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Editors • Winnie Septiani, Wahyukaton Wahyukaton, Rahmi Maulidya and Desinta Rahayu Ningtyas

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Optimization of capacitated vehicle routing problems for basic needs of urban logistics - The case of the city of Bandung 🛒

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Annisa Uswatun Khasanah; Mufti Sayid Muqaffi; Nurcahyati

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Multiobjective heterogeneous vehicle routing problem with multi-trips in urban logistics context ⌲

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Dynamic programming for shortest path problem in a multimodal transportation network comprising intermediate sinks ⌲

Asyia Mobeen; Muhammad Junaid Mohsin; Muhammad Shafiq; Iphov Kumala Sriwana

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Sri Raharno; Muhammad Zulfahmi Febriansyah; Yatna Yuwana Martawirya

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Lean manufacturing implementation strategy in the pharmaceutical industry production processes: A VSM and AHP approach ⌲

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PREFACE

Bismillahirrahmanirrahim,
Assalamu'alaikum Warrahmatullah Wabarrakatuh,

First of all, we apologize for the inconvience in the 13th ISIEM 2021 event, due to current condition and situation of COVID 19. The situation made us has to make some critical modification in the event, including: online presentation of keynote speaker, online presentation for all candidates that cannot attend the seminar. but we hope we all remain excited to continue to contribute to research publications. Nonetheless, we are trying to prepare this seminar as best we can.

This issue is published in line with the Thirteen International Seminar on Industrial Engineering and Management (13th ISIEM) 2021. The articles cover a broad spectrum of topics in Industrial Engineering and Management, which are Quality Engineering Management, Decision Support System and Artificial Intelligent, Ergonomics, Supply Chain Management, Production System, Operation Research, and Industrial Management. These articles provide an overview of critical research issues reflecting on past achievements and future challenges. Those papers were selected from 137 abstracts, and we send these papers to AIP to be published there as an Open Access Proceeding Scopus. This statistic shows the high competition to get published on this proceeding. This issue and seminar become special as more delegates come and join from various country as well as universities. We host 90 delegates both from abroad and local.

The 13th ISIEM is hosted by eight universities, which are Universitas Pasundan, Universitas Esa Unggul, Universitas Trisakti, Universitas Tarumanagara, Universitas Al-Azhar Indonesia, Atma Jaya Catholic University of Indonesia, Universitas Pancasila and Universitas Mercubuana. This is the thirteenth years of the collaboration of those universities, and the first time we had MOU with AIP in America to publishing the papers that is indexed by Scopus. This is also the second years of our international partnership join committee with Chung Yuan Christian University – Taiwan, Yuan Ze University – Taiwan, Kasetsart University – Thailand and Bright Star University – Libya.

In this occasion, let us give special thanks to Prof.Yung-Tsan Jou, PhD (Professor and Chair Department of Industrial and Systems Engineering, Chung Yuan Christian University – Taiwan), Prof. Yun-Chia Liang, PhD (Professor and Chair, Department of Industrial Engineering and Management, Yuan Ze University – Taiwan), Elisa Lumbantoruan (President Director & CEO at ISS Indonesia, Independent Commissioner at PT Indosat Tbk, and Independent Commissioner at Garuda Indonesia) and Naraphorn Paoprasert, Ph.D (Researcher, Department of Industrial Engineering, Faculty of Engineering, Kasetsart University – Thailand), for their contribution as keynote speakers, to Prof. Abdelnaser Omran from Brightstar University, and supported by Indonesian Association of Industrial Engineering Higher Education (BKSTI) and the Institution of Engineer Indonesia – Industrial Engineering Chapter (BKTI-PII). We are also grateful to all reviewers and editors, for their commitment, effort and dedication in undertaking the task of reviewing all of the abstracts and full papers. Without their help and dedication, it would not be possible to produce this proceeding in such a short time frame. I highly appreciate all members of committees (advisory, steering, and organizing committees) for mutual efforts and invaluable contribution for the success of seminar.

Wassalamu'alaikum Warrahmatullah Wabarrakatuh.

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Decision support system for raw material supplier selection by using fuzzy AHP-TOPSIS method in PT Mulia glass

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Decision support system for raw material supplier selection by using fuzzy AHP-TOPSIS method in PT Mulia glass FREE

W. Septiani ✉; R. Pahlevi; T. S. Dewayana

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Decision Support System for Raw Material Supplier Selection by Using Fuzzy AHP-TOPSIS Method in PT Mulia Glass

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Abstract. PT. Mulia Glass is a company that produces glass sheets. The raw materials procurement process which is conducted by previous purchasing division is only emphasized price and other subjective criteria. This research aims to design a Decision Support system (DSS) selection of raw material suppliers using the Fuzzy-AHP and TOPSIS methods. The design of a decision support system begins with the initiation and analysis system. System databases consist of the user database, suppliers, raw materials, criteria, comparison of criteria, master TFN, criteria weights and alternative values. Model Base consists of a Fuzzy-AHP model to determine the value of the criterion weights and TOPSIS model is used for supplier alternative alignment. The DSS implementation is designed using the PHP and MySQL programming languages. Criteria for the selection of raw material suppliers such as price, quality, time of payment, customer care, and service. Result of Fuzzy-AHP TOPSIS consists of rank with the first place is PT.C with evaluation value 0.578, second and place PT.A with a value of 0.414. The validation result of a manual calculation and DSS shows the same result, it is concluded that the raw material supplier selection DSS is valid.

Keywords: Supplier selection, raw material, DSS , Fuzzy AHP, TOPSIS

INTRODUCTION

PT. Mulia Glass is a company engaged in glass production manufacturing. The company is a subsidiary of PT. Mulia Industrindo, TBK, which is located in Cikarang, Bekasi, West Java. The company has two divisions, the Float Division which produces glass sheets, and the Container Division that produces glass bottles and glass Block. The object in this study is the production of glass sheets. The raw materials used in the manufacturing process are divided into main raw materials and additives. The main raw materials consist of silica sand, dolomite, soda ash, and cullet, while the additives are feldspar and salt cake.

The procurement of raw materials greatly affects production activities. Suppliers are part of the company's supply chain. Supplier selection is an effort in minimizing the impact in the whole company's supply chain, from the procurement of raw materials to the delivery of finished products to customers [1], [2]. In operational activities, the company aims to increase profits by lowering costs.

The survey results show that the company in the previous purchasing division only had a supplier selection system that emphasizes the price and other added assessments that are subjective, like a partnership. Such supplier selection systems can harm the company. The criteria used in the supplier selection are only the price and other subjective criteria. In fact, the criteria other than price may affect the assessment in assessing a supplier.

Supplier selection criteria is an important part of supplier selection [3], [4]. Research on the selection of supplier of wall, cladding and roof materials has the most complete criteria as much as 48 criteria [5]. The latest identified criteria include technology, payment terms, conceptual manufacturing, manufacturing challenges, driving force,

waiting time, personnel capability, solution-oriented, global factors, and environmental risks. There are several methods or approaches commonly used in supplier selection such as Analytical Hierarchy Process (AHP), Fuzzy AHP, Technique for Order of Preference by Similarity to Idea (TOPSIS) VIKOR, Simple Additive Weighting (SAW), Weighted product (WP), and so on. [6] conducted the selection using an integrated AHP-VIKOR approach. Several recent studies [3], [7] Applying the Fuzzy AHP and fuzzy TOPSIS to determine the relative importance of multi-criteria and assess suppliers while translating subjective judgments of decision-makers. Scott [8] Using the AHP-QFD method, a series of scoring criteria scores were made to assess the supplier. Abdollahi [9] Conducted supplier selection based on the DEMATEL-ANP-DEA method.

The DSS usage on supplier development highlights the areas that use a lot of decision-supporting models [10], [11]. Previous research [12], [13] shows that the research results on the development of decision support systems. This research aims to design the DSS raw material supplier selection at PT. Mulia Glass. The raw material to be focused on the selection is feldspar. The methods used in this research are fuzzy AHP and TOPSIS. This research is expected to assist the purchasing staff to determine the selected supplier in the procurement process of raw materials.

Therefore, it needs a method that can be used to assist the selection of suppliers. Supplier selection should consider many criteria with a multi-criteria approach in the analysis [3]. One solution that can overcome these problems is by utilizing the DSS. This system helps the appropriate supplier decision-making process according to the company's needs [4].

This research aims to design the DSS raw material supplier selection at PT. Mulia Glass. The raw material to be focused on the selection is feldspar. The methods used in this research are fuzzy AHP and TOPSIS. This research is expected to assist the purchasing staff to determine the selected supplier in the procurement process of raw materials.

METHOD

The main steps in the implementation of the study: the first step is having the prior research and interviews is a preliminary step for the research plan. The interview activity is conducted directly with the company employees in the company's divisions involved such as purchasing, logistics, etc. The second step of the DSS design is using a waterfall development system approach, consisting of four main phases which are initiation, analysis, design, and implementation that are assisted with the literature study [5]. The analysis phase consists of an analysis using the PIECES method, Ishikawa diagram, and requirement analysis. The Data collected in the analysis is a fusion between interviews and observations.

The DSS design configuration consists of the design of the base data, model base, and user interface. Databases consist of user databases, suppliers, raw materials, criteria, supplier assessments as well as criteria, and history, designed with MySQL. The database design component is by creating a context diagram, Data Flow Diagram (DFD), Entity Relationship Diagram (ERD), and Physical Data Model (PDM). The base model consists of a weighting model with Fuzzy-AHP and a ranking model with the TOPSIS method. Next is the User interface which is designed with the PHP programming language. Verification of the DSS model is conducted for testing with the model if there are debug or error occurred. The validation phase is to manually compare the calculation results with the DSS output.

RESULTS AND DISCUSSION

Initiation Phase

The initiation phase consists of preliminary research whose purpose is to define the scope, objectives, and existing issues. The scope of the research is on the Purchasing Department of PT. Mulia Glass. The issue is the absence of a system that can assist the selection process of raw material suppliers. The objective of the system design is to design a DSS for the selection of raw material suppliers with the Fuzzy-AHP and TOPSIS methods.

Analysis Phase

The analysis phase is useful to identify the existing issues, system needs, and to develop a decision support system. An improvement and specifies all requirements in a decision support system. Analysis of the problem with

this method consists of performance, information, economy, control, efficiency, and service analysis. The results of the analysis with the PIECES method are shown in TABLE 1.

TABLE 1. Analysis of Problem Using PIECES Method

Analysis Type	Analysis System	Suggested System Model
Performance	Current performance cannot be maximal because supplier valuation is subjective	Measurable Criteria Selection
Information	The information in the company is not open	The system is designed to be accessible to authorized users.
Economy	The selection of existing suppliers can risk errors that can be economically harmful	Making a decision support system will minimize the risk of error in supplier selection
Control	The currently used system is still manual	DSS has automatically stored data in the system
Efficiency	Existing supplier selection system requires immeasurable time	The decision-making process can be done faster.
Service	The company currently does not have the service for the raw material supplier selection system	The system can provide ease in the supplier valuation process

The purpose of the system needs analysis is to explore the needs of the system. Analysis of the system needs is divided into functional needs and non-functional needs.

1. Functional Requirement Analysis
   The system which will be made can provide the best alternative information in the selection of raw material suppliers. The results will be used by the purchasing staff in carrying out the procurement process of raw materials. The system has a utility for storing data, which are criteria, raw material data, supplier data, and criteria weight data.
2. Non Functional Needs Analysis
   - The system to be designed could be used on any type of operating system (OS) because the system is designed using a web base.
   - The system to be designed will be equipped with passwords for each user
3. User Needs Analysis
   The decision support system for supplier selection will be used by the Purchasing division consisting of staff and managers. These needs are useful for the systematic selection of suppliers that is fast and recorded.

Identifying Criteria and Supplier Selection Alternative

Quality assessment of raw materials from suppliers is based on the company's standard limits set by the Quality and Lab Service departments. If it is not appropriate, the company would immediately complain to the supplier to request the replacement of raw materials or re-order it to other suppliers to complete the raw material needs. Service assessments are conducted from ordering raw materials until raw materials are at the company's location through supply activities. Payment is defined as the repayment of the booking fee within the period set by both parties. Assessment of the time of payment criteria is based on the fulfillment of payment terms and payment methods. The results of the identification of supplier selection criteria from the literature obtained 20 criteria in TABLE 2. The criteria selection was carried out using the cut-off point method [14].

TABLE 2. The criteria selection using Cut off point method

No	Criteria	Level of importance			Number of Respondents	Total	Average
		Very Important (3)	Important (2)	Not Important (1)			
1	Quality	3	0	0	3	9	3
2	Cost	3	0	0	3	9	3
3	Delivery	2	1	0	3	8	2.67
4	Flexibility	1	2	0	3	7	2.33
5	Guarantee and Claim	1	2	0	3	7	2.33
6	Service Quality	3	0	0	3	9	3
7	*Responsibilities*	1	2	0	3	7	2.33
8	Quantity	0	3	0	3	6	2
9	Discount	2	1	0	3	8	2.67
10	Time of Payment	3	0	0	3	9	3
11	Packaging	0	3	0	3	6	2
12	*Expired date*	0	3	0	3	6	2
13	*Customer care*	3	0	0	3	9	3
14	Employee capability	0	0	3	3	3	1
15	*After Sales Support*	1	2	0	3	7	2.33
16	Response to customer	0	3	0	3	6	2
17	Geographical location	2	1	0	3	8	2.67
18	Communication system	0	3	0	3	6	2
19	Can be trusted	0	0	3	3	3	1
20	Politic Situation	0	1	2	3	4	1.33

Assessment in pricing criteria is by adjusting the company's purchasing capability towards the price offered. The company will select suppliers who have the minimum price but also do not override the quality aspects of the products offered. Customer Care consists of complaints responding, making the replacement of the reject material, and communication.

The results from determining those 5 criteria will put in the hierarchy of supplier selection and comparison matrix in pairs. Alternative suppliers of feldspar raw material consist of PT. A, PT. B, and PT. C. The hierarchy of decision making in raw material suppliers can be seen in Figure 1.
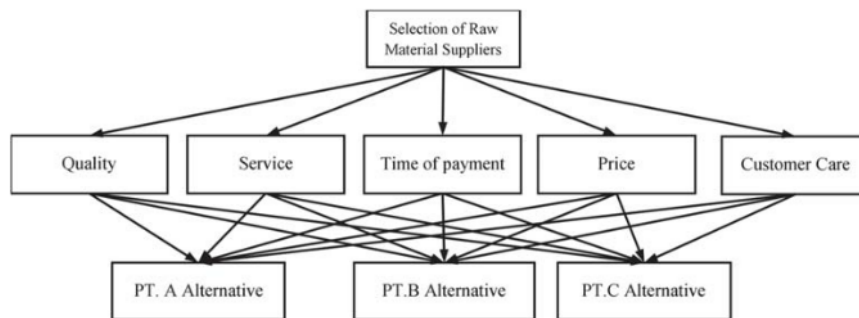

FIGURE 1. The Hierarchy in Selecting the Best Supplier

Design Phase

In developing the database, it starts by making an Entity Relationship Diagram (ERD) and Physical Data Model (PDM) following the system that has been made. FIGURE shows the Physical Data Model (PDM) for the decision support system in the selection of raw material suppliers.
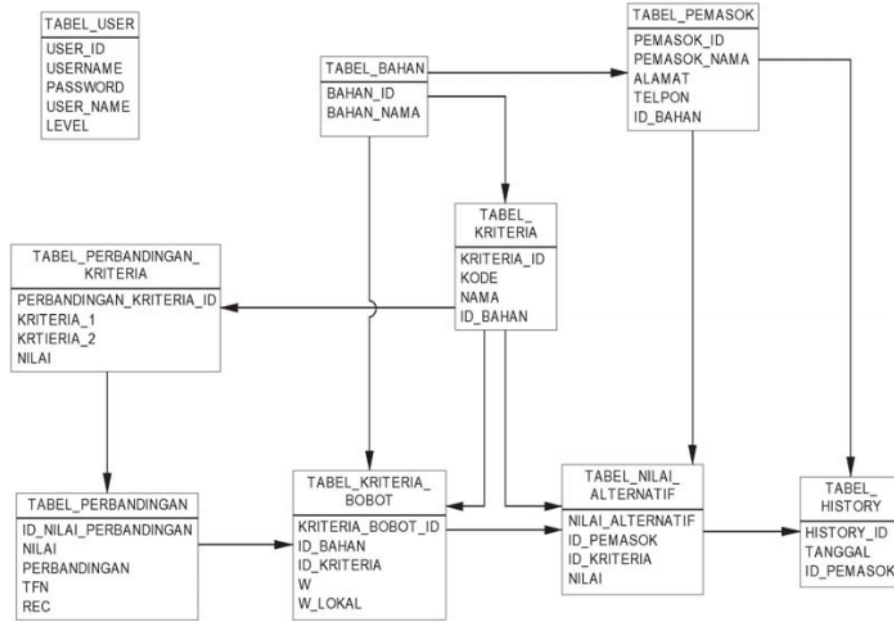

FIGURE 2. Physical Data Model (PDM)

The already designed context diagram, then going through the decomposition stage to be a Data Flow Diagram. The weight criteria process will be described as DFD Level 1 in Figure 2. The criteria weight process consists of the assessment criteria, followed by weight calculation with Fuzzy AHP steps. Furthermore, a Fuzzy calculation is conducted to produce weight criteria. The value of the weight criteria then stored in the database. the fuzzy-AHP calculation process consisting of a series of processes which are the assessment input process, consistency check, weight calculation result. The result of the calculation is the final weight obtained following the Fuzzy calculations which consist of the conversion to the TFN, the fuzzy synthesis, normalization, defuzzification, weights.

Designing Model Base

Criterion Weighting Model with Fuzzy-AHP Method

In this study, the F-AHP method using the Triangular Fuzzy Number (TFN) scale serves to combine two lines (linear). Next weights are calculated by the Fuzzy method as follows [6]:

a. Converting the AHP comparison matrix into a Fuzzy comparison matrix, using the Triangular Fuzzy Number (TFN) scale.

b. Calculates the synthesis value of the priority Fuzzy (Si) priority with the following equations:

$$Si = \sum_{j=1}^{m} M_i^j \; x \frac{1}{\sum_{i=1}^{n} \sum_{m=1}^{m} M_i^j} \tag{1}$$

Where $\sum_{j=1}^{m} M_i^j$ is the line summation on the comparison matrix in pairs.

c. Determine the vector value (V) and calculate the defuzzification value ordinate (d').

If the results obtained by each *Fuzzy matrix*, is M2≥M1 where, the value of M2 = (l2,m2,u2) and M1 = (l1,m1,u1) then the vector value is shown with the equation below:

$$V(S2 \geq S1) = \begin{cases} 1 \\ 0 \\ \dfrac{(l1-u2)}{(m2-u2)-(m1-u1)} \end{cases} \tag{2}$$

if $m2 \geq m1$, if $l1 \geq u2$ the others

d. Normalize the vector weight value (W) that has been obtained, this stage will generate local W that is used as weighted criteria for the next stage. The equation in this stage is as follows:

$$W' = (d'(A1), d'(A2), ... d'(An))^T \tag{3}$$

Where Ai = 1,2,..., n is n of decision element. The value of vector weight that has been normalized is shown in this equation:

$$W = (d(A1), d(A2), ... d(An))^T \tag{4}$$

Supplier Ranking Model with TOPSIS Method

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is based on the best alternate concept not only having the closest distance from the positive ideal solution but also having the farthest distance from the negative ideal solution [7]. The TOPSIS calculation steps are as follows [8]:
a. Calculating the normalized decision matrix.
   At this stage, the equation used as a transformation on each X_{ij} element is:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \text{ with } i = 1, 2, 3, \ldots, m; \text{ and } j = 1, 2, 3, \ldots, n; \tag{5}$$

   where r_{ij} is an element from normalized matrix R. X_{ij} is the matrix element from X decision.
b. Calculating a weighted normalized decision matrix.
   With weight wi = (w_1, w_2, w_3, ... ,w_n) where w_j is the weight number-j and $\sum_{j=1}^{n} W_j = 1$ then the matrix weight normalization V is:

$$V_{ij} = W_j . r_{ij} \text{ with } i = 1, 2, 3, \ldots, m; \text{ and } j = 1, 2, 3, \ldots, n; \tag{6}$$

   where v_{ij} is the element of each decision matrix that has been weight normalized V. w_{ij} is the weight of each performance number-j. r_{ij} the element of each normalized decision matrix R.
c. Determining the ideal positive solution matrix and the ideal negative solution (A)
   At this stage, the positive ideal solution is denoted A +, while the ideal negative solution is denoted A −. The following is the formula equation of the ideal solution A + and A −:
   1. $A^+ = \{(\max . V_{ij} \mid j \in J), (\min . V_{ij} \mid j \in J'), i = 1,2,3, ..., m\} = \{v_1^+, v_2^+, v_3^+, ..., v_n^+\}$ (7)
   2. $A^- = \{(\min . V_{ij} \mid j \in J), (\max . V_{ij} \mid j \in J'), i = 1,2,3, ..., m\} = \{v_1^-, v_2^-, v_3^-, ..., v_n^-\}$ (8)

d. Calculating the Separation Value. This stage has the following equations:
   1. D^+ is the alternative distance from a positive ideal solution, defined as:

$$D^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2}, \text{ with } i = 1,2,3,..., m \tag{9}$$

   2. D^- is the alternative distance from a negative ideal solution, defined as:

$$D^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}, \text{ with } i = 1,2,3,..., m \tag{10}$$

   where :
   v_{ij} is the element of normalized weighted decision matrix V,
   v_j^+ is the element of positive ideal solution matrix,

v_j^- is the element of negative ideal solution matrix.

e. Calculating relative proximity towards the ideal positive solution (V)

The relative proximity of each alternative is based on an ideal positive solution with the following equation:

$$C_i^+ = \frac{s_i^-}{(s_i^- + s_i^+)}, 0 \le C_i^+ \text{ with i} = 1,2,3,...,\text{m} \tag{11}$$

where c_i^+ is the relative proximity number-i towards the ideal positive solution, s_i^+ is an alternate distance number-i from the ideal positive solution and s_i^- is an alternate distance number-i of the ideal negative solution.

f. Ranking Alternatives.

The result of the coefficient is sorted from the largest C^+ value to the smallest value. An alternative that has a coefficient with the largest C^+ value is the best solution.

Verification and Validation

Verification in the DSS of raw material supplier selection is done by comparing the conceptual model with the DSS model design. The result of the analysis shows that DSS has been verified with the conceptual model has been developed and applied to be a DSS. Validation is conducted by comparing both calculation results. When the manual calculation results are compared towards the calculations with DSS, both show the same results and it can be concluded that the decision support system for the raw material suppliers selection is valid.

Implementation

DSS is a website-based design. Website-based DSS is chosen because of its ease of use. Besides, website-based applications do not require an installation that has special specifications but can use any computer or smartphone specifications. The DSS implementation uses the PHP programming language as the user interface and MySQL as the database. This preview is an assessment of the criteria that has been selected, next is to be calculated by the Fuzzy-AHP method which generates weights on each criterion presented in Figure 3.

FIGURE 3. Weighted Criteria Menu Interface Design

This preview is a supplier's assessment of each raw material, later calculated by the TOPSIS method that generates an alternative to each supplier, presented in Figure 4.
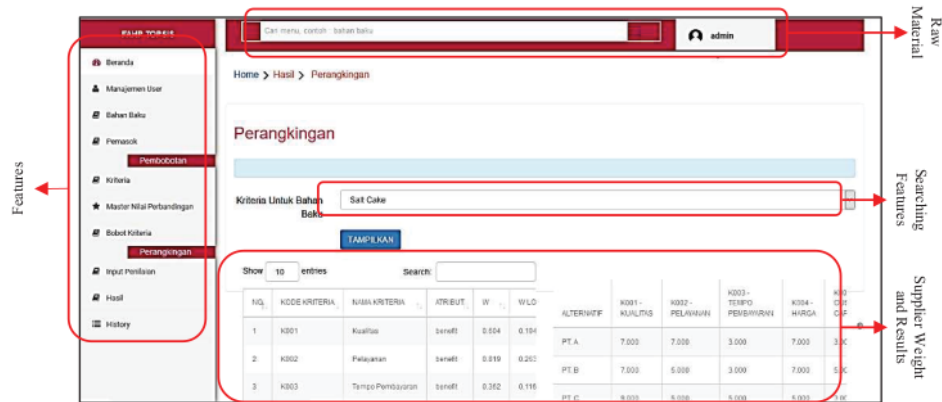
FIGURE 4. Result Menu Interface Design

McCall's factors used in user testing are the factors related to the product operational, namely Correctness, Reliability, Integrity, and Usability. The user testing questionnaire consists of 20 questions that are following the access rights (roles) of each user (Table 3).

TABLE 3. Average aspect calculation

Aspect	Amount of question	Total aspect assessment	Average aspect	Qualitative criteria
Correctness	6	22.00	3.66	Excelent
Reliability	7	24.33	3.47	Excelent
Integrity	1	3.66	3.66	Excelent
Usability	6	18.33	3.05	Good

Overall, based on the Betha test, the results show the DSS for selecting raw material suppliers meets user needs, displays information according to user input appropriately, safe from unauthorized parties. The DSS displays attractive and easy to use.

CONCLUSION

1. DSS development approach is using a waterfall development method. Databases consist of user databases, suppliers, raw materials, criteria, comparison of criteria, master TFN, criteria weights, alternative values, and history. The base model consists of a criterion-weighted model using the Fuzzy-AHP method and a ranking model for an alternative supplier using the TOPSIS method. The User interface is built using the PHP programming language. The verification results show that based on the tests conducted, the support system that has been created does not encounter errors and debug. The result of the validation process indicates that the system for the raw material supplier selection is valid.
2. Determining 5 main criteria of the interview which are quality, service, payment due, price, and customer care. These criteria will be the company's focus on determining the supplier of feldspar raw materials. Based on the calculation results using FAHP and TOPSIS methods, the best supplier with 5 criteria needed by the company, in the first place is PT. C together with evaluation value 0.578, second place is PT. A with a value of 0.414, the third place is PT. B with the value 0.011.

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