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# Analysis of supplier selection criteria using fuzzy analytical hierarchy process by contractors in Yogyakarta

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**ABSTRACT**

One of the factors that can support the success of a project being completed on time and within budget is the right choice of suppliers. The right selection can guarantee the availability of materials necessary to maintain the production path. Supplier selection is a multi-criterion issue where each criterion has a different level of importance and needs to be accurately assessed. This study aims to prioritize the factors contractors can use to select suppliers to determine which suppliers are the best. This study also conducts testing on the contractors at CV. Jogja Karunia Cipta. One of the supplier selection methods is the Fuzzy Analytic Hierarchy Process (Fuzzy AHP) method. This method is widely used as many studies state it provides more accurate results. Based on a literature review, the study identified 18 factors that influence the choice of material suppliers, grouped into six categories: Delivery, Quality, Price, Service, Performance, and Management. Data collection in this study was conducted using a questionnaire distributed to 10 respondents and processed using the Fuzzy AHP method. Based on the data processing that has been carried out, it is found that the criteria prioritized by local contractors in Yogyakarta in selecting suppliers are quality criteria, cost criteria, and delivery criteria. The test results on CV. Jogja Karunia Cipta is validated with manual calculations, identifying CV. Sinar Laut is the best supplier.

**Keywords:** Fuzzy analytic hierarchy process, Multi-criteria decision-making, Supplier selection.

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## INTRODUCTION

The construction project involves various activities and utilizes resources, including human labor or workers, materials, and equipment. This results in a high complexity of work within the construction industry's supply chain. Among the various resources used, materials represent a significant percentage, approximately 50% to 70% of the total project cost (Safa et al., 2014). Therefore, effective management, particularly in material procurement activities, is crucial (Abdullah et al., 2018), as poor procurement of materials is one of the five dominant factors causing cost overruns in construction projects in Indonesia (Limantoro et al., 2023).

The role of material procurement is a primary concern associated with the continuity of the construction supply chain and is closely linked to supplier selection. Thoughtful selection of suitable material suppliers will establish a collaborative relationship between the contractor and the supplier. This can include single-sourced material procurement with agreed-upon value and prices, negotiation to achieve mutually beneficial prices, and smooth product acquisition from the supplier, thereby fostering a sense of comfort regarding the supplier's professionalism (Fitriana & Santosa, 2020).

Supplier selection is a process in which a company must identify, evaluate, and contract with suppliers (Beil, 2011). Selecting suppliers based solely on offering low prices is no longer efficient. To achieve optimal performance in Supply Chain Management, it is essential to integrate relevant criteria aligned with the company's objectives (Ulum, 2020). Hence, companies need to understand the necessary criteria for evaluating suppliers to acquire the right supplier.

(Fitriana & Santosa, 2020) conducted similar research related to the study of material supplier selection factors in construction business services using the fuzzy AHP method. The analysis identified the main factors as material suitability, raw material prices, and suitability of delivery dates. Comparisons of data processing using fuzzy AHP and AHP conducted by Faisol (Faisol et al., 2014)show that fuzzy AHP has an accuracy rate of 84.62%, higher than the AHP method, which is only 23.08%. The results of analyzing the accuracy of decision-making using fuzzy AHP by Afriliansyah (Afriliansyah et al., 2018) showed a significant increase in accuracy when using the fuzzy AHP method compared to using AHP (Safa et al., 2014). Therefore, effective management is crucial, particularly in material procurement activities (Abdullah et al., 2018), as poor procurement of materials is one of the five dominant factors causing cost overruns in construction projects in Indonesia (Limantoro et al., 2023).

The role of material procurement is a primary concern associated with the continuity of the construction supply chain and is closely linked to supplier selection. Thoughtful selection of suitable material suppliers will establish a collaborative relationship between the contractor and the supplier. This can include single-sourced material procurement with agreed-upon value and prices, negotiation to achieve mutually beneficial prices, and smooth product acquisition from the supplier, thereby fostering a sense of comfort regarding the supplier's professionalism (Fitriana & Santosa, 2020).

Supplier selection is a process in which a company must identify, evaluate, and contract with suppliers (Beil, 2011). Selecting suppliers based solely on offering low prices is no longer efficient. To achieve optimal performance in Supply Chain Management, it is essential to integrate relevant criteria aligned with the company's objectives (Ulum, 2020). Hence, companies need to understand the necessary criteria for evaluating suppliers to acquire the right supplier. (Fitriana & Santosa, 2020) conducted similar research related to the study of material supplier selection factors in construction business services using the fuzzy AHP method. The analysis identified the main factors as material suitability, raw material prices, and suitability of delivery dates. Comparisons of data processing using fuzzy AHP and AHP conducted by Faisol (Faisol et

al., 2014) show that fuzzy AHP has an accuracy rate of 84.62%, higher than the AHP method, which is only 23.08%. Analysis of the accuracy of decision-making using fuzzy AHP by Afriliansyah (Afriliansyah et al., 2018) showed a significant increase in accuracy when using the fuzzy AHP method compared to AHP.

With the limited application of Supply Chain Management, this research aims to establish priority criteria that local contractors in Yogyakarta can use to determine which suppliers can deliver the best performance.

## METHOD

This research investigates the application of supplier selection using the Fuzzy AHP method, employing quantitative methods. Quantitative research aims to obtain data in numerical form or quantified qualitative data (Sugiyono, 2011). In this study, data collection was based on field observations through interviews or direct observations of the actual conditions within the company, as well as questionnaire data obtained from respondents selected according to specific needs. The questionnaires were given to local contractors in Yogyakarta. Information was gathered from a literature review to identify the factors influencing contractors' considerations in selecting material suppliers.

Table 1. Supplier selection criteria based on literature

| Criteria | (Pitchipoo et al., 2013) | (Kaur, 2014) | (Merry et al., 2014) | (Stević et al., 2016) | (Patil & Kant, 2014) | (Laksono et al., 2018) | (Messah et al., 2016) |
|---|---|---|---|---|---|---|---|
| Delivery | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ |
| Quality | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Cost | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Service | | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Management | | | ✓ | | | ✓ | |
| Perform | | ✓ | ✓ | | | ✓ | |

A sample of 10 respondents who passed consistency tests was used to determine the priority scale of criteria considered by contractor companies when choosing material suppliers. Subsequently, an analysis was conducted using the Fuzzy Analytical Hierarchy Process method to obtain the prioritized ranking of these criteria. This research will also be validated by analyzing the supplier selection of CV. Jogja Karunia Cipta through testing three suppliers from the company.

Table 2. Subcriteria list for supplier selection

| Criteria | Subcriteria |
|---|---|
| Delivery (D) | Timeliness of delivery (D1)<br>Accuracy of material quantity as preorder (D2)<br>Delivery frequency (D3) |
| Quality (Q) | Material compliance with specifications (Q1)<br>Material defect rate (Q2)<br>Consistency in material quality (Q3) |
| Cost (C) | Material price (C1)<br>Shipping and administrative costs (C2)<br>Payment method (C3) |
| Service (S) | Flexibility and responsiveness (S1)<br>Warranty (S2)<br>Ease of claim procedures (S3) |
| Management (M) | Document completeness (M1)<br>Certification (M2)<br>Company age (M3) |
| Perform (P) | Supplier reputation (P1)<br>Duration of collaboration (P2)<br>Performance history (P3) |

**Analytical Hierarchy Process**

The Analytical Hierarchy Process (AHP) is a model that possesses the flexibility to provide opportunities for individuals or groups to define problems by making their respective assumptions and obtaining desired solutions or resolutions. AHP provides a framework for decision-making or problem-solving (Saaty, 1994). The AHP method follows a workflow or steps as described (Kusrini, 2007).

**Step 1**: The distributed questionnaire will use Saaty's scale to conduct pairwise comparison scoring between criteria and subcriteria.

**Step 2**: After obtaining the comparison results from the questionnaire, the next step is to create paired comparison matrices.

**Step 3**: Synthesizing paired comparison matrices.

**Step 4**: Calculating the maximum lambda (λmax)

**Step 5**: Computing the Consistency Index (CI)

$$CI = \frac{(\lambda max - n)}{(n-1)} \quad (1)$$

Table 3. The scale of comparison evaluation in AHP.

| Level of Importance | Definition |
|---|---|
| 1 | Equally important |
| 3 | Slightly more important |
| 5 | More important |
| 7 | Very important |
| 9 | Absolutely more important |
| 2, 4, 6, 8 | A value between two choices |

**Step 6**: Determining the Random Consistency Index (I.R.). For the I.R. value, refer to the values provided by Saaty, as shown in Table 4.

Table 4. *Index Random* (I.R.)

| n | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| I.R. | 0 | 0 | 0,58 | 0,9 | 1,12 | 1,24 | 1,32 | 1,41 |

**Step 7**: Calculating the Consistency Ratio (C.R.)

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{IR}} \quad (2)$$

The result of the C.R. calculation should be ≤ 0,1 or 10% to be considered acceptable.

**Step 8**: Calculating the mean of the results of 10 respondents

$$\text{Average (mean)} = \frac{\text{number of data values}}{\text{number of data}} \quad (3)$$

Steps 2 to 7 are carried out on each questionnaire result from the 10 respondents, producing 10 tables of weighting results for each respondent who has passed the consistency test. If the Consistency Ratio (CR) results from each respondent meet the consistency test requirements, the average calculation of the results from the 10 respondents is conducted to obtain the final weighting results of the criteria and subcriteria.

**Fuzzy Analytical Hierarchy Process**

The Fuzzy Analytical Hierarchy Process (FAHP) addresses the shortcomings of the Analytical Hierarchy Process (AHP). One of the weaknesses of the AHP method is the subjectivity in evaluating criteria. To overcome this limitation, the FAHP method utilizes a set of rules represented in the form of triangular fuzzy numbers (TFN) structured based on linguistic assessments. Thus, the evaluation scale from AHP is transformed into the TFN scale (Afifah, 2018).

Here are the steps of the Fuzzy AHP method (Patil & Kant, 2014).

**Step 1**: Constructing a fuzzy comparison matrix.

After forming the comparison matrix, the AHP scale values are transformed into Triangular Fuzzy Number (TFN) scales.

**Step 2**: Calculate the value of the fuzzy synthetic extent.

$$Si = \sum_{j=1}^{m} M_{gi}^{j} \times \left[\sum_{i=1}^{n}, \sum_{i=1}^{n} M_{gi}^{i}\ \right]^{-1} \tag{4}$$

**Step 3**: Performing summation for all TFN values.

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \tag{5}$$

**Step 4**: Then, the summation is conducted for each column of lower, median, and upper values.

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right] = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \tag{6}$$

**Step 5**: Performing inversion using arithmetic operations on TFN.

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \tag{7}$$

**Step 6**: Calculate the comparison of the possibility levels among fuzzy numbers. If the obtained result in each

fuzzy matrix is $M_2 \geq M_1$ ($M_2 = l_2, m_2, u_2$) and $M_1 = (l_1, m_1, u_1)$, then the vector value can be calculated by

$$V(M_2 \geq M_1) = \begin{cases} 1, & \text{if } m_2 \geq m_1, \\ 0, & \text{if } l_1 \geq u_2, \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{the others} \end{cases} \tag{8}$$

**Step 7**: Then, calculate defuzzification (d') or the possibility level for a fuzzy number defined as follows

$$d'(A_i) = \min V (S_i \geq S_k) \tag{9}$$

for k = 1, 2, …, n; k≠i, thus, the obtained value is the weight of the fuzzy vector (W')

$$W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))^T \tag{10}$$

**Step 8**: Normalizing the weight vector.

$$W = (d(A_1), d(A_2), \ldots, d(A_n)) \tag{11}$$

Table 5. Triangular Fuzzy Numbers (TFN)

| AHP Scale | Fuzzy Scale | Repricoral | Definition |
|---|---|---|---|
| 1 | (1, 1, 1) / (1, 1, 3) | (1, 1, 1) / (1/3, 1, 1) | Just equal |
| 2 | (1, 2, 4) | (1/4, 1/2, 1) | Intermediate |
| 3 | (1, 3, 5) | (1/5, 1/3, 1) | Moderately important |
| 4 | (2, 4, 6) | (1/6, 1/4, 1/2) | Intermediate |

Table 5. Triangular Fuzzy Numbers (TFN)

| AHP Scale | Fuzzy Scale | Repricoral | Definition |
|---|---|---|---|
| 5 | (3, 5, 7) | (1/7, 1/5, 1/3) | Strongly important |
| 6 | (4, 6, 8) | (1/8, 1/6, 1/4) | Intermediate |
| 7 | (5, 7, 9) | (1/9, 1/7, 1/5) | Very strong |
| 8 | (6, 8, 10) | (1/10, 1/8, 1/6) | Intermediate |
| 9 | (7, 9, 11) | (1/11, 1/9, 1/7) | Extremely strong |

## RESULTS AND DISCUSSION

### Analytical Hierarchy Process

The calculation provided here is an example of the results from one respondent. At the end, the average calculation results from the 10 respondents will be presented.

Comparisons are made pairwise by comparing all the criteria used. The values entered are numerical, referring to the AHP scale in Table 3. Then, the summation of values aija_{ij}aij in each matrix column is performed. The result of the pairwise comparisons is in the form of a matrix, as shown in Table 6.

Table 6. Paired comparions matrices

| Criteria | C | D | M | P | Q | S |
|---|---|---|---|---|---|---|
| C | 1 | 7 | 7 | 7 | 1 | 9 |
| D | 0,143 | 1 | 1 | 0,2 | 0,111 | 1 |
| M | 0,143 | 1 | 1 | 0,2 | 0,143 | 1 |
| P | 0,143 | 5 | 5 | 1 | 0,167 | 5 |
| Q | 1 | 9 | 7 | 6 | 1 | 7 |
| S | 0,111 | 1 | 1 | 0,2 | 0,143 | 1 |
| Total | 2,54 | 24 | 22 | 14,6 | 2,563 | 24 |

Normalize the results from Table 6. Priorities for each criterion, based on their contribution to the objective, can be calculated by dividing each matrix element by the sum of each column.

Table 7. Normalized paired comparison matrices

| Criteria | C | D | M | P | Q | S |
|---|---|---|---|---|---|---|
| C | 0,394 | 0,292 | 0,318 | 0,479 | 0,39 | 0,375 |
| D | 0,056 | 0,042 | 0,045 | 0,014 | 0,043 | 0,042 |
| M | 0,056 | 0,042 | 0,045 | 0,014 | 0,056 | 0,042 |
| P | 0,056 | 0,208 | 0,227 | 0,068 | 0,065 | 0,208 |
| Q | 0,394 | 0,375 | 0,318 | 0,411 | 0,39 | 0,292 |
| S | 0,044 | 0,042 | 0,045 | 0,014 | 0,056 | 0,042 |
| Total | 1 | 1 | 1 | 1 | 1 | 1 |

The following is an example of normalization calculation for the Cost criterion against the Delivery criterion. The same method is applied to all criteria.

$$D = \frac{7}{24} = 0{,}292$$

After obtaining the normalized matrix, calculate the partial weights by averaging each row of the normalized matrix, as exemplified in Table 8. The following is an example of the partial weight calculation for the Cost criterion.

$$C = \frac{0{,}394+0{,}292+0{,}318+0{,}479+0{,}39+0{,}375}{6} = 0{,}375$$

Table 8. Partial weights

| Criteria | Partial weights |
|---|---|
| C | 0,375 |
| D | 0,04 |
| M | 0,042 |
| P | 0,139 |
| Q | 0,363 |
| S | 0,04 |

The next step is to calculate the value of the eigenvector. The eigenvector is calculated by multiplying the initial matrix with the partial weights. The following is an example of eigenvector calculation for the Cost criterion.

C = (1 x 0,375) + (7 x 0,04) + (7 x 0,042) + (7 x 0,139) + (1 x 0,363) + (9 x 0,04) = 2,645

Table 9. Eigen vector

| Criteria | Eigen vector |
|---|---|
| C | 2,645 |
| D | 0,244 |
| M | 0,255 |
| P | 0,863 |
| Q | 2,506 |
| S | 0,243 |

Next, the calculation of the weighted normalized decision matrix (VB) is carried out. This calculation is done by dividing the values of the eigenvector by the respective partial weights.

$$C = \frac{2{,}645}{0{,}375} = 7{,}081$$

$$D = \frac{0{,}244}{0{,}04} = 6{,}067$$

$$M = \frac{0{,}255}{0{,}042} = 6{,}044$$

$$P = \frac{0{,}863}{0{,}139} = 6{,}251$$

$$Q = \frac{2,506}{0,363} = 6,921$$

$$S = \frac{0,243}{0,04} = 6,061$$

Total = 38,426

The maximum eigenvalue is calculated by summing the total of V.B. (∑V.B.) and then dividing it by the size of the existing matrix (n). The calculation of the maximum eigenvalue is as follows:

$$\lambda max = \frac{\sum VB}{n} = \frac{38,426}{6} = 6,404$$

The maximum eigenvalue will be used to calculate the Consistency Index (CI). The calculation of the Consistency Index (CI) is as follows:

$$CI = \frac{(6,404-6)}{(6-1)} = 0,081$$

The result from calculating the Consistency Index (CI) above is used to compute the Consistency Ratio (C.R.). Here is the calculation for the Consistency Ratio (C.R.).

$$CR = \frac{0,081}{1,24} = 0,065$$

Since the value of C.R. is less than 0,1, it is considered consistent. Therefore, the assessments provided by the respondents regarding the respective data are considered appropriate.

**Fuzzy Analytical Hierarchy Process**

The transformation of Triangular Fuzzy Numbers into the AHP scale is used to minimize uncertainty in the AHP scale. This involves changing the AHP Scale to the TFN Scale. In this stage, the results from the comparison matrix, which are still numerical values in the AHP scale, are converted into TFN (Triangular Fuzzy Number) scaled values based on Table 5. The transformed results can be seen in Table 10.

Table 10. The matrix of Triangular Fuzzy Numbers (TFN)

| | C | | | D | | | M | | | P | | | Q | | | S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | l | m | u | l | m | u | l | m | u | l | m | u | l | m | u | l | m | u |
| C | **1** | **1** | **1** | 5 | 7 | 9 | 5 | 7 | 9 | 5 | 7 | 9 | 1 | 1 | 3 | 7 | 9 | 11 |
| D | 0,111 | 0,143 | 0,2 | **1** | **1** | **1** | 1 | 1 | 3 | 0,143 | 0,2 | 0,333 | 0,091 | 0,111 | 0,143 | 1 | 1 | 3 |
| M | 0,111 | 0,143 | 0,2 | 0,333 | 1 | 1 | **1** | **1** | **1** | 0,143 | 0,2 | 0,333 | 0,111 | 0,143 | 0,2 | 1 | 1 | 3 |
| P | 0,111 | 0,143 | 0,2 | 3 | 5 | 7 | 3 | 5 | 7 | **1** | **1** | **1** | 0,125 | 0,167 | 0,25 | 3 | 5 | 7 |
| Q | 0,333 | 1 | 1 | 7 | 9 | 11 | 5 | 7 | 9 | 4 | 6 | 8 | **1** | **1** | **1** | 5 | 7 | 9 |
| S | 0,091 | 0,111 | 0,143 | 0,333 | 1 | 1 | 0,333 | 1 | 1 | 0,143 | 0,2 | 0,333 | 0,111 | 0,143 | 0,2 | **1** | **1** | **1** |

They are performing the calculation of the Fuzzy Synthetic Extent Value. At this stage, three values in the Triangular Fuzzy Number (TFN) scale are calculated: the lower (l), middle (m), and upper (u) values, following the calculation process referred to in equation 5. Next, the summation for $M_{gi}^{j}$ is is carried out, which involves summing up each column's lower, median, and upper values. The results of this calculation process can be seen in Table 11.

Table 11. The calculation of the Fuzzy Synthetic Extent value.

| Criteria | l | m | u |
|---|---|---|---|
| C | 24 | 32 | 42 |
| D | 3,345 | 3,454 | 7,676 |
| M | 2,698 | 3,486 | 5,733 |
| P | 10,236 | 16,31 | 22,45 |
| Q | 22,333 | 31 | 39 |
| S | 2,011 | 3,454 | 3,676 |
| Total | 64,623 | 89,704 | 120,535 |

Lower value $\sum_{j=1}^{n} lj$ = 1 + 5 + 5 + 5 + 1 + 7 = 24

Median value $\sum_{j=1}^{n} mj$ = 1 + 7 + 7 + 7 + 1 + 9 = 32

Upper value $\sum_{j=1}^{n} uj$ = 1 + 9 + 9 + 9 + 3 + 11 = 40

Then, the previously totaled result is inversely operated using arithmetic operations for TFN, resulting in the inverse TFN as follows

$$\left(\frac{1}{120{,}535}, \frac{1}{89{,}704}, \frac{1}{64{,}623}\right)$$

Next, calculate the Fuzzy Synthetic Extent by performing multiplication for each row of Table 10 with the inverse TFN.

$$Si = 24, 32, 42 \times \left(\frac{1}{120{,}535}, \frac{1}{89{,}704}, \frac{1}{64{,}623}\right)$$

= 0,199, 0,357, 0,650

Table 12. The result of the Fuzzy Synthetic Extent value.

| Criteria | l | m | u |
|---|---|---|---|
| C | 0,199 | 0,357 | 0,650 |
| D | 0,028 | 0,039 | 0,119 |
| M | 0,022 | 0,039 | 0,089 |
| P | 0,085 | 0,182 | 0,347 |
| Q | 0,185 | 0,346 | 0,604 |
| S | 0,017 | 0,039 | 0,057 |
| Total | 0,536 | 1 | 1,865 |

Comparison of Fuzzy Synthetic Extent Values. In this stage, pairwise comparisons between criteria are made, referring to equation 8.

$$M_2 \geq M_1 = 1$$

Next, find the minimum value in each column by referring to equation 11. The results of this calculation process can be seen in Table 13.

Table 13. Comparison of Fuzzy Synthetic Extent Values

| Criteria | C | D | M | P | Q | S | Min |
|---|---|---|---|---|---|---|---|
| C | | 1 | 1 | 1 | 1 | 1 | 1 |
| D | 0 | | 1 | 0,191 | 0 | 1 | 0 |
| M | 0 | 1 | | 0,026 | 0 | 1 | 0 |
| P | 0,459 | 1 | 0,497 | | 0,005 | 1 | 0,459 |
| Q | 0,973 | 1 | 1 | 1 | | 1 | 0,973 |
| S | 0 | 1 | 1 | 0 | 0 | | 0 |
| Total | | | | | | | 2,432 |

The next step is to normalize the weight vector in Table 14 using Equation 11. In this stage, it produces the final values for the weights of each criterion by dividing the minimum value for each criterion by the total minimum value of all criteria.

Table 14. The minimum value for each criterion.

| Criteria | Minimum value |
|---|---|
| C | 1 |
| D | 0,694 |
| M | 0,228 |
| P | 0,465 |
| Q | 0,990 |
| P | 0,553 |
| Total | 3,930 |

Next, ranking is performed for each factor weight. The criteria and subcriteria weights can be seen in Table 15 and Table 16. Then calculate the global weight by multiplying the weight values of the criteria and subcriteria in Table 17.

Table 15. Criteria weight.

| Criteria | Weight |
|---|---|
| C | 0,411 |
| D | 0 |
| M | 0 |
| P | 0,189 |
| Q | 0,400 |
| S | 0 |

Table 16. Subcriteria weight.

| Subcriteria | Weight |
|---|---|
| Material price | 1 |
| Shipping and administrative costs | 0 |
| Payment method | 0 |
| Timeliness of delivery | 0,455 |
| Accuracy of material quantity as preorder | 0,545 |
| Delivery frequency | 0 |
| Document completeness | 0,702 |
| Certification | 0,298 |
| Company age | 0 |
| Supplier reputation | 0,400 |
| Duration of collaboration | 0,201 |
| Performance History | 0,400 |
| Material compliance with specifications | 0,561 |
| Material defect rate | 0 |
| Consistency in material quality | 0,439 |
| Flexibility and responsiveness | 0,561 |
| Warranty | 0,439 |
| Ease of claim procedures | 0 |

Table 17. Global weight.

| Subcriteria | Weight |
|---|---|
| Material price | 0,411 |
| Shipping and administrative costs | 0 |
| Payment method | 0 |
| Timeliness of delivery | 0 |
| Accuracy of material quantity as preorder | 0 |
| Delivery frequency | 0 |
| Document completeness | 0 |
| Certification | 0 |
| Company age | 0 |
| Supplier reputation | 0,075 |
| Duration of collaboration | 0,038 |
| Performance History | 0,075 |
| Material compliance with specifications | 0,224 |
| Material defect rate | 0 |
| Consistency in material quality | 0,176 |
| Flexibility and responsiveness | 0 |
| Warranty | 0 |
| Ease of claim procedures | 0 |

The table above shows the result of calculating the global criteria ranking for 1 respondent. The same calculations are carried out for other respondents. Then, the global weight results of all respondents are averaged to obtain a single global weight result. The final result of the global weight vector can be seen in Table 18.

Table 18. The average of global subcriteria

| Subcriteria | Respondents | | | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| Material price | 0,123 | 0,178 | 0,500 | 0,254 | 0,159 | 0,172 | 0,136 | 0,468 | 0,161 | 0,203 | 0,235 |
| Shipping and administrative costs | 0,108 | 0,157 | 0 | 0 | 0,040 | 0,172 | 0,136 | 0,046 | 0,102 | 0,083 | 0,084 |
| Payment method | 0,056 | 0,082 | 0 | 0,254 | 0,143 | 0,086 | 0,136 | 0 | 0,043 | 0,034 | 0,083 |
| Timeliness of delivery | 0,056 | 0,003 | 0 | 0,078 | 0,088 | 0,099 | 0,117 | 0,047 | 0,049 | 0,046 | 0,058 |
| Accuracy of material quantity as preorder | 0,135 | 0,008 | 0 | 0,078 | 0,088 | 0,145 | 0,066 | 0,056 | 0,180 | 0,046 | 0,08 |
| Delivery frequency | 0,096 | 0,005 | 0 | 0 | 0,088 | 0 | 0 | 0,007 | 0,077 | 0,009 | 0,028 |
| Document completeness | 0,161 | 0,376 | 0,28 | 0,177 | 0,19 | 0,127 | 0,204 | 0,241 | 0,146 | 0,365 | 0,227 |
| Certification | 0,055 | 0,129 | 0 | 0 | 0,064 | 0,127 | 0 | 0 | 0,041 | 0,072 | 0,049 |
| Company age | 0,027 | 0,062 | 0,220 | 0,159 | 0,032 | 0 | 0,204 | 0,135 | 0,056 | 0,095 | 0,099 |
| Supplier reputation | 0,041 | 0 | 0 | 0 | 0,036 | 0,029 | 0 | 0 | 0,029 | 0,008 | 0,014 |
| Duration of collaboration | 0,071 | 0 | 0 | 0 | 0,036 | 0,029 | 0 | 0 | 0,058 | 0,020 | 0,021 |
| Performance History | 0,071 | 0 | 0 | 0 | 0,036 | 0,015 | 0 | 0 | 0,058 | 0,018 | 0,02 |
| Material compliance with specifications | 0,123 | 0,178 | 0,500 | 0,254 | 0,159 | 0,172 | 0,136 | 0,468 | 0,161 | 0,203 | 0,235 |
| Material defect rate | 0,108 | 0,157 | 0 | 0 | 0,040 | 0,172 | 0,136 | 0,046 | 0,102 | 0,083 | 0,084 |
| Consistency in material quality | 0,056 | 0,082 | 0 | 0,254 | 0,143 | 0,086 | 0,136 | 0 | 0,043 | 0,034 | 0,083 |
| Flexibility and responsiveness | 0,056 | 0,003 | 0 | 0,078 | 0,088 | 0,099 | 0,117 | 0,047 | 0,049 | 0,046 | 0,058 |
| Warranty | 0,135 | 0,008 | 0 | 0,078 | 0,088 | 0,145 | 0,066 | 0,056 | 0,180 | 0,046 | 0,08 |
| Ease of claim procedures | 0,096 | 0,005 | 0 | 0 | 0,088 | 0 | 0 | 0,007 | 0,077 | 0,009 | 0,028 |

Next, a performance assessment of suppliers is conducted. CV. Jogja Karunia Cipta evaluated 3 suppliers: CV. Sinar Laut as S1, TB. Handoko as S2, and CV. Sekawan Makmur as S3. In assessing the performance of suppliers, respondents from CV. Jogja Karunia Cipta will fill out a questionnaire related to the assessment of supplier performance using a scale of 0-10 for each sub-criteria. The higher the number given when assessing the supplier, the better the performance provided by the supplier. The results of the supplier performance assessment will be multiplied by the weight of each sub-criteria to obtain the final weight value of each supplier. The following are the results of weighting suppliers for each sub-criteria.

Table 19. Supplier performance assessment

| Subcriteria | S1 | S2 | S3 |
|---|---|---|---|
| Material price | 1,205 | 0,937 | 1,071 |
| Shipping and administrative costs | 0,581 | 0,581 | 0,509 |
| Payment method | 0,479 | 0,383 | 0,383 |
| Timeliness of delivery | 0,608 | 0,608 | 0,608 |
| Accuracy of material quantity as preorder | 0,937 | 0,937 | 0,937 |
| Delivery frequency | 0,062 | 0,055 | 0,055 |
| Document completeness | 0,198 | 0,198 | 0,222 |
| Certification | 0,208 | 0,156 | 0,208 |
| Company age | 0,064 | 0,050 | 0,057 |
| Supplier reputation | 0,513 | 0,513 | 0,342 |
| Duration of collaboration | 0,147 | 0,131 | 0,115 |
| Performance History | 0,404 | 0,404 | 0,315 |
| Material compliance with specifications | 1,280 | 1,138 | 1,138 |
| Material defect rate | 0,200 | 0,178 | 0,178 |
| Consistency in material quality | 0,787 | 0,787 | 0,787 |
| Flexibility and responsiveness | 0,437 | 0,437 | 0,340 |
| Warranty | 0,569 | 0,512 | 0,399 |
| Ease of claim procedures | 0,353 | 0,282 | 0,247 |
| Total | 9,034 | 8,289 | 7,911 |

## CONCLUSION

Based on the results of the supplier performance assessment, CV. Jogja Karunia Cipta identified CV. Sinar Laut is the best supplier, with a score of 9.034. This finding aligns with the recommendations from interviews conducted with respondents before completing the questionnaire. Therefore, it can be concluded that the calculation results are consistent with the respondents' recommendations.

Based on the data processing conducted using the Fuzzy AHP method, it is found that the priority criteria for local contractors in Yogyakarta in selecting suppliers are cost criteria with a value of 0,426, followed by quality criteria with a value of 0,371 and delivery criteria with a value of 0,157.

Analyzing the weight values of criteria and sub-criteria reveals that the cost criterion, with a weight value of 0.426, influences decision-making in supplier selection by 42.6%. This finding aligns with previous research indicating that the unit price of materials significantly affects the supplier selection process by Wann-Yih Wu and Badri Munir S (Wu et al., 2009) titled "An Integrated Multi-Objective Decision-Making Process for Supplier Selection With Bundling Problem." This study indicates that the unit price of the material significantly affects the supplier selection process.

The second-highest weight value is for the quality criteria, at 0.371, indicating that it influences decision-making by experts in supplier selection by 37.1%. This high value is attributed to the significant impact of material quality on fieldwork outcomes. The high weight of the quality criterion in the sub-criterion of material suitability with specifications aligns with previous research used as literature, "Criteria for Achieving Efficient Contractor-Supplier Relations" by Mikael Frodell (Frödell, 2011), which states that supplier performance and material quality are criteria for achieving effectiveness between contractors and material suppliers.

The delivery criterion, with a weight value of 0.157, ranks third and influences experts in supplier selection decision-making by 15.7%. This result corresponds with previous research emphasizing the importance of production capacity and capability in supplier selection, as mentioned in the research by Ali Kokangul and Zeynep Susuz (Kokangul & Susuz, 2009) titled "Integrated Analytical Hierarchy Process and Mathematical Programming to Supplier Selection Problem with Quantity Discount."

Based on the research conducted by A.E. Cengiz, O. Aytekin, I. Ozdemir, H. Kusanb, and A. Cabuk (A.E. Cengiz et al., 2017) on the topic "A Multi-Criteria Decision Model for Construction Material Supplier Selection," the construction industry in Turkey has survey results indicating that cost is the most significant supplier selection criterion, followed by quality, delivery criteria, and technical material criteria.

The research findings are consistent with previous studies, such as the one by (A.E. Cengiz et al., 2017) which highlighted cost as the most significant supplier selection criterion, followed by quality and delivery criteria. Contractors in Yogyakarta generally prioritize price over quality, although the difference in weighting between quality and price criteria is not significant. This indicates that while contractors prioritize price, they still consider the quality offered by service providers. Contractors, as service providers, must acquire affordable materials while ensuring quality. They are obligated to complete projects according to the agreed-upon quality standards with the owner. Therefore, contractors must secure competitive prices to avoid losses during the work.

Understanding the factors that service providers expect enables construction businesses to achieve success in the construction process. This has been confirmed by several experienced experts in supplier selection, thereby ensuring the accuracy and reliability of the generated data. These insights are derived from the literature and the successful experiences of experts in developing their careers in the construction business services sector.

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