the-job training) to new operators before working independently.	So that operators understand the correct printing techniques so that they can reduce the occurrence of failures.	Printing area.	Before the new operator works independently and is done periodically.	senior operators and new operators	Senior operators accompany new operators during the adaptation period, provide examples of correct working methods, and carry out capability evaluations before the operator works alone.

Source: Data Processing

4. Conclusion

This study analyzed product failure risks in the paving block production process at UD. Baja Mulia using the *Failure Mode and Effects Analysis* (FMEA) method. The results showed that failure risks varied across the identified failure modes. Grivis during the molding process had the highest *Risk Priority Number* (RPN) value of 343, followed by grivis during the mixing process (294) and cracks during the mixing process and the drying and curing stages (252). These failure modes were identified as the main priorities for corrective action because they posed higher risks than the other failure modes. Meanwhile, chipping during the molding process was classified as a moderate-risk failure mode with an RPN value of 144.

Improvement proposals were developed using the Kaizen 5W1H approach, focusing on the failure mode with the highest RPN value. The proposed actions included arranging paving blocks on wooden pallets to prevent contact between products during drying and storage, implementing mixture testing before the molding process, and providing *on-the-job training* for new operators. These improvements are expected to reduce the occurrence of grivis failures and improve the overall quality of the paving block production process.

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6. Abbreviations

RPN	Risk Priority Number
%	Percentage
S	Severity
D	Detection
O	Occurrence

7. References

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