

## Causes of Damage to Cement Products Upon Receipt at the Gresik DC Buffer Warehouse of PT Bali Age

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### ABSTRAK

*Penelitian ini bertujuan untuk mengidentifikasi dan menganalisis faktor-faktor penyebab utama kerusakan produk semen saat proses penerimaan di Gudang DC Buffer Gresik PT Bali Age, serta mengevaluasi penerapan metode Failure Mode and Effect Analysis (FMEA) dalam upaya menurunkan tingkat kerusakan. Penelitian menggunakan pendekatan mixed methods dengan desain studi kasus. Data diperoleh melalui wawancara mendalam, observasi lapangan, dokumentasi, serta penilaian risiko menggunakan metode FMEA dengan perhitungan Severity, Occurrence, Detection, dan Risk Priority Number (RPN). Hasil penelitian menunjukkan bahwa faktor utama penyebab kerusakan produk semen meliputi faktor manusia human error, kondisi peralatan seperti forklift yang kurang optimal, ketidaksesuaian penerapan SOP, serta faktor lingkungan berupa kelembapan gudang yang tinggi. Berdasarkan analisis FMEA, beberapa mode kegagalan memiliki nilai RPN tinggi sehingga diprioritaskan untuk tindakan perbaikan. Rekomendasi perbaikan meliputi peningkatan pelatihan karyawan, penguatan pengawasan operasional, perawatan berkala peralatan, penyempurnaan SOP bongkar muat, serta perbaikan sistem ventilasi gudang. Penerapan FMEA terbukti membantu manajemen dalam mengidentifikasi risiko secara sistematis dan menentukan prioritas tindakan korektif secara terukur. Dengan implementasi rekomendasi tersebut, diharapkan tingkat kerusakan produk semen dapat ditekan, biaya kerugian dapat diminimalkan, serta efektivitas pengendalian mutu dan kinerja rantai pasok perusahaan menjadi lebih optimal dan berkelanjutan.*

**Kata kunci:** kerusakan produk semen, gudang distribusi, human error, Failure Mode and Effect Analysis (FMEA)

### ABSTRACT

*This study aims to identify and analyze the main factors causing damage to cement products during the receiving process at the Gresik Buffer DC Warehouse of PT Bali Age, and to evaluate the application of the Failure Mode and Effect Analysis (FMEA) method in an effort to reduce the level of damage. The study used a mixed methods approach with a case study design. Data were obtained through in-depth interviews, field observations, documentation, and risk assessment using the FMEA method with Severity, Occurrence, Detection, and Risk Priority Number (RPN) calculations. The results showed that the main factors causing damage to cement products include human error, equipment conditions such as suboptimal forklifts, non-compliance with SOP implementation, and environmental factors such as high warehouse humidity. Based on the FMEA analysis, several failure modes had high RPN values so they were prioritized for corrective action. Recommendations for improvement include improving employee training, strengthening operational supervision, regular equipment maintenance, improving loading and unloading SOPs, and improving the warehouse ventilation system. The application of FMEA has been proven to assist management in systematically identifying risks and determining measurable priorities for corrective action. By implementing these recommendations, it is hoped that the level of damage to cement products can be reduced, the cost of losses can be minimized, and the effectiveness of quality control and the performance of the company's supply chain can be more optimal and sustainable.*

**Keywords:** cement product damage, distribution warehouse, human error, Failure Mode and Effect Analysis (FMEA)

## **INTRODUCTION**

The cement industry is a strategic sector in national development because it contributes significantly to economic growth and infrastructure development. Cement consumption levels are often used as an indicator of economic activity, with higher consumption indicating increased development. In Indonesia, national cement production capacity is expected to reach 119.9 million tons per year by 2024, making Indonesia the largest producer in Southeast Asia. However, domestic consumption only reaches 64.9 million tons, resulting in an overcapacity of 55 million tons per year. This situation is caused by stagnant infrastructure projects in several regions and intense competition among cement producers, both domestic and foreign, which requires companies to improve operational efficiency, particularly in distribution, warehouse management, and product quality control (Wang et al., 2021).

In the cement industry, product quality is not only determined at the production stage in the factory but is also greatly influenced by post-production processes, such as transportation, receiving, and storage in distribution warehouses. Long supply chains increase the risk of product quality degradation if not supported by an efficient logistics system and strict quality control (Macnico et al., 2022). Physical damage such as torn cement bags, leaks, or clumping due to humidity is a common problem. This not only impacts product quality but also causes financial losses, lowers customer satisfaction, and increases operational costs.

One of the key points in the cement distribution chain is the Gresik Buffer Distribution Center (DC), which serves as a transit warehouse for PT Semen Indonesia (Persero) Tbk's products before they are distributed to various regions in East Java. This warehouse has a capacity of approximately 7,000 tons per month, with loading and unloading activities reaching 25–30 trucks per day. Furthermore, the warehouse is managed by

PT Bali Age, an operational partner, creating management complexity between the owner and operator. This condition makes the Gresik Buffer DC a vital point in maintaining smooth distribution and product quality.

Empirical data from 2024 shows that the damage rate of cement products at the Gresik Buffer Center fluctuates, with the number of damaged bags ranging from 137 to 494 sacks per month. Although the percentage is relatively low (below 0.4%), this fluctuation indicates instability in the quality control system and SOP implementation. When compared to other distribution centers in East Java, the Gresik Buffer Center has the highest damage rate at 1.6%, far above the national average of 0.8%. This indicates weaknesses in operational supervision, environmental control, and compliance with standard operating procedures.

Previous research has shown that product damage in logistics systems is influenced by various factors, such as human error (human error), equipment conditions, and environmental factors. In this case, damage was largely caused by operators failing to follow procedures, suboptimal forklift conditions, and high warehouse humidity levels (75–80%). However, previous research has generally focused on general logistics efficiency and has not specifically examined structured risk analysis of the cement receiving and storage process in distribution warehouses.

This indicates a research gap (research gap), namely the absence of a systematic approach based on risk analysis that is able to identify, evaluate, and determine the priority of the causes of product damage comprehensively in cement warehouse operations.

To address this gap, this study uses the method Failure Mode and Effect Analysis (FMEA). This method is able to identify potential failures in the process, assess the severity of the failures (severity), frequency of occurrence (occurrence), as well as detection capabilities (detection), and generate value Risk Priority Number (RPN) as a basis for

determining repair priorities (Putri et al., 2024). With this approach, the study aims to systematically analyze the root causes of cement product damage at the Gresik DC Buffer and formulate effective and measurable repair steps.

This research is expected to provide theoretical and practical contributions, particularly in risk management in cement warehouse operations. Furthermore, the results are expected to provide recommendations for improvements, such as refining standard operating procedures (SOPs), optimizing warehouse layout, improving equipment maintenance, and training the workforce. This will reduce product damage, increase operational efficiency, and optimize and sustain supply chain performance.

## **LITERATURE REVIEW**

Quality is a key factor in maintaining industrial competitiveness, including the cement industry, which is characterized by heavy products and is susceptible to physical damage. In this context, quality is determined not only at the production stage but also throughout the entire logistics process, such as transportation, receiving, and warehouse storage. Quality control (quality control) functions to ensure that every process runs according to standards and prevents product defects. The modern quality concept emphasizes a preventive approach (preventive) and continuous improvement (continuous improvement) as part of an integrated quality management system (Chynthia Ferdiana et al., 2023).

The implementation of an effective quality control system has been shown to significantly reduce product defect rates, even by up to 40% in the manufacturing industry (Fernandi et al., 2022). Furthermore, approaches such as Total Quality Management (TQM) emphasize that quality is the responsibility of all elements of the organization, while the latest developments through the concept of Quality 4.0 integrating digital technologies such as Internet of Things (IoT) and Big Data in quality real-

time (Liu et al., 2023). Thus, quality control is not only inspection-based, but also a data-based prevention system.

In an effort to identify and minimize the risk of product damage, the method Failure Mode and Effect Analysis (FMEA) is a widely used approach. FMEA is a systematic method for identifying potential failures, analyzing their causes and impacts, and prioritizing improvements based on risk levels. Risk assessment in FMEA is based on three main parameters: severity (severity level), occurrence (incidence rate), and detection (detection capability), which is then calculated in the form Risk Priority Number (RPN) (Recently, 2020).

$$RPN = S \times O \times D$$

The RPN value is used to determine risk management priorities, with the higher the value, the more critical the corrective action. Therefore, FMEA is highly relevant in analyzing cement product failures involving various operational factors in a warehouse.

In addition, the theory Lean Logistics or Lean Supply Chain also becomes an important foundation in this research. Lean Logistics aims to eliminate waste in the logistics process without reducing value for customers. This principle includes optimizing warehouse layout, implementing Just in Time (JIT), reduced waiting time, and efficient flow of goods (Kristanto & Padmakusumah, 2025). Research shows that the implementation of Lean Supply Chain can increase logistics efficiency by up to 30% and reduce the risk of product damage due to excessive handling (Yulyani et al., 2025).

On the other hand, the human factor (human error) also has a significant role in the occurrence of product damage. Human errors are errors that occur due to actions that do not comply with established work procedures. These errors can be influenced by a lack of training, an unsupportive work environment, and weak supervision (Rohmadhon & Yuamita, 2023). The implementation of clear and consistent Standard Operating Procedures (SOPs) has been shown

to reduce error rates by up to 45% in warehouse operations (Ikwan Lubis et al., 2024).

Thus, the integration between quality theory, FMEA, Lean Logistics, as well as human error and SOPs, provide a strong conceptual framework for this research. These four theories complement each other in explaining the causes of cement product damage and provide a basis for formulating effective, measurable, and sustainable repair solutions.

## **METHOD**

This research uses an approach-mixed method with a qualitative descriptive design supported by quantitative analysis. The qualitative approach was used to understand operational processes, work behavior, and factors causing product damage in depth, while the quantitative approach was used to measure the level of risk using the method Failure Mode and Effect Analysis (FMEA) through calculations Risk Priority Number (RPN). According to Sugiyono (2023), descriptive research aims to describe phenomena systematically, factually, and accurately without testing the relationship between variables. This research was conducted at the Gresik DC Buffer Warehouse located at Jl. Veteran No. 93, Gresik because it has high operational activity and is relevant to the research focus. The population in this study was all workers involved in the cement receiving and storage process in the warehouse. The sample was determined using a random sampling technique. purposive sampling, namely the selection of informants based on direct involvement in operational activities. The informants numbered 7 people consisting of a warehouse manager, an operational supervisor, a goods receiving officer, two forklift operators, and two quality control staff. The unit of analysis for this study was all operational activities of receiving and storing cement, while the research object included physical damage to

the product and its causal factors, such as human error, equipment conditions, environment, and SOP non-compliance. The selection of this unit of analysis is based on Sugiyono's (2023) view that the unit of analysis is the main focus in understanding the phenomenon being studied as a whole. Data collection was conducted through structured interviews, direct observation, and questionnaires to obtain relevant primary data. Data analysis was conducted qualitatively using an interactive model proposed by Matthew B. Miles and A. Michael Huberman, which includes data reduction, data presentation, and conclusion drawing and verification. In addition, quantitative analysis was conducted using the FMEA method to determine risk priorities based on parameters. severity, occurrence, And detection. The validity of the data is tested using the criteria trustworthiness by Yvonna S. Lincoln and Egon G. Guba which includes credibility, transferability, dependability, And confirmability, so that the research results can be scientifically accounted for.

## **RESULTS**

This research was conducted flexibly, adapting to the time and location agreed upon with the informants. Prior to conducting the interviews, the researcher contacted each informant several days in advance via social media to determine the interview schedule. Informants were selected randomly. purposive, These were informants directly involved in the receiving, handling, and quality control of cement products at the Gresik DC Buffer, thus aligning with the research focus on product damage control. The interviews were conducted based on a previously developed structured interview guide. The entire research process, including interviews with informants, was conducted in December 2025.

Table 1. Schedule of informant interview activities

No	Informant Name	Type of work	Interview Schedule	Interview Venue
1	Mr. Achmad Anis	Head of Warehouse	December 8, 2025	DC Buffer Gresik
2	Mr. Patno	Warehouse Operations Supervisor	December 9, 2025	DC Buffer Gresik
3	Mr. Wijaya	Goods Receipt Officer	December 16, 2025	DC Buffer Gresik
4	Mr. Alfian	Staff <i>Quality Control</i>	December 9, 2025	DC Buffer Gresik
5	Mr. Hadi	Staff <i>Quality Control</i>	December 16, 2025	DC Buffer Gresik
6	Mr. Suparman	Operator Forklift	December 16, 2025	DC Buffer Gresik
7	Mr. Sutomo	Operator Forklift	December 16, 2025	DC Buffer Gresik

Source: Author's Processing (2025)

**Table 2. Recapitulation of Values*Severity***

No	Failure Mode	Respondent Score							Shoes	Rate-rate (S)
		R1	R2	R3	R4	R5	R6	R7		
1	Cement sack torn due to friction from forklift forks	7	9	9	9	8	8	7	57	8
2	Stack of cement pallets collapsed	8	9	7	8	7	9	9	57	8
3	Cement clumps due to warehouse humidity	9	8	9	9	8	9	9	61	9
4	Damage due to fragile pallets	7	7	6	7	8	8	8	51	7
5	Damage caused by load on tilted truck	7	7	7	6	8	8	8	51	7
6	Damage due to inconsistent SOPs	7	6	9	9	9	9	9	58	8

Source: Data processed based on questionnaire results (2025)

Based on the value recapitulation table*severity*, it can be seen that failure *mode* in the cement receiving process at the Gresik DC Buffer Warehouse, it has a value*Severity* in the range of 7 to 9, which indicates that most failures have a financial impact that is serious enough to be very serious to affect warehouse operations.

**Table 3. Recapitulation of Occurrence Values**

No	Failure Mode	Respondent Score							Shoes	Rate-rate (S)
		R1	R2	R3	R4	R5	R6	R7		
1	Cement sack torn due to friction from forklift forks	6	7	7	7	5	6	5	43	6
2	Stack of cement pallets collapsed	5	6	7	5	5	6	5	39	5
3	Cement clumps due to warehouse humidity	6	6	5	5	4	5	5	36	5
4	Damage due to fragile pallets	5	6	5	5	4	7	5	37	5
5	Damage caused by load on tilted	5	6	4	4	5	8	6	38	5

truck										
6	Damage due to inconsistent SOPs	6	7	9	9	9	8	8	56	8

Source: Data processed based on questionnaire results (2025)

*Occurrence*(O) shows how often a failure occurs in the cement receiving process at the Gresik DC Buffer Warehouse of PT Bali Age. The value *Occurrence* obtained from the assessment of seven respondents who were directly involved in warehouse operational activities, thus reflecting actual conditions in

the field. The higher the value *Occurrence*, the more frequently the failure occurs and the greater the potential risk that must be controlled. Based on the Value Recapitulation table *Occurrence*(O), it is known that the value *Occurrence* is in the range of 5 to 8, which indicates that most failures are classified as fairly frequent to frequent.

Table 4. Recapitulation of Values *Detection*

No	Failure Mode	Respondent Score							Shoes	Rate-rate (S)
		R1	R2	R3	R4	R5	R6	R7		
1	Cement sack torn due to friction from forklift forks	4	2	2	2	2	3	2	17	2
2	Stack of cement pallets collapsed	4	4	3	2	4	5	5	27	4
3	Cement clumps due to warehouse humidity	6	7	6	9	5	5	4	42	6
4	Damage due to fragile pallets	5	4	4	5	4	5	4	31	4
5	Damage caused by tilted truck load	4	6	6	5	4	5	4	34	5
6	Damage due to inconsistent SOPs	4	2	2	2	2	2	2	16	2

Source: Data processed based on questionnaire results (2025)

Based on the Value Summary Table *Detection*(D), the average value is obtained *Detection* the assessment results of seven respondents who were in the range of 2 to 6.

Table 5. Summary of Risk Priority Number (RPN) Values

No	Failure Mode	Severity (S)	Occurrence (THE)	Detection (D)	RPN
1	Cement sack torn due to friction from forklift forks	8	6	2	96
2	Stack of cement pallets collapsed	8	5	4	160
3	Cement clumps due to warehouse humidity	9	5	6	270
4	Damage due to fragile pallets	7	5	4	140
5	Damage caused by tilted truck load	7	5	5	175
6	Damage due to inconsistent SOPs	8	8	2	128

Source: Data processed based on questionnaire results (2025)

Table 6. Risk priority order based on (RPN)

Ranking	Failure Mode	RPN	Risk Level
1	Cement clumps due to warehouse humidity	270	Very high
2	Damage caused by load on tilted truck	175	High

3	Stack of cement pallets collapsed	160	High
4	Damage due to fragile pallets	140	Currently
5	Damage due to inconsistent SOPs	128	Currently
6	Cement sack torn due to forklift friction	96	Low

Source: Data processed based on questionnaire results (2025)

Based on the calculation results *Risk Priority Number*(RPN), it is known that each failure mode has a different level of risk. The difference in RPN values is influenced by the combination of the severity of the impact.(*Severity*), frequency of occurrence(*Occurrence*), as well as the system's ability to detect potential damage(*Detection*).In-depth analysis of each failure *mode is* needed so that the determination of repair priorities can be carried out appropriately and effectively.

Research on controlling damage to cement products in warehouses using the method Failure Mode and Effect Analysis(FMEA) shows that product damage is a real problem that frequently occurs in operational activities, particularly during the receiving and storage stages. This damage not only reduces product quality but also increases operational costs, causes company losses, and has the potential to reduce customer satisfaction.

The research results show that the company has implemented a damage control system through various stages, such as physical inspection upon receipt, monitoring the loading and unloading process, arranging warehouse layouts, and implementing a FIFO system for inventory management. This process involves various parties, from warehouse managers to forklift operators, thus demonstrating the existence of a structured control system. However, in practice, weaknesses are still found that cause damage to occur repeatedly.

The most common types of damage include torn packaging, leaking sacks, falling

products during loading and unloading, and clumping due to warehouse humidity. This damage is influenced by various factors, such as human error, non-compliance with SOP implementation, equipment condition, work pressure due to high volumes of goods, and warehouse environmental factors. Furthermore, a lack of operator accuracy and supervision also increases the risk of damage, given that cement products are highly sensitive to impact and humidity.

The company has a mechanism for handling damaged products through separation, recording, evaluation, and determining follow-up actions for unsaleable products. The validity of the research data has been tested through source triangulation, observation, and documentation, which demonstrates the consistency of the research results. Thus, the FMEA method has proven effective in identifying potential failures, determining the root cause of damage, and assisting the company in setting improvement priorities to more systematically reduce product damage levels.

**DISCUSSION**

The research results show that damage to cement products in warehouses is a complex and multidimensional operational problem. Damage occurs primarily during the receiving and storage stages, with the main forms being torn packaging, collapsed pallets, and cement clumping due to high humidity. This condition not only impacts product quality but also increases operational costs, causes material

losses, and increases occupational safety risks for warehouse operators. These findings confirm that cement product quality is not only determined at the production stage but is also significantly influenced by logistics and warehousing processes until the product reaches consumers (Hendrawan et al., 2020).

The dominant factor causing damage is human error, particularly in the handling process using forklifts during loading and unloading. Errors in equipment operation, lack of precision, and work pressure due to high volumes of goods are the main triggers for damage. This aligns with the human error theory, which states that human error is often influenced by work environment factors, fatigue, and inconsistencies in procedural implementation (Rohmadhon & Yuamita, 2023). Furthermore, weak implementation of SOPs is also a significant factor increasing the risk of damage, as previous research has shown that inconsistent SOP implementation can increase operational errors (Sukirno & Nurwahidah, 2022).

Besides human factors, warehouse environmental conditions, particularly humidity levels, have also been shown to be a major cause of damage, particularly cement clumping. From the perspective of modern quality theory, this condition indicates that the quality control system is not yet operating optimally, particularly in terms of environmental control (quality control). Draft Quality 4.0 emphasized the importance of real-time environmental monitoring using digital technology to prevent product damage (Liu et al., 2023). However, in practice, the controls are still manual, making them less effective in detecting potential damage early. From a Lean Logistics, busy warehouse operational conditions, queues of trucks, and limited storage space indicate waste (waste) in the form of waiting time and unnecessary motion (Alfarisy & Abi Hanif Dzulquarnain, 2023). This waste not only reduces operational efficiency but also increases the risk of product damage due to repetitive and inefficient handling. This

aligns with research showing that optimizing warehouse layout and product flow can significantly reduce product damage rates (Maulana Akbar et al., 2023).

Application of the method Failure Mode and Effect Analysis (FMEA) in this study was proven to be able to identify failure mode, analyzing the causes of failure, and determining risk priorities based on value Risk Priority Number (RPN). The results of the analysis show that failure mode with the highest risk being cement clumping due to warehouse humidity (highest RPN), followed by damage due to tilted truck loads and collapsed pallets. These findings indicate that environmental and distribution factors contribute significantly to product damage, not just internal warehouse factors.

Theoretically, this result is in accordance with the FMEA concept which states that the combination of severity, occurrence, and detection can be used to determine improvement priorities systematically (Yaqin et al., 2020). The values of severity high values indicate a significant impact of damage on product quality, while the occurrence The FMEA reflects the frequency of occurrence, and the detection value indicates the system's limitations in detecting certain damage. Thus, FMEA provides a comprehensive analytical framework for managing operational risk. Furthermore, the implementation of FIFO and regular damage recording demonstrates an effort to integrate FMEA with the principles of risk management in a lean supply chain. The FIFO system helps reduce the risk of quality degradation due to prolonged storage, while damage recording supports the process of continuous improvement in quality control (Anggi et al., 2025).

This is in line with the concept Total Quality Management (TQM) which emphasizes continuous improvement as part of the quality management system (Aradhana & Darmawan, 2023).

However, this study has several limitations. First, the study was conducted at a

single location, thus limiting the generalizability of the results. Second, the number of informants was relatively small, so it may not represent all operational perspectives. Third, the control system analyzed was manual, thus not reflecting the implementation of modern technology in warehouse management. These limitations open up opportunities for further research to expand the scope of the study.

Therefore, further research is suggested to develop technology-based approaches such as Quality 4.0 with the use of humidity sensors and digital monitoring systems, expanding the research object to several distribution warehouses, and combining the FMEA method with other approaches such as Six Sigma logistics simulation. With this development, it is hoped that future research will provide more comprehensive and applicable solutions to reduce the rate of damage to cement products and increase supply chain efficiency sustainably.

## **CONCLUSION**

The study concludes that damage to cement products in warehouses is a complex operational issue influenced by multiple interrelated factors. The primary forms of damage include torn packaging, collapsed pallets, and cement clumping due to high humidity, which significantly affect product quality, increase operational costs, and pose safety risks. The dominant cause of damage is human error, particularly in forklift operations during loading and unloading, exacerbated by work pressure and inconsistent implementation of standard operating procedures (SOPs). In addition, environmental factors—especially high humidity—play a critical role in product deterioration, indicating that current quality control systems are not yet optimal. Inefficiencies in warehouse operations, such as limited storage space and excessive handling, further increase the risk of damage. The application of Failure Mode and Effect Analysis (FMEA) successfully identifies

priority risks, with cement clumping due to humidity as the most critical issue. Overall, the study emphasizes the importance of improving operational discipline, strengthening SOP implementation, enhancing environmental control systems, and adopting technology-based monitoring to reduce damage and improve supply chain efficiency sustainably.

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