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An Integrated AHP–TOPSIS Model for Evaluating and Selecting Ship Docking Material Suppliers
(Case Study: PT SMKU Tegal)

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ABSTRACT

This study aims to determine the priority of criteria and select the best supplier of ship docking materials at PT Samugara Multikarya Utama (PT SMKU) Tegal using the Analytical Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods. The research employs a mixed methods approach, combining quantitative analysis through questionnaires to obtain criteria weights and supplier rankings, and qualitative analysis through interviews and field observations to understand operational conditions and company needs in the procurement process. The results indicate that the top priority in supplier selection is material quality (quality), which is the most crucial factor in supporting production continuity. The second priority is cost, followed by supplier service and reputation, production capacity and reliability, and delivery timeliness, which ranks last. Based on AHP-TOPSIS calculations, the best supplier for ship docking materials is PT Krakatau Posco as the first choice, followed by PT Samugara Multikarya Utama as the second choice, and PT Gunung Ciremai Sejahtera as the third choice. These findings highlight the importance of systematic, evidence-based evaluation of criteria to support efficient and consistent procurement decisions. This study demonstrates that the AHP-TOPSIS method can provide objective and rational supplier recommendations while enhancing the effectiveness of material procurement processes in the shipbuilding industry.

Keywords: *Supplier Selection, AHP-TOPSIS, Criteria Priority, Ship Docking Materials*

Introduction

The shipbuilding industry is one of the sectors that plays an important role in the economy, particularly in the transportation of goods and the support of national trade [1]. The performance of this industry is highly dependent on the efficiency of the ship-docking process, including maintenance and repair activities that require optimal coordination among labour, equipment, and materials. The availability of materials in a timely and high-quality availability of materials is a key factor in maintaining operational continuity and reducing production costs. Inaccurate material supply can cause delays in the docking schedule, increased costs, and reduced service quality, thereby exposing companies to significant operational risks. Various supplier alternatives are available with different characteristics, ranging from price, quality, delivery time, to reputation, which makes supplier selection a complex challenge.

PT SMKU Tegal faces supplier alternatives with varying characteristics, including material quality, price, and delivery time, making supplier selection a complex decision that requires careful consideration. When supplier selection is not carried out optimally, it can lead to various operational inefficiencies, such as delays in the ship-docking process, unnecessary stock accumulation, or significant increases in production costs. Dependence on certain suppliers without systematic evaluation can increase the risk of supply disruptions that affect the entire company supply chain.

The supplier selection process in many companies remains largely subjective, relying on personal experience or personal relationships with suppliers, making it difficult to ensure that decisions are truly effective and efficient [2]. This condition indicates that companies require a more objective, structured decision-making method to evaluate each supplier alternative comprehensively against relevant criteria

[3]. Through a systematic approach, management can minimize the risk of errors in supplier selection, improve operational efficiency, and ensure the sustainability of ship docking processes.

Supplier selection is one of the strategic decisions that influence operational continuity, production costs, and company service quality; it must be conducted systematically and objectively [4]. This decision-making process needs to consider various interrelated criteria, including price and total cost to ensure budget efficiency, material quality to ensure docking results meet technical standards, and delivery timeliness, which directly affects production schedules. After-sales service and supplier reputation are also important factors in assessing suppliers' reliability and ability to handle problems or additional requests, while supplier production capacity must be considered to ensure supply continuity in line with company needs.

The identification of the number and types of suppliers frequently used by the company, whether local, national, or international, was conducted to understand the supplier selection conditions at PT SMKU Tegal.

Table 1. Number of Frequently Used Suppliers

Supplier Category	Number of Suppliers	Percentage
Local Suppliers	5	50%
National Suppliers	4	40%
International Suppliers	1	10%
Total	10	100%

Source: PT SMKU Tegal Data (2025).

Based on Table 1, the majority of suppliers used by PT SMKU Tegal are domestic, comprising 5 local suppliers (50%) and 4 national suppliers (40%), while only 1 supplier (10%) is international, for a total of 10 active suppliers. This indicates that the company tends to rely on domestic suppliers to meet ship-docking material needs, likely due to logistical convenience, lower transportation costs, and geographical proximity to the company's location. The limited use of international suppliers also indicates challenges in obtaining specific materials that may only be available overseas, therefore the company must ensure that domestic supply chain management operates optimally. Latif & Wahyuning (2024) explain that companies have the opportunity to build long-term relationships and negotiate more flexible pricing because most suppliers are domestic, but they must also be aware of the risk of dependency on certain suppliers. The shipyard industry is highly dependent on the timely availability of materials in the ship docking process. Any delay in material delivery will directly affect ship repair schedules, increase operational costs, and potentially reduce customer trust.

This condition indicates that the current supplier selection system has not fully guaranteed a smooth material supply. The company tends to emphasize price and material quality aspects, while other factors, such as delivery timeliness, production capacity, supplier reputation, and after-sales service, have not been considered comprehensively and systematically. This imbalance in considering various criteria can lead to inappropriate supplier selection. As a result, risks of delivery delays and mismatches in material supply still occur frequently. This indicates that the decision-making process in supplier selection is not fully objective and has not fully accounted for all strategic factors that influence the sustainability of company operations.

Table 2. Frequency and Quantity of Docking Materials 2023–2025

No	Material Type	2023 (Ton)	Freq	2024 (Ton)	Freq	2025 (Ton)	Freq
1	Steel Plate	120	9	145	11	170	13
2	Welding Electrode	34	10	42	12	50	14
3	Steel Pipe	38	7	52	9	65	10
4	Marine Coating Paint	18	6	23	7	28	8
5	Bolts & Special Fittings	13	5	17	6	20	7

Source: PT SMKU Tegal Data (2025).

Table 2 shows the development of ship docking material requirements during the period 2023–2025. Based on the data, there has been a consistent increase in both quantity (tonnage) and order frequency for all material types. Steel plates hold the highest share in usage each year, amounting to 120 tons in 2023, rising to 145 tons in 2024, and increasing again to 170 tons in 2025. This increase is also reflected in the frequency of orders, which rose from 9 to 13 times over three years.

Welding electrodes show a significant increase, from 34 tons in 2023 to 50 tons in 2025, with the highest order frequency compared to other materials. The high frequency indicates that electrode purchases are made gradually following the docking work progress. Steel pipes, marine coating paint,

and bolts and special fittings also experienced increasing demand each year. This increase indicates growth in the volume of docking work at the company, resulting in greater and more complex material requirements. Based on these data, docking material demand shows a stable upward trend year over year. This condition requires supplier readiness to meet needs in larger quantities and more frequent ordering.

Table 3. Material Delivery Delays Data 2023–2025

Year	Total Orders	Delay Cases	Percentage	Average Delay
2023	37	8	21.60%	4–6 days
2024	45	11	24.40%	5–7 days
2025	52	14	26.90%	6–8 days

Source: PT SMKU Tegal Data (2025).

Table 3 shows the level of material delivery delays during the period 2023–2025. It can be seen that the total number of orders increased each year, in line with the increasing material demand shown in Table 1.2. This increase was followed by a rise in the number of delay cases. In 2023, out of 37 orders, there were 8 delay cases or 21.6%. In 2024, delays increased to 11 cases out of 45 orders (24.4%). In 2025, there were 14 delay cases out of 52 orders or 26.9%. To the increase in cases, the average delay duration also increased from 4–6 days in 2023 to 6–8 days in 2025. These data indicate a tendency for increasing delay risks as material demand rises. This suggests that suppliers' ability to meet demand has not been fully optimal, particularly in facing increasing order volumes and frequencies.

One method relevant in industrial management is the Analytical Hierarchy Process (AHP)**.** AHP is a multi-criteria decision-making method used to solve complex problems by considering multiple factors simultaneously [5]. This method structures problems into hierarchical levels consisting of goals, criteria, subcriteria, and alternatives. AHP enables systematic decision-making by weighting and ranking alternatives according to predetermined criteria.

Another method widely used in supplier selection is the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)**.** TOPSIS is based on the concept that the best alternative is the one closest to the positive ideal solution and farthest from the negative ideal solution. Through Euclidean distance calculations, TOPSIS can generate supplier rankings quantitatively and objectively. The integration of AHP and TOPSIS is expected to improve decision-making accuracy, minimize supplier selection risks, and support the efficiency of ship docking operations [6].

This study focuses on the selection of docking material suppliers in a modern shipyard, specifically at PT SMKU Tegal**,** which has not been widely studied previously. Unlike earlier studies that focused only on bamboo ships, spare parts, steel materials, or marine engines, this research evaluates all the main materials used in ship docking processes. The evaluation includes technical aspects, production capacity, service quality, and delivery timeliness. All criteria are systematically evaluated using the AHP method, providing a more comprehensive and quantitative approach than subjective methods previously used.

The results of this study are expected not only to produce an optimal supplier ranking but also to serve as a practical guideline for management in making strategic decisions related to the docking material supply chain. This study is relevant to the Indonesian shipbuilding industry because it can improve operational efficiency, reduce the risk of delays, and significantly lower production costs.

Research Methods

This study employs a mixed methods approach, combining qualitative and quantitative methods within a single research framework to obtain a comprehensive understanding of the supplier selection problem for ship docking materials. The research adopts a sequential explanatory strategy, where quantitative data collection and analysis are conducted in the first stage, followed by qualitative data collection and analysis in the second stage to explain and strengthen the quantitative findings [7]. The qualitative approach is used to identify problems, analyze company needs, and determine the criteria and indicators for selecting docking material suppliers based on operational conditions at PT Samugara Multikarya Utama (PT SMKU) Tegal. This approach is carried out through field observations and interviews with parties directly involved in the procurement process of docking materials. Meanwhile, the quantitative approach uses the Analytical Hierarchy Process (AHP) to process numerical data, determine the priority weights of each criterion, rank alternative suppliers, and generate objective, measurable recommendations for the best supplier.

The research was conducted at PT Samugara Multikarya Utama (PT SMKU) located at Jl. Raya Tegal–Pemalang Km. 12, Purwahamba, Suradadi, Tegal City, Central Java, Indonesia. The selection of this research location is based on the relevance of the problems faced by the company, particularly in the supplier selection process for ship docking materials, which still requires a more systematic and objective decision-making system. The research was conducted over a six-month period, from January to June 2026, covering the stages of preliminary study, data collection, data analysis, development of an AHP-based supplier selection model, and preparation of the research report. The types of data used in this study include both qualitative and quantitative. Qualitative data were obtained through interviews with management, purchasing staff, and Quality Control personnel, as well as through direct observation of the docking material procurement process. Quantitative data were obtained from pairwise-comparison questionnaires that assessed the relative importance of criteria and the performance of supplier alternatives using the AHP scale.

The data collection process was carried out through several techniques, namely in-depth interviews, field observations, questionnaire distribution, documentation studies, and literature studies. Interviews and observations were conducted to identify problems and determine supplier selection criteria, while questionnaires were used to obtain quantitative data for AHP analysis. The criteria used in this study include cost, material quality, delivery timeliness, production capacity, and supplier service and reputation, each of which consists of several sub-criteria as measurement indicators. Data analysis was conducted using the Analytical Hierarchy Process (AHP) method to determine the priority weights of criteria through pairwise comparisons and consistency testing, followed by the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method to rank suppliers based on their closeness to the positive ideal solution and distance from the negative ideal solution [8]. The results of this analysis produce preference scores used to determine the best supplier for PT SMKU Tegal in make more systematic and objective decisions regarding the procurement of ship docking materials.

Results and Discussion

Hierarchical Structure

The hierarchical structure is an important initial stage in applying the Analytical Hierarchy Process (AHP) method in combination with the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) model. The purpose of constructing a hierarchical structure is to break down complex problems into simpler, more systematic components, making the analysis and decision-making process easier. In this study, a hierarchical structure is used to describe the relationships among the main objective, evaluation criteria, subcriteria, and supplier alternatives to be assessed in selecting a supplier for ship docking materials at PT SMKU Tegal.

Through the development of the hierarchical structure, each component involved in the decision-making process can be analyzed in a more structured and logical manner. The AHP method helps determine the weight of importance for each criterion and sub criterion through a pairwise comparison process, resulting in priority values that reflect the relative importance of each factor. The TOPSIS method ranks supplier alternatives based on their closeness to the positive ideal solution and their distance from the negative ideal solution. The integration of these two methods allows the supplier evaluation process to be conducted more objectively and measurably.

In this study, the criteria in the AHP-TOPSIS method are arranged in a hierarchical structure consisting of several levels. Level 0 represents the main objective: selecting the best supplier for ship docking materials. Level 1 consists of the criteria used as the basis for supplier selection. Level 2 contains the sub criteria that further describe each criterion in Level 1. Level 3 represents the alternative suppliers to be compared to determine which is the most appropriate and recommended for the company to choose.

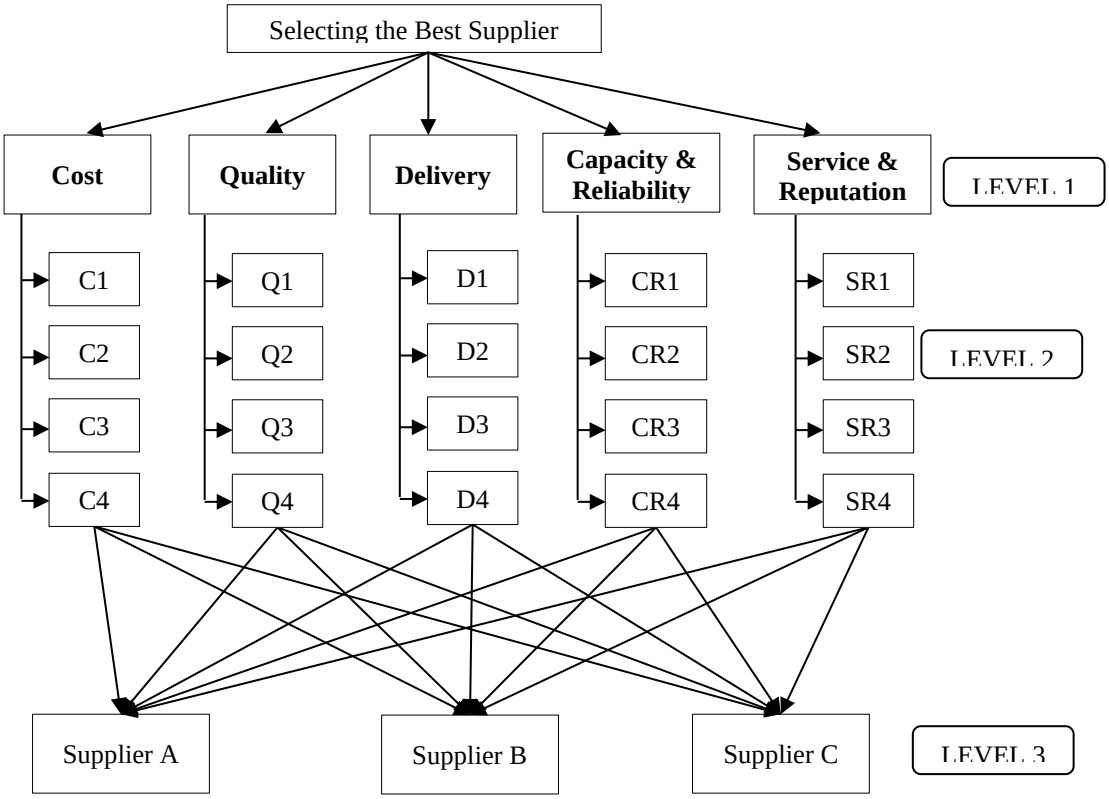

Figure 1. Hierarchical Structure of the Ship Docking Material Supplier Selection Problem at PT SMKU Tegal

Weights/Priority of Importance at Level 1 (Criteria)

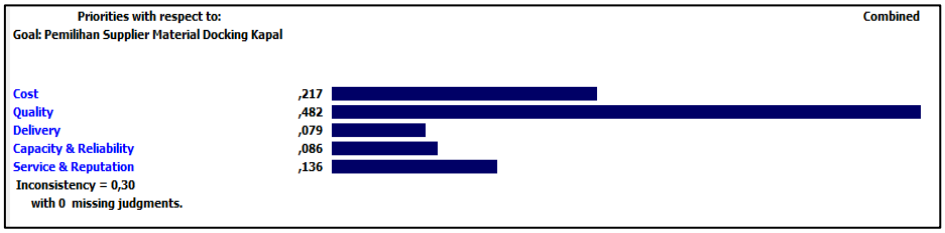

Figure 2. Priority of Criteria Importance in Selecting Suppliers for Ship Docking Materials at PT SMKU Tegal

Based on the AHP analysis results, each criterion in the supplier selection process for ship docking materials at PT SMKU Tegal has a different level of importance. The weighting results indicate the priority order of the criteria considered most influential in determining the best supplier.

The first priority is material quality (quality) with a weight of 0.482. This indicates that material quality is the most important factor considered by PT SMKU Tegal in selecting suppliers. High-quality materials are essential in the ship-docking process because they directly affect the ship's safety, durability, and operational reliability after maintenance. If the materials used are of poor quality, it can lead to faster damage, increased maintenance costs, and potential safety risks. Suppliers who are able to consistently provide materials that meet the required standards and specifications will be prioritized.

The second priority is price and cost (cost) with a weight of 0.217. Although quality is the main consideration, cost remains an important factor in supplier selection. PT SMKU Tegal must ensure that the procurement of docking materials is carried out efficiently to control operational costs. Competitive pricing from suppliers allows the company to maintain cost efficiency without sacrificing the quality of materials required for ship docking activities.

The third priority is supplier service and reputation (service & reputation) with a weight of 0.136. This criterion reflects the importance of good cooperation between the company and suppliers. Suppliers with good service quality, clear communication, responsiveness, and a positive reputation are considered more reliable in supporting operational activities. A supplier with a good reputation also

indicates consistent performance and trustworthiness, based on prior experience or recommendations from other partners.

The fourth priority is production capacity and reliability (capacity & reliability) with a weight of 0.086. This criterion relates to the supplier's ability to consistently meet the required material demand in terms of quantity and continuity. Suppliers with adequate production capacity and reliable operational systems are better able to ensure material availability when needed. This is important because ship docking activities often have strict schedules and require materials to be available on time.

The fifth and final priority in PT SMKU Tegal's supplier selection is delivery timeliness (delivery) with a weight of 0.079. Although it has the lowest weight among the criteria, delivery time remains a relevant factor in supporting the docking process. Timely delivery helps ensure that ship repair and maintenance schedules are not disrupted due to delays in material supply. Even though this criterion has a lower weight, suppliers who can deliver materials on schedule will still add value to the company's overall operational efficiency.

The weighting results show that PT SMKU Tegal places greater emphasis on the quality of materials, followed by cost efficiency, supplier service and reputation, production capacity and reliability, and delivery timeliness in selecting suppliers for ship docking materials. This priority structure reflects the company's commitment to maintaining operational quality and safety while still considering efficiency and reliability in its supply chain management.

Weight/Priority of Importance at Level 2 (Sub-Criteria)

Before presenting the table of priority of importance among sub-criteria, it is necessary to explain that at Level 2 of the hierarchical structure, each criterion is broken down into several sub-criteria to provide a more detailed and specific assessment. Each sub-criterion is assigned a weight indicating its relative importance to the main criterion, facilitating the evaluation and ranking of supplier alternatives. The following table shows the weights and priorities of each sub-criterion based on the AHP results, which will be used in the TOPSIS stage to determine the best supplier of ship docking materials at PT SMKU Tegal.

Table 4. Priority of Importance among Sub-Criteria

Criterion	Sub-Criterion	Weight	Priority
Price and Cost (Cost)	Unit price of material (C1)	0.150	3
	Price suitability with quality (C2)	0.450	1
	Total procurement cost (C3)	0.146	4
	Flexibility in price negotiation (C4)	0.253	2
Material Quality (Quality)	Compliance with technical material specifications (Q1)	0.363	1
	Material durability and reliability (Q2)	0.224	2
	Defect or return rate of materials (Q3)	0.197	4
	Compliance with quality standards and certification (Q4)	0.216	3
Delivery Timeliness (Delivery)	Accuracy of delivery schedule (D1)	0.114	3
	Responsiveness to material requests (D2)	0.511	1
	Consistency of delivery time (D3)	0.087	4
	Ability to meet urgent needs (D4)	0.259	2
Production Capacity and Reliability (Capacity & Reliability)	Supplier production capacity (CR1)	0.189	2
	Availability of material stock (CR2)	0.109	4
	Consistency of supply (CR3)	0.116	3
	Ability to fulfill large orders (CR4)	0.586	1
Supplier Service and Reputation (Service & Reputation)	Quality of after-sales service (SR1)	0.139	3
	Speed of handling complaints (SR2)	0.322	2
	Supplier reputation and experience (SR3)	0.133	4
	Ease of communication and coordination (SR4)	0.406	1

Based on Table 4, the weights and priority levels among the sub criteria at Level 2 of the hierarchical structure for selecting ship docking material suppliers at PT SMKU Tegal show clear differences in the relative importance of each factor. In the Cost criterion, the highest-priority subcriterion is the price-quality ratio (C2), with a weight of 0.450. This emphasizes that the company

places great importance on obtaining materials with prices proportional to the quality received, as low-cost materials of poor quality could pose operational risks. The second priority is flexibility in price negotiation (C4), with a weight of 0.253, indicating that the supplier's ability to adjust prices to meet the company's needs is a crucial consideration in decision-making. The sub criterion unit material price (C1) ranks third with a weight of 0.150, suggesting that while the unit price is relevant, it is not as significant as the price-quality ratio and negotiation flexibility. Total cost of procurement (C3) ranks fourth with a weight of 0.146, indicating that procurement cost is more of a complementary factor than the others.

In the Material Quality (Quality) criterion, the top priority is compliance with material technical specifications (Q1) with a weight of 0.363, as proper technical specifications greatly influence docking performance and operational safety. The second priority is material durability and reliability (Q2) with a weight of 0.224, highlighting that long-term material resilience is a major consideration after technical specifications. Compliance with quality standards and certification (Q4) ranks third (0.216), showing that while certifications enhance supplier credibility, they are not as decisive as technical specifications and durability. Meanwhile, material defect or return rate (Q3) is ranked fourth (0.197), indicating that while reducing defective materials is important, it is less critical compared to technical and reliability factors.

For the Delivery criterion, the highest priority sub criterion is responsiveness to material requests (D2) with a weight of 0.511, emphasizing that a supplier's quick response to company demands is crucial for smooth docking operations. The second priority is the ability to meet urgent needs (D4) with a weight of 0.259, reinforcing that a supplier who can fulfil urgent orders enhances operational flexibility. On-time delivery (D1) ranks third (0.114), while consistency in delivery schedule (D3) ranks fourth (0.087), indicating that although timely and consistent delivery is important, responsiveness and urgent fulfilment are more dominant in the evaluation.

In the Capacity & Reliability criterion, the priority emphasizes volume and supplier capability. Ability to fulfil large orders (CR4) has the highest weight of 0.586, highlighting that large production capacity is a key factor to ensure optimal availability of docking materials. The second priority is supplier production capacity (CR1), at 0.189, which supports the fulfilment of regular company needs. Supply consistency (CR3) ranks third (0.116), and material stock availability (CR2) ranks fourth (0.109), showing that continuous stock availability is a supporting factor compared to the ability to meet large orders.

In the Service & Reputation criterion, the top priority is ease of communication and coordination (SR4) with a weight of 0.406, emphasizing the importance of smooth interactions between the company and supplier to accelerate decision-making, problem-solving, and project coordination. The second priority is the speed of complaint handling (SR2), at 0.322, highlighting that a quick response to issues is critical for operational continuity. After-sales service quality (SR1) ranks third (0.139), while supplier reputation and experience (SR3) rank fourth (0.133), indicating that although supplier reputation matters, active interaction and responsive service are more decisive in evaluating service and reputation.

Selecting the Best Supplier

After calculating the weights and priorities for each criterion and sub criterion, the next step is to synthesise the overall weights for each supplier alternative. This synthesis is carried out by combining the previously determined weights of criteria and sub criteria, allowing each supplier alternative to be evaluated comprehensively based on the relative contribution of all criteria. This process enables the company to assess suppliers not only on a single aspect but also by considering key factors such as cost, material quality, delivery timeliness, production capacity, and supplier service and reputation.

Using this approach, the synthesis results provide a clear overview of the overall ranking of supplier alternatives, making it easier for PT SMKU Tegal to determine the most optimal supplier for ship docking material needs. The following table and figure present the overall weights of each supplier alternative, which serve as the basis for strategic decision-making in selecting the best supplier.

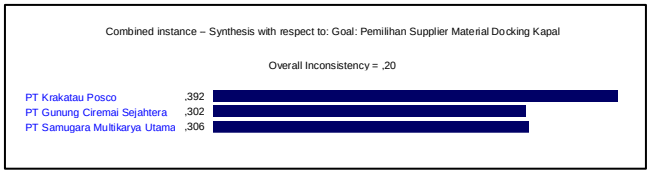

Figure 3. Overall Weights of Alternatives

Based on the results of the overall weight synthesis, PT SMKU Tegal can determine ship docking material suppliers more objectively. The first priority is PT Krakatau Posco (Supplier A) with an overall weight of 0.392. This weight indicates that Supplier A has a comprehensive advantage in meeting all established criteria, including cost, material quality, delivery timeliness, production capacity, and supplier service and reputation. This confirms that PT Krakatau Posco is the most optimal choice for the company to fulfil its ship docking material needs.

The second priority is PT Samugara Multikarya Utama (Supplier C) with a weight of 0.306. Although its weight is lower than Supplier A, Supplier C still performs well, particularly in certain criteria such as price adjustment flexibility and responsiveness to material requests. This supplier becomes a viable alternative if there are limitations or supply constraints from Supplier A.

The third or last priority is PT Gunung Ciremai Sejahtera (Supplier B) with a weight of 0.302. This weight places Supplier B slightly below Supplier C, indicating that while Supplier B meets the established criteria, it has relative weaknesses, for example, in handling large production volumes or responding quickly to urgent needs. Nevertheless, Supplier B can still serve as a backup supplier to ensure smooth docking operations.

The ranking of these three suppliers provides a clear guideline for PT SMKU Tegal in making strategic decisions for ship docking material procurement, allowing the company to minimize risk and maximize efficiency in the procurement process.

Table 5. Alternative Weights Related to Each Criterion

Criterion	PT Krakatau Posco (Supplier A)	PT Gunung Ciremai Sejahtera (Supplier B)	PT Samugara Multikarya Utama (Supplier C)
Cost	0.432	0.278	0.290
Material Quality	0.365	0.316	0.319
Delivery Timeliness	0.386	0.340	0.274
Production Capacity & Reliability	0.386	0.342	0.272
Supplier Service & Reputation	0.443	0.238	0.320

Based on Table 5, the evaluation of supplier alternatives in relation to the selection criteria for ship docking materials at PT SMKU Tegal reveals notable differences in performance across each criterion, which provide a comprehensive understanding of supplier strengths and weaknesses.

In the Cost criterion, PT Krakatau Posco (Supplier A) has the highest weight at 0.432, indicating that this supplier provides the most favourable balance between material price and cost-effectiveness. This suggests that Supplier A can meet the company's budgetary expectations while maintaining satisfactory quality levels. PT Samugara Multikarya Utama (Supplier C) ranks second with a weight of 0.290, indicating moderate competitiveness in pricing, while PT Gunung Ciremai Sejahtera (Supplier B) has the lowest weight of 0.278, suggesting that its cost offerings are less advantageous to the company. This clearly positions Supplier A as the preferred choice when cost efficiency is critical.

Regarding Material Quality, Supplier A maintains its lead with a weight of 0.365, reflecting strong compliance with technical specifications, high material reliability, and low defect rates. Supplier C and Supplier B have similar weights, 0.319 and 0.316, respectively, indicating that while both suppliers can deliver materials that meet the required standards, Supplier A still provides a slight advantage in overall quality assurance. This suggests that choosing Supplier A reduces potential operational risks associated with substandard materials.

For Delivery Timeliness, Supplier A again demonstrates strong performance with a weight of 0.386, slightly ahead of Supplier B at 0.340, while Supplier C is considerably lower at 0.274. This indicates that Supplier A is more reliable in meeting delivery schedules and responding promptly to material requests, which is crucial for maintaining smooth docking operations. Supplier C's lower weight highlights potential challenges in meeting urgent timelines, which could affect operational efficiency if selected as the primary supplier.

In the Production Capacity & Reliability criterion, Supplier A and Supplier B are almost comparable, with weights of 0.386 and 0.342, respectively. This shows that both suppliers have sufficient production capabilities to fulfil large orders and ensure a stable material supply. Supplier C, with a weight of 0.272, appears less capable in terms of production scale, which could limit the company's flexibility in handling large or urgent orders. Supplier A's leading weight reinforces its suitability as a supplier capable of reliably supporting large-scale docking operations.

In Supplier Service & Reputation, Supplier A achieves the highest weight of 0.443, demonstrating excellence in communication, coordination, complaint responsiveness, and after-sales support. Supplier C follows with 0.320, while Supplier B has the lowest weight of 0.238, indicating a relative weakness in service quality and supplier reputation. This distinction highlights that Supplier A not only meets operational and technical requirements but also ensures smooth collaboration, which is essential for long-term supplier partnerships.

The detailed analysis of Table 2 shows that PT Krakatau Posco (Supplier A) consistently outperforms the other alternatives across nearly all criteria. Supplier A's strengths in cost management, material quality, timely delivery, production capacity, and service excellence make it the most optimal choice for PT SMKU Tegal. Supplier C serves as a viable secondary option, particularly if flexibility or backup supply is needed, while Supplier B may be considered as a supplementary option due to relative weaknesses in cost competitiveness and service performance. This ranking provides a solid foundation for strategic and evidence-based supplier selection.

Consistency

In the Analytical Hierarchy Process (AHP) method, the comparison of criteria, sub-criteria, and alternatives is based on human perception. Due to the subjective nature of human judgment, inconsistencies may occur, especially when comparing a large number of criteria simultaneously. These inconsistencies can affect the accuracy of the resulting weights, making it essential to perform a consistency test to validate the AHP results.

To ensure that respondents' evaluations are reliable, the Consistency Ratio (CR) was analyzed using the Expert Choice 11 software. The CR value measures the level of consistency in pairwise comparisons; a CR value below 0.10 indicates that the evaluations are consistent. This consistency test ensures that respondents' preferences and assessments reflect logical and stable considerations, so the final calculation of criteria, sub-criteria, and alternative weights can serve as a valid basis for decision-making.

Table 6 presents the results of the Consistency Ratio (CR) analysis for all pairwise comparisons, including comparisons between criteria, sub-criteria, and alternatives. The table shows that all CR values are below the maximum threshold of 0.10, indicating that all respondent evaluations are within a good level of consistency. These results strengthen the reliability of the data used in the AHP process and confirm that the obtained weights provide a sound basis for selecting the optimal ship-docking material supplier at PT SMKU Tegal.

Table 6. Respondents' Consistency Ratio (CR) Values

Description	CR Value	Conclusion
Pairwise comparison among criteria	0.03	Consistent
Pairwise comparison among Cost subcriteria	0.09	Consistent
Pairwise comparison among Quality subcriteria	0.02	Consistent
Pairwise comparison among Delivery subcriteria	0.04	Consistent
Pairwise comparison among Capacity & Reliability subcriteria	0.06	Consistent
Pairwise comparison among Service & Reputation subcriteria	0.02	Consistent
Pairwise comparison of alternatives with subcriterion C1	0.05	Consistent
Pairwise comparison of alternatives with subcriterion C2	0.00	Consistent
Pairwise comparison of alternatives with subcriterion C3	0.08	Consistent
Pairwise comparison of alternatives with subcriterion C4	0.04	Consistent
Pairwise comparison of alternatives with subcriterion Q1	0.01	Consistent
Pairwise comparison of alternatives with subcriterion Q2	0.00	Consistent
Pairwise comparison of alternatives with subcriterion Q3	0.04	Consistent
Pairwise comparison of alternatives with subcriterion Q4	0.02	Consistent
Pairwise comparison of alternatives with subcriterion D1	0.06	Consistent
Pairwise comparison of alternatives with subcriterion D2	0.08	Consistent
Pairwise comparison of alternatives with subcriterion D3	0.00	Consistent
Pairwise comparison of alternatives with subcriterion D4	0.08	Consistent
Pairwise comparison of alternatives with subcriterion CR1	0.00	Consistent
Pairwise comparison of alternatives with subcriterion CR2	0.00	Consistent
Pairwise comparison of alternatives with subcriterion CR3	0.02	Consistent
Pairwise comparison of alternatives with subcriterion CR4	0.00	Consistent
Pairwise comparison of alternatives with subcriterion SR1	0.00	Consistent

Pairwise comparison of alternatives with subcriterion SR2	0.00	Consistent
Pairwise comparison of alternatives with subcriterion SR3	0.00	Consistent
Pairwise comparison of alternatives with subcriterion SR4	0.00	Consistent

Table 6 presents the results of the Consistency Ratio (CR) analysis for respondents' evaluations in pairwise comparisons, including comparisons among criteria, subcriteria, and alternatives, conducted using Expert Choice 11 software. The table shows that all CR values are below 0.10, indicating that all respondents' evaluations are consistent and logical. This ensures that the resulting weights are reliable for decision-making in supplier selection.

For pairwise comparisons among criteria, the CR value is 0.03, demonstrating very good consistency in prioritizing criteria such as cost, quality, delivery, capacity, and supplier service/reputation. For the Cost sub-criterion, the CR value is 0.09, still within the consistent range, indicating that respondents were able to logically assess unit price, price-quality suitability, total procurement cost, and price-negotiation flexibility. Other sub-criteria, including Quality (0.02), Delivery (0.04), Capacity & Reliability (0.06), and Service & Reputation (0.02), also show good consistency, indicating that evaluations of material quality, delivery timeliness, production capacity, and supplier service were conducted in a stable and rational manner.

Pairwise comparisons of alternatives for each subcriterion also exhibit high consistency. For example, for the Cost subcriteria C1, C2, C3, and C4, the CR values range from 0.00 to 0.08, showing that evaluations of PT Krakatau Posco, PT Gunung Ciremai Sejahtera, and PT Samugara Multikarya Utama were logical and aligned. The same pattern is observed for the Quality subcriteria (0.00–0.04), Delivery (0.00–0.08), Capacity & Reliability (0.00–0.02), and Service & Reputation (0.00). These low CR values indicate that respondents' judgments were consistent, with no significant contradictions in their rankings of alternatives across sub-criteria.

These CR results strengthen the validity of the AHP process applied in this study. All evaluations are consistent, meaning that the derived weights for criteria, sub-criteria, and alternatives can serve as a reliable foundation for making informed decisions in selecting the best ship docking material supplier for PT SMKU Tegal.

The study results indicate that the decision-making process for selecting Docking Ship material suppliers at PT SMKU Tegal is carried out using a systematic multi-criteria approach, in accordance with Industrial Engineering principles. Supply Chain Management theory emphasizes that efficient supply chain management requires a comprehensive assessment of suppliers to support smooth production. Supplier evaluation was conducted by considering various interrelated aspects, ensuring that decisions are not partial and can minimize operational risks. This demonstrates that the application of Supply Chain Management theory is not merely conceptual but can also be implemented in practice to enhance industrial performance [9].

The AHP-TOPSIS method used aligns with Industrial Engineering Decision Making theory, which emphasizes simultaneous quantitative and qualitative analysis to achieve optimal decisions. This method allows the integration of multiple complex criteria, so that the evaluation results reflect the company's operational reality [10]. The study shows that supplier alternatives were evaluated holistically, demonstrating the effectiveness of AHP-TOPSIS in reducing human subjectivity and improving decision consistency [11]. This systematic approach supports evidence-based decision-making, which is a key principle in Industrial Engineering practice.

The findings affirm the relevance of the Total Quality Management (TQM) concept in supplier selection. Decisions were made by considering quality comprehensively, in line with the TQM principle that quality should be the primary factor in improving production efficiency and reducing waste [12]. The results indicate that the selected suppliers were capable of meeting the expected quality standards, which in turn supports the continuity of the production process. This strengthens the connection between industrial quality theory and practical procurement applications.

From an Operations Management perspective, the study shows that optimal supplier selection can improve operational reliability and consistency. Decisions that consider overall supplier performance support supply stability and minimize production disruption risks. This aligns with Capacity Planning theory, which holds that reliable resources are key to maintaining operational efficiency. In other words, integrating capacity theory with systematic supplier evaluation helps the company plan production more effectively [13].

The study shows that the use of AHP-TOPSIS produces a high level of consistency in the evaluation of alternatives, supporting Analytic Hierarchy Process theory, which emphasizes the importance of consistency in human preference-based decision-making. This consistency ensures that the decisions taken can be technically and logically justified [14]. The findings indicate that, although decisions involve human perception, the use of formal methods can maintain decision quality. This

demonstrates that AHP theory can be effectively applied in industrial engineering contexts for supplier evaluation [15].

Practically, the supplier evaluation process supports the principle of System Optimization by emphasizing a balance between quality, capacity, and service. Decisions accounted for the impact of multiple criteria simultaneously, allowing the company to optimize procurement performance [16]. The study shows that the method used enables the company to assess trade-offs between various factors, resulting in more rational and efficient decisions. This approach reflects the application of optimization theory in real operational contexts.

The study also shows that holistic supplier selection can reduce operational risks, consistent with Risk Management principles in Industrial Engineering. By evaluating suppliers based on comprehensive performance, the company can anticipate potential issues, such as supply delays or quality nonconformities. The study confirms that data-driven and systematic decision-making can minimize risks and improve supply chain reliability. This demonstrates the relevance of risk management theory in operational decision-making [17].

Integrating criteria in supplier evaluation supports the principles of Lean Manufacturing, which aim to reduce waste and increase value-added in the production process. Selected suppliers met the company's needs on time and to optimal quality, reducing potential downtime and waste [18]. The study shows that applying a multi-criteria approach can improve procurement efficiency and support smooth production. Lean Manufacturing theory proves relevant in supplier selection practices.

In the context of Strategic Sourcing, the study emphasizes the importance of selecting suppliers that provide long-term strategic contributions to the company. Evaluation of overall performance ensures that procurement decisions support the company's sustainable objectives. The study shows that AHP-TOPSIS allows the company to select suppliers capable of consistently delivering added value [19]. This highlights the connection between strategic sourcing theory and industrial decision-making practice.

The findings support Performance Measurement theory in Industrial Engineering, which emphasizes that decision-making should be based on performance evaluation. Systematic supplier assessment demonstrates that integrating quantitative and qualitative criteria can yield optimal decisions. The study shows that data-based evaluation improves transparency and accuracy in decision-making. This approach reinforces the principles of accountability and effectiveness in supply chain management [20].

The findings affirm the relevance of Decision Support System (DSS) theory, as the use of Expert Choice 11 software facilitated calculations and analysis. Decision support systems help reduce human errors and accelerate evaluation processes. The study shows that DSS can improve the quality of strategic decisions, particularly in industrial procurement involving multiple variables. This demonstrates the integration of information technology in modern Industrial Engineering practice [21].

Optimal supplier selection directly enhances operational efficiency. Operations Research theory emphasizes the importance of quantitative analysis in decision-making to maximize output and reduce costs [22]. The study findings indicate that quantitative and systematic decision-making can improve company productivity and efficiency [23]. This confirms that Operations Research principles can be effectively applied in industrial procurement management.

The study confirms that the use of AHP-TOPSIS is consistent with Industrial Engineering Decision Making principles, as it produces holistic, consistent, and performance-based decisions [24]. The integration of various industrial engineering theories from supply chain, quality management, to decision support shows that systematic supplier selection can enhance efficiency, productivity, and operational sustainability [25]. The study reinforces the relationship between industrial engineering theory and practical decision-making in real-world contexts.

Conclusion

Based on the discussion of the research findings, several conclusions can be drawn regarding PT SMKU Tegal’s decision-making process in selecting suppliers for Docking Ship materials. First, the primary priority in supplier selection is material quality, indicating that the company emphasizes compliance with technical specifications and standards to ensure smooth production processes. The next priority is cost, highlighting that efficiency in expenditure and alignment of price with quality remain crucial considerations. The third priority is supplier service and reputation, reflecting the company’s need for effective communication, after-sales service, and supplier experience in supporting operational activities. Following this, production capacity and reliability become the fourth priority,

indicating that the supplier's ability to fulfill large orders consistently is a key factor. The last priority is delivery punctuality, which, although ranked lowest, remains important in maintaining a smooth supply chain.

Based on the multi-criteria evaluation, the best supplier for Docking Ship materials capable of meeting PT SMKU Tegal's needs comprehensively is PT Krakatau Posco, which becomes the first priority based on overall performance. The second priority is PT Samugara Multikarya Utama, which, while not ranking first, demonstrates adequate capability in fulfilling the evaluation criteria. The third priority is PT Gunung Ciremai Sejahtera, which, despite having a slightly lower weight, remains a viable alternative. These conclusions show that supplier selection is conducted systematically, considering both qualitative and quantitative aspects, so that the decisions made are not only optimal but also support operational efficiency, production quality, and the sustainability of the company's supply chain.

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