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A Comprehensine Examination of Coarse Aggregate Selection Utilized in Concrete Production Across Several Ready-Mix Companies. Case Study on Lombok Island

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Coarse Aggregate; Ready-Mix Concrete; ANP; TOPSIS; Laboratory Testing.

ABSTRACT
The increasing demand for ready-mix concrete in Lombok Island has intensified the need for high-quality coarse aggregates capable of ensuring concrete strength, durability, and long-term performance. However, variations in aggregate characteristics, mining permit compliance, and operational conditions among quarry sources complicate the selection process. This study aims to determine the most suitable coarse aggregate source for ready-mix concrete production by integrating the Analytic Network Process (ANP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), followed by validation through laboratory testing. Primary data were collected through field observations, expert interviews, and pairwise comparison questionnaires involving directors, production managers, and quality control personnel from five ready-mix concrete companies on Lombok Island. The ANP method was employed to determine the relative importance of decision criteria and sub-criteria, while TOPSIS was used to rank five alternative aggregate sources. Laboratory tests, including gradation, abrasion resistance, specific gravity, and silt content analyses, were conducted to verify the decision-making results. The findings indicate that technical criteria (0.445) and mining permit criteria (0.419) are the most influential factors in aggregate selection. TOPSIS ranked Pringgabaya as the best alternative (0.6169), followed by Sembelia (0.5878), while Bilelando obtained the lowest preference value. Laboratory testing generally confirmed the decision-making results, particularly for gradation, specific gravity, and silt content. The study concludes that the integrated ANP–TOPSIS approach provides a reliable and comprehensive decision-support framework for selecting coarse aggregates and can improve material selection practices in ready-mix concrete production.

INTRODUCTION

The success of Lombok Island in implementing infrastructure projects using ready-mix concrete represents a tangible example of the utilization of high-quality construction materials to support sustainable development in archipelagic regions (Nawir et al., 2023). This is particularly evident in the execution of national strategic and regional government-funded

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projects, such as the construction of Lombok International Airport, the Mandalika Special Economic Zone, the NTB Islamic Center, and the Integrated Emergency Unit (IGD) and IRNA Building of the NTB Provincial Hospital (Rahman et al., 2022). This development has led to an increasing demand for ready-mix concrete (Skrzypczak et al., 2020), which in turn drives the demand for coarse aggregate as a primary material, where its quality and availability significantly influence the final performance of concrete (Bashir & Kour, 2019). The selection of coarse aggregate for ready-mix concrete production in Lombok Island plays a crucial role in determining the strength and durability of concrete (Mkpaidem et al., 2022). The characteristics of locally sourced coarse aggregates in Lombok are highly variable due to differences in material sources (Teymen, 2023). A study by Sutrisna (2021) revealed significant variations in the physical properties of coarse aggregates obtained from Slowjan (Central Lombok) and Pringgabaya (East Lombok). The bulk specific gravity of aggregates from Slowjan was approximately 2.563 g/cm^3 with water absorption of 1.834%, whereas aggregates from Pringgabaya exhibited a bulk specific gravity of 2.674 g/cm^3 and water absorption of 1.272%. Although both sources meet the national specification limits (absorption < 3%) (Kim et al., 2020), these results confirm the existence of inter-location variability that may affect the strength and durability of concrete (Subash et al., 2025). In addition to technical aspects, the availability of high-quality coarse aggregates remains a significant challenge in ready-mix concrete production on Lombok Island (Vijerathne et al., 2024). This issue is closely related to the legal and licensing aspects of quarry mining, where several mining operators in East Lombok have not fully complied with official operational permits (Antara News, 2022; Rohman et al., 2024). Although West Lombok possesses abundant Class C mineral resources such as andesite, sand-gravel mixtures (sirtu), and coarse aggregates, their utilization remains limited due to regulatory constraints and difficult access to quarry locations (West Lombok Regency Government, 2023).

Considering the complexity of factors influencing concrete quality and the variability of local coarse aggregate characteristics, a scientific approach is required to evaluate multiple criteria objectively and systematically (Masudin et al., 2024). Therefore, this study employs a combination of the Analytic Network Process (ANP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to analyze and determine the most suitable type of coarse aggregate for ready-mix concrete production (Avikal et al., 2021). This approach enables a comprehensive evaluation of interrelated aspects, resulting in more accurate weighting and ranking of alternatives (Marzouk & Sabbah, 2021). ANP provides a framework in which the weights of criteria and sub-criteria are determined by considering interdependencies among decision elements, both between criteria and among sub-criteria (Rahim et al., 2021). Consequently, the resulting weights are more representative of real-world complex decision systems (Kheybari et al., 2020). Once these weights are obtained, TOPSIS is applied to rank the alternatives based on their proximity to the positive ideal solution and distance from the negative ideal solution (Wibowo & Pramesti, 2026). Thus, the selected alternative not only aligns with the assigned weights but also closely approximates the ideal criteria as a whole. This method has previously been applied by Fasa (2025) in a study on the selection of fine aggregate for concrete production in ready-mix companies on Lombok Island. The results indicated that mining permit and quality criteria had the highest weights, while the TOPSIS analysis showed that fine aggregate from Aikmel ranked first with a preference value of 0.681. Another study by Abdel-Basset et al. (2018) applied a Neutrosophic ANP–TOPSIS approach for supplier selection problems, demonstrating that this combination is more effective in handling uncertainty in expert judgment compared to conventional methods. Their findings indicated an increase in decision accuracy by 9.4% when incorporating subjective variables such as reputation and supply stability.

This study aims to evaluate the weighting of each criterion for coarse aggregates sourced from several quarry locations and to determine the most optimal alternative for use in construction based on predefined criteria and sub-criteria. Furthermore, the study analyzes the conformity between the results obtained from the ANP-TOPSIS methods and laboratory testing outcomes.

METHOD

Data Collection

At this stage, two types of surveys were conducted to ensure the accuracy of data in selecting the appropriate type of coarse aggregate. The first survey aimed to identify the criteria, sub-criteria, and alternative types of coarse aggregates commonly used on Lombok Island. The results served as the basis for constructing the ANP network structure, ensuring that the relationships among elements were logically represented and aligned with field conditions. The second survey was conducted more comprehensively through field observations, interviews with construction experts, and the distribution of questionnaires to civil engineering practitioners, both online and offline. Respondents were asked to compare two elements at a time based on their relative importance with respect to the main objective of the study. This survey was used to validate the ANP network structure and to obtain pairwise comparison data for further analysis. The results provided a strong foundation for determining the weights of criteria, ensuring that the resulting decisions are both practical and scientifically sound.

Respondent Selection

The selected respondents were individuals holding strategic positions in the procurement and selection process of coarse aggregate materials, such as production managers or logistics managers in ready-mix concrete supplier companies. In the Lombok Island region, five ready-mix supplier companies were selected as research objects, namely PT. VARICON Bangun Indonesia (Labuapi, West Lombok), PT. Utama Beton Perkasa (Dasan Cermen, Mataram City), PT. Varia Usaha Beton (Mertak, Central Lombok), PT. Sanur Jaya Utama (Labulia, Central Lombok), and PT. Damai Indah Utama Concrete (Bengkel, West Lombok). The following section provides a more detailed description of the distribution of respondents from each ready-mix supplier involved in this study, as presented in Table 1 List of Respondents:

Table 1. List of Respondents

No	Responden	Supplier Ready Mixed
1	Director	PT. VARICON
2	Production Manager	PT. VARICON
3	Quality Control	PT. VARICON
4	Director	PT. Utama Beton Perkasa
5	Production Manager	PT. Utama Beton Perkasa

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6	Quality Control	PT. Utama Beton Perkasa
7	Director	PT. Varia Usaha Beton
8	Production Manager	PT. Varia Usaha Beton
9	Quality Control	PT. Varia Usaha Beton
10	Director	Damai Indah Utama Concrate
11	Production Manager	Damai Indah Utama Concrate
12	Quality Control	Damai Indah Utama Concrate
13	Branch Director	PT. Sanur Jaya Utama
14	Production Manager	PT. Sanur Jaya Utama
15	Quality Control	PT. Sanur Jaya Utama

Data Prosessing Stage

The designed network model was subsequently entered into the SuperDecisions 2.10 software to facilitate the analysis process. At this stage, the interrelationships among elements were clearly defined, including both relationships within the same cluster and relationships between different clusters. The ANP model was systematically structured by placing the main objective at the first level, the criteria and sub-criteria at the second level, and the alternative types of coarse aggregates at the third level, as illustrated in Figure 1. This model reflects the existence of feedback relationships among elements, representing the actual conditions of a complex decision-making process. The data obtained from the questionnaires were then input into the SuperDecisions 2.10 software for further processing. Through this application, the consistency level of the pairwise comparison values could be directly evaluated, enabling the identification of whether the resulting data met the required criteria. If the Consistency Ratio (CR) value was below 0.1 (or 10%), the judgments were considered consistent and suitable for further analysis. However, if the CR value was ≥ 0.1, respondents were asked to clarify or revise their assessments. An example of the pairwise comparison model generated using SuperDecisions 2.10 is presented in Figure 2.

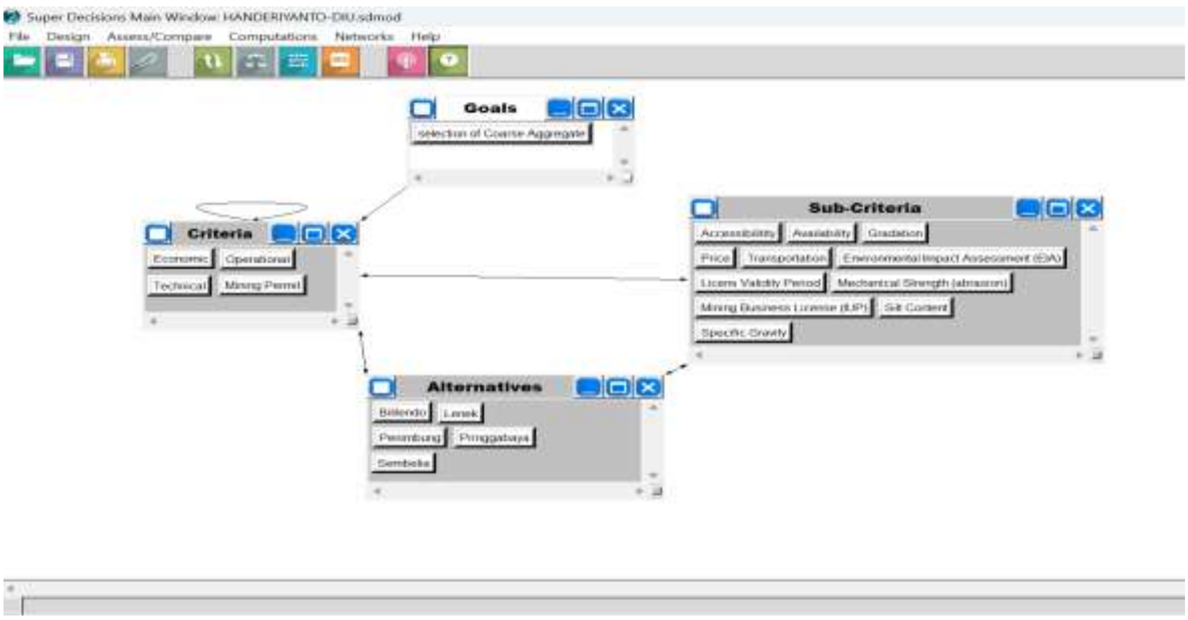

Figure 1. ANP Network Model

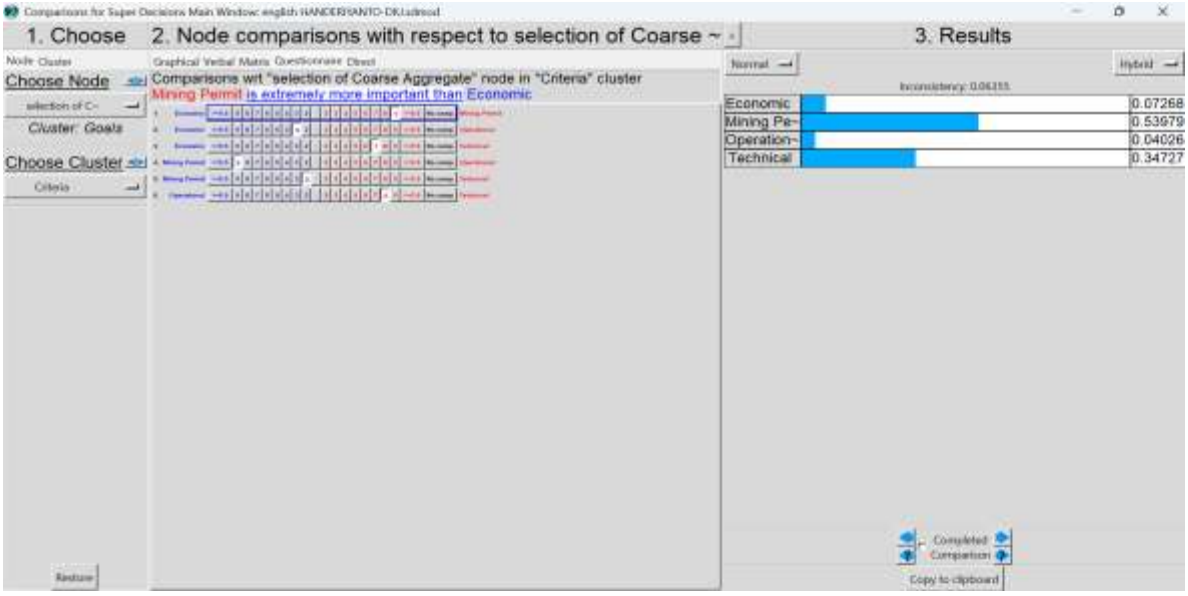

Figure 2. Pairwise Comparison

Based on Forman & Gass (2001) and Ishizaka & Labib (2011), the fundamental scale commonly used in the Analytical Network Process (ANP) is presented in Table 2. This scale represents the level of importance intensity ranging from 1 to 9. After obtaining the priority weights of each criterion using the ANP method, the next step is to evaluate the available alternatives based on these weights. This analysis is conducted using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), which aims to determine the best alternative based on its relative closeness to the ideal solution. The assessment in this method is based on a scale of 1 to 5, where: 1 = Very Poor, 2 = Poor, 3 = Fair, 4 = Good, and 5 = Very Good.

Table 2. Fundamental Assessment Scale in ANP

Intensity of interest	Definition	Explanation
1	*Eual Importance*	Both elements have the same effect
2	*Weak Slight*	Values between a scale of 1 and 3
3	*Moderate Importance*	One of the elements is slightly more important than the others
4	*Moderate Plus*	Scores between 3 and 5
5	*Strong imortance*	One element is clearly more important than its partner
6	*Strong plus*	Scores between 5 and 7 on a scale
7	*Very strong or demonstrated importance*	One element is absolutely more important than the other elements
8	*Very, very strong*	Scores between 7 and 9 on a scale
9	*Extrame importance*	One element is absolutely more important than the other elements

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RESULT AND DISCUSSION

Criteria Aspects

The criteria aspects compared in this study include quality, mining permit, cost, and delivery.

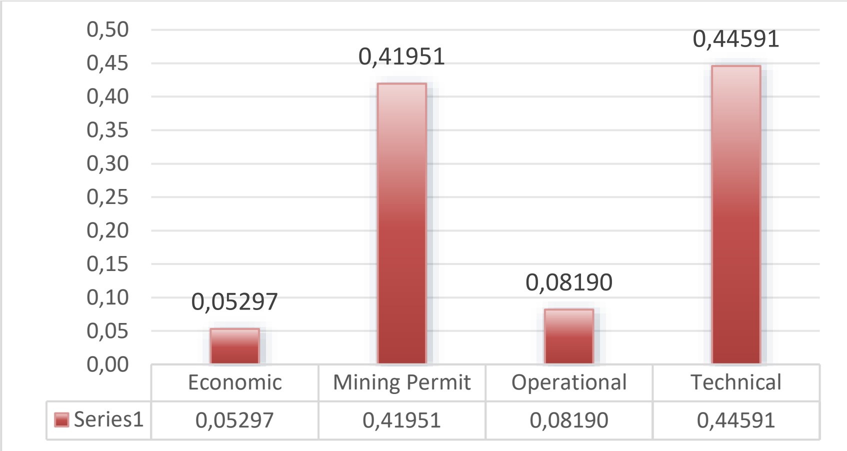

Figure 3. esults of Criteria Data Analysis

Based on Figure 3, which illustrates the criteria weights, it can be observed that the technical criterion has the highest priority value of 0.445, indicating that technical aspects constitute the primary consideration in the decision-making process. This finding suggests that material quality, physical characteristics, and compliance with technical standards play the most dominant role in determining the selection of coarse aggregates. Furthermore, the Mining Permit criterion ranks second with a value of 0.419, reflecting the importance of legality and licensing aspects in ensuring the sustainability and legitimacy of material sources. Meanwhile, the Operational criterion has a value of 0.081, followed by the Economic criterion with a value of 0.052, indicating that these two aspects have relatively smaller influences compared to the other criteria. Overall, this weight distribution demonstrates that the decision-making process is primarily focused on technical and legal considerations, while cost and operational factors are still taken into account but are not regarded as the main priorities. The level of agreement among respondents was evaluated using Kendall's Coefficient of Concordance (W; $0 < W \leq 1$). A W value approaching 1 indicates a very high degree of agreement among respondents, whereas a value approaching 0 indicates a low level of agreement or substantial differences in judgment. In the context of this study, the coefficient of concordance (W) obtained for the analyzed criteria was 0.861. This value indicates a high level of consensus among respondents, suggesting that the assessments provided are relatively consistent and reliable as the basis for subsequent analyses.

Sub-Critera Aspects

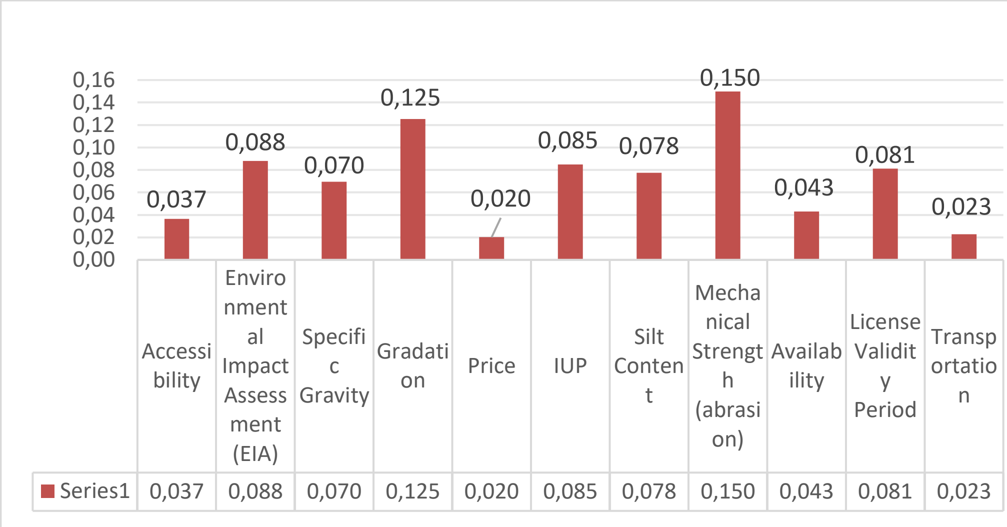

Figure 4. Results of Sub-Criteria Data Analysis

Based on Figure 4, which presents the sub-criteria weights, it can be observed that Mechanical Strength has the highest value of 0.150, indicating that material strength is the primary consideration in the selection of coarse aggregates. Furthermore, Gradation ranks second with a value of 0.125, highlighting the importance of particle size distribution in determining the quality of concrete mixtures. Other sub-criteria, such as Environmental Impact Assessment (EIA) (0.088), Mining Business License (IUP) (0.085), Permit Validity Period (0.081), and Silt Content (0.078), also contribute significantly, particularly in terms of legal compliance and material quality. On the other hand, Specific Gravity (0.070), Availability (0.043), and Accessibility (0.037) exhibit relatively smaller influences, while Transportation (0.023) and Cost (0.020) are the sub-criteria with the lowest weights. Overall, these results indicate that the decision-making process places greater emphasis on the technical characteristics of the materials and licensing aspects, whereas cost and transportation factors serve primarily as supporting considerations.

Priority Ranking of Alternatives

After obtaining the weights of the criteria and sub-criteria using the ANP method, the analysis stage was continued by applying the TOPSIS method to determine the priority ranking of each alternative. In this process, the evaluation of the six coarse aggregate alternatives was carried out by respondents or experts through the prepared questionnaires. The collected data were then processed using Microsoft Excel to facilitate the calculations and minimize potential errors. Subsequently, all assessment values were averaged to obtain representative scores for each alternative, reflecting the overall performance based on the evaluations of all respondents. These average values were then used as the basis for constructing the decision matrix, which is presented in Table 3 as the initial step in the TOPSIS calculation process. The construction of the decision matrix constitutes an important stage, as it serves as the foundation for the normalization, weighting, and determination of the best alternative based on its distance from the positive and negative ideal solutions.

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Table 3. Decision Matrix for the Selection of Coarse Aggregate Types

Criteri/Alterative	Sembelia	Bilelando	Pringgabaya	Lenek	Penimbung
Economic	2,93	2,27	4,87	2,31	2,44
Technical	3,40	2,00	4,93	2,63	2,38
Operational	2,73	2,67	4,60	2,19	2,88
Mining Permit	4,07	3,60	4,87	3,38	3,56
Price	3,60	3,07	4,87	2,88	3,13
Transportation	2,27	3,27	4,27	2,44	3,38
Silt Content	3,53	2,80	4,73	1,19	3,00
Gradation	4,00	2,93	4,87	3,31	3,00
Mechanical Strength (abrasion)	3,93	2,40	4,87	3,13	2,69
Specific Gravity	3,80	2,53	4,93	2,94	2,75
Availability	3,47	3,47	4,67	2,63	2,50
Accessibility	3,67	3,47	4,87	3,19	2,94
IUP	3,87	3,53	4,87	3,31	3,56
License Validity Period	3,80	3,33	4,87	3,19	3,38
Environmental Impact Assessment (EIA)	3,80	3,47	4,73	3,00	3,13

After the calculation of the decision matrix was completed, the next step involved normalizing the matrix. This stage aimed to standardize the assessment scale so that each criterion could be compared more objectively. The normalization results of the entire decision matrix are presented in Table 4, which displays the normalized decision matrix for the selection of coarse aggregate types.

Table 4. Normalized Decision Matrix for the Selection of Coarse Aggregate Types

Criteri/Alterative	Sembelia	Bilelando	Pringgabaya	Lenek	Penimbung
Economic	0,4203	0,3248	0,6973	0,3313	0,3492
Technical	0,4696	0,2762	0,6813	0,3625	0,3280
Operational	0,3913	0,3818	0,6585	0,3132	0,4116
Mining Permit	0,4626	0,4096	0,5537	0,3840	0,4053
Price	0,4497	0,3831	0,6080	0,3592	0,3904
Transportation	0,3163	0,4559	0,5954	0,3402	0,4710
Silt Content	0,4847	0,3841	0,6493	0,1629	0,4115
Gradation	0,4841	0,3550	0,5890	0,4009	0,3631
Mechanical Strength (abrasion)	0,4999	0,3050	0,6185	0,3972	0,3416
Specific Gravity	0,4850	0,3233	0,6297	0,3749	0,3510
Availability	0,4515	0,4515	0,6078	0,3419	0,3256
Accessibility	0,4449	0,4206	0,5904	0,3867	0,3564

IUP	0,4471	0,4086	0,5628	0,3830	0,4120
License Validity Period	0,4517	0,3962	0,5784	0,3789	0,4011
Environmental Impact Assessment (EIA)	0,4621	0,4216	0,5756	0,3648	0,3800

After obtaining the values in the normalized decision matrix, the next stage in the TOPSIS method is the construction of the weighted normalized matrix. This process is carried out by multiplying each element in the normalized matrix by the weights of the corresponding criteria and sub-criteria previously determined using the ANP method. The weighting process aims to reflect the relative importance of each criterion in the decision-making process, thereby producing more representative values. Consequently, the weighted normalized matrix not only represents the performance of each alternative but also incorporates the priority level of each criterion considered in the analysis. The final results of this calculation are systematically presented in Table 5, which contains the weighted normalized matrix as the basis for the subsequent analysis stages, namely the determination of the positive ideal solution and the negative ideal solution.

Table 5. Weighted Normalized Matrix

Criteria/Alternative	Sembelia	Bilelando	Pringgabaya	Lenek	Penimbung
Economic	0,0223	0,0172	0,0369	0,0176	0,0185
Technical	0,2094	0,1232	0,3038	0,1617	0,1463
Operational	0,0320	0,0313	0,0539	0,0256	0,0337
Mining Permit	0,1941	0,1718	0,2323	0,1611	0,1700
Price	0,0091	0,0077	0,0123	0,0072	0,0079
Transportation	0,0072	0,0104	0,0136	0,0078	0,0108
Silt Content	0,0376	0,0298	0,0504	0,0126	0,0319
Gradation	0,0606	0,0445	0,0738	0,0502	0,0455
Mechanical Strength (abrasion)	0,0749	0,0457	0,0927	0,0595	0,0512
Specific Gravity	0,0338	0,0225	0,0438	0,0261	0,0244
Availability	0,0194	0,0194	0,0261	0,0147	0,0140
Accessibility	0,0163	0,0181	0,0254	0,0166	0,0153
IUP	0,0380	0,0176	0,0242	0,0165	0,0177
License Validity Period	0,0367	0,0170	0,0249	0,0163	0,0172
Environmental Impact Assessment (EIA)	0,0406	0,0181	0,0247	0,0157	0,0163

After the weighted normalized matrix has been established, the next step is to determine the positive ideal solution and the negative ideal solution. The positive ideal solution represents the best or maximum value of each criterion in the matrix, reflecting the most desirable condition. In contrast, the negative ideal solution represents the lowest value of each criterion, indicating the least desirable condition. These two solutions are subsequently used as the basis for measuring the relative closeness of each alternative to the ideal condition. The calculation results of the positive ideal solution and the negative ideal solution are presented in Table 6.

Table 6. Solusi Ideal Positif dan Solusi Ideal Negatif

Criteria/Alternative	Classification	Max	Min
Economic	cost	0,0172	0,0369
Technical	benefit	0,3038	0,1232
Operational	benefit	0,0539	0,0256
Mining Permit	benefit	0,2323	0,1611
Price	cost	0,0072	0,0123
Transportation	benefit	0,0136	0,0078
Silt Content	Cost	0,0126	0,0504
Gradation	Cost	0,0445	0,0738
Mechanical Strength (abrasion)	Cost	0,0457	0,0927
Specific Gravity	benefit	0,0438	0,0225
Availability	benefit	0,0261	0,0140
Accessibility	benefit	0,0254	0,0153
IUP	benefit	0,0380	0,0165
License Validity Period	benefit	0,0367	0,0163
Environmental Impact Assessment (EIA)	benefit	0,0406	0,0157

After obtaining the distance values from the ideal solutions, the next step is to calculate the closeness coefficient for each alternative. This value is used to indicate the degree of closeness of an alternative to the overall ideal condition, where a higher value reflects a better alternative. Prior to this stage, the separation measures in the TOPSIS method were first calculated by measuring the distance of each alternative from two main reference points, namely the positive ideal solution (D^+) and the negative ideal solution (D^-). The value of D^+ represents the distance of an alternative from the best possible condition, while D^- indicates the proximity of an alternative to the worst condition. The results of these distance calculations are presented in Table 7, which contains the D^+ and D^- values for each analyzed alternative. Furthermore, the results of the relative closeness calculations are presented in Table 8, which displays the ranking of each alternative based on the obtained closeness coefficient values.

Table 7. Distance to the Positive Ideal Solution and Distance to the Negative Ideal Solution

Alternatif	**D+**	**D-**
Sembelia	0,0179	0,0256
Bilelando	0,0390	0,0234
Pringgabaya	0,0248	0,0400
Lenek	0,0287	0,0240
Penimbung	0,0328	0,0220

Table 8. Results of Relative Closeness Coefficient Calculation

Alternatif	Preferensi (V)	Rank
Sembelia	0,5878	2
Bilelando	0,3756	5
Pringgabaya	0,6169	1
Lenek	0,4552	3
Penimbung	0,4015	4

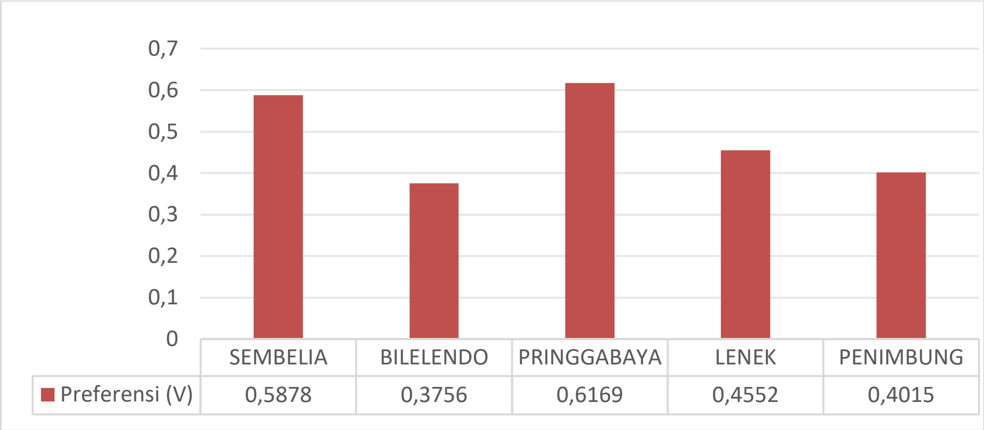

Figure 5. Graph of Relative Closeness Coefficient Results

The figure 5 presents the ranking results of coarse aggregate alternatives based on the closeness coefficient (Ci) obtained using the TOPSIS method. This value indicates the relative proximity of each alternative to the ideal solution. The higher the Ci value of an alternative, the greater its level of conformity with the predefined criteria, which include cost, quality, legal compliance, and delivery aspects.

Based on the graph, Pringgabaya ranks first with a value close to 0.61, making it the best alternative as it most comprehensively satisfies all criteria. Sembelia occupies the second position with a relatively close value, indicating that it remains competitive. Furthermore, Lenek (0.455) and Penimbung (0.401) fall within the intermediate category, suggesting that both adequately meet the criteria but are not as optimal as the top two alternatives. In contrast, Bilelando has the lowest value (less than 0.40), indicating the lowest level of suitability, which may be influenced by factors such as material quality, cost, availability, or distribution. Overall, the variation in preference values among the alternatives demonstrates a clear selection priority, where the alternative with the highest value is considered the most recommended.

Laboratory Test Results

Coarse Aggregate Gradation: The gradation analysis of coarse aggregates was conducted to determine the particle size distribution of aggregates used in concrete mixtures, referring to the SNI 03-2834-2000 standard. Proper gradation results in a well-graded aggregate structure, which enhances the density and overall quality of the produced concrete. The complete results of the gradation test are presented in tabular 9 form.

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Table 9. Summary of Coarse Aggregate Gradation Test Results

No	Quarry	FM	Gradation
1	Pringgabaya	6,05	Gradation max 40 mm
2	Lenek	6,06	Gradation max 40 mm
3	Sembelia	6,09	Gradation max 40 mm
4	Penimbung	6,09	Gradation max 40 mm
5	Bilelando	6,32	Gradation max 40 mm

Based on sieve analysis in accordance with SNI 03-2834-2000, all five quarry locations meet the required gradation specifications, indicating their potential to produce concrete with good workability, strength, and durability. In addition, the fineness modulus (FM) values show that Bilelando has the highest value (6.32), followed by Penimbung and Sembelia (6.09), Lenek (6.06), and Pringgabaya (6.05). A higher FM value indicates coarser aggregate particles, whereas a lower value reflects a relatively finer particle distribution.

Abrasion Resistance Analysis: The mechanical strength of coarse aggregates was evaluated through abrasion testing to determine the material's resistance to wear caused by friction and impact. A lower percentage of wear indicates better aggregate quality in resisting loads and abrasion, thereby making it more suitable for use in concrete mixtures.

Table 10. Summary of Coarse Aggregate Abrasion Test Results

No	Sample	Wear %	
		100x Spin	500x Spin
1	Lenek	6,43	22,46
2	Penimbung	7,65	25,57
3	Sembelia	4,85	18,50
4	Pringgabaya	5,27	22,46
5	Bilelando	3,59	5,28

Based on the test results in tabular 10 form, it can be observed that at 100 revolutions, Bilelando exhibits the lowest abrasion value of 3.59%, followed by Sembelia (4.85%), Pringgabaya (5.27%), Lenek (6.43%), and Penimbung (7.65%). At 500 revolutions, Bilelendo again demonstrates the lowest value at 5.28%, which is significantly lower than the other alternatives, followed by Sembelia (18.50%), while Lenek and Pringgabaya share the same value of 22.46%, and Penimbung records the highest value at 25.57%. These results indicate that the coarse aggregate from Bilelendo possesses the highest abrasion resistance among all locations, reflecting superior mechanical durability against wear. Sembelia also demonstrates relatively good performance, with low and consistent abrasion values at both levels of revolutions. In contrast, Penimbung exhibits the highest abrasion values, indicating that aggregates from this location are more susceptible to deterioration due to friction.

Specific Gravity of Coarse Aggregate: This test was conducted in accordance with the method specified in SNI 1970-2016, involving a soaking procedure for 15 to 24 hours.

Table 11. Summary of Coarse Aggregate Specific Gravity Test Results

No	Quarry	Specific Grafity of SSD Condition (gram)	Dry Specific Grafity (gram)	Absorption (%)
1	Lenek	2,43	2,36	2,83
2	Penimbung	2,52	2,50	0,96
3	Sembelia	2,56	2,61	0,52
4	Pringgabaya	2,63	2,615	0,77
5	Bilelando	2,36	2,35	0,30
	Syarat	2,5 - 2,7	≥ 2,5	Max 5%

The test results at table 11 indicate that the physical characteristics of coarse aggregates from each quarry exhibit noticeable variation, particularly in terms of specific gravity and water absorption. Under saturated surface-dry (SSD) conditions, aggregates from Pringgabaya (2.63), Sembelia (2.56), and Penimbung (2.52) fall within the required standard range of 2.5–2.7, and can therefore be categorized as having good quality in terms of density. In contrast, Lenek (2.43) and Bilelando (2.36) have values below the minimum threshold, indicating that aggregates from these locations are relatively lighter and potentially possess higher porosity.

A similar trend is observed in the dry specific gravity values, where Pringgabaya (2.615), Sembelia (2.61), and Penimbung (2.50) meet the required standard of ≥ 2.5, while Lenek (2.36) and Bilelando (2.35) remain below the acceptable limit. These findings suggest that aggregates from Pringgabaya, Sembelia, and Penimbung have denser structures and are more suitable for supporting concrete strength. In terms of water absorption, all samples meet the maximum allowable limit of 5%, with the highest absorption observed in Lenek (2.83%) and the lowest in Bilelendo (0.30%). Lower absorption values indicate fewer pores within the aggregate, resulting in reduced water uptake in concrete mixtures.

Silt Content: The silt content test of coarse aggregates was conducted to evaluate the cleanliness of the material, as excessive silt content can interfere with the bond between aggregate and cement paste, thereby potentially reducing concrete strength.

Table 12. Summary of Silt Content Test Results

No	Quarry	Silt Content (%)	Standard (%)	Description
1	Lenek	1,005	1	Not Compliant
2	Penimbung	0,623	1	Compliant
3	Sembelia	0,550	1	Compliant
4	Pringgabaya	0,525	1	Compliant
5	Bilelando	1,550	1	Not Compliant

Based on the test results at table 12, the allowable silt content standard is a maximum of 1%, in accordance with SNI S–04–1989–F. The data indicate that aggregates from Penimbung (0.623%), Sembelia (0.550%), and Pringgabaya (0.525%) meet the specified requirements, and

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can therefore be classified as having low silt content that does not interfere with the concrete formation process. In contrast, aggregates from Lenek (1.005%) and Bilelando (1.550%) exceed the permissible limit.This condition indicates that aggregates from these two locations contain relatively high amounts of fine materials, which may reduce the bonding capacity between aggregate and cement paste, thereby potentially decreasing the resulting concrete strength. Excessive silt content may also increase the water demand in the mixture, leading to a reduction in the overall quality of the concrete.

Conformity Analysis between MCDM (ANP-TOPSIS) Results and Laboratory Testing

This analysis aims to evaluate the level of conformity between the ranking results obtained from the ANP-TOPSIS method and the laboratory testing results as a form of validation of the resulting decisions. Based on the ANP-TOPSIS analysis, the priority ranking of coarse aggregate alternatives is Pringgabaya, Sembelia, Lenek, Penimbung, and Bilelando. These results are primarily influenced by the weighting of the criteria, in which technical aspects constitute the most dominant factor, particularly the sub-criteria of gradation and mechanical strength, which provide the greatest contribution to the assessment process.

When examined from the laboratory testing results for the gradation parameter, only Pringgabaya and Sembelia satisfy the required standards. This finding demonstrates a strong conformity with the ANP-TOPSIS results, as both alternatives also occupy the highest rankings. Considering that gradation is a key factor influencing concrete workability and density, the dominance of these two alternatives can be regarded as both logical and technically consistent.

However, a different pattern is observed in the mechanical strength (abrasion resistance) parameter. Bilelando demonstrates the best performance, followed by Sembelia and Pringgabaya. Nevertheless, Bilelando remains ranked last in the ANP-TOPSIS results. This indicates that although mechanical strength is an important sub-criterion, its influence cannot stand alone without support from other parameters, particularly gradation.

Furthermore, in terms of specific gravity, aggregates from Pringgabaya, Sembelia, and Penimbung meet the required standards, indicating that these alternatives possess good density characteristics. This finding is also supported by the silt content test results, where the same three locations again satisfy the specified standards, reflecting relatively clean and suitable material quality for concrete production. In contrast, Lenek and Bilelando tend to fail to meet several important parameters, which consequently affects their positions in the final ranking.

CONCLUSION

This study demonstrates that the integration of the Analytic Network Process (ANP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) provides a comprehensive and systematic framework for selecting the most appropriate coarse aggregate for ready-mix concrete production on Lombok Island. The ANP results indicate that technical criteria (0.445) and mining permit criteria (0.419) are the most influential factors in the decision-making process, highlighting that material quality and legal compliance are prioritized over economic and operational considerations. The TOPSIS analysis identifies Pringgabaya as the highest-ranked alternative (0.6169), followed by Sembelia (0.5878), Lenek (0.4552), Penimbung (0.4015), and Bilelando (0.3756). Furthermore, laboratory testing generally supports the MCDM results, particularly for gradation, specific gravity, and silt content, where Pringgabaya and Sembelia consistently satisfy the required standards. Although Bilelando exhibits the best abrasion resistance, its lower performance in several other technical and legal parameters reduces its overall ranking. These findings confirm that the combined ANP–TOPSIS approach is effective in evaluating multiple interrelated criteria and can serve as a reliable decision-support tool for selecting coarse aggregates in ready-mix concrete production.

Future research is recommended to expand the scope of evaluation by incorporating additional technical, environmental, and sustainability-related criteria, such as long-term durability, life-cycle assessment, carbon emissions, and aggregate recycling potential. Increasing the number of quarry alternatives and involving a broader range of stakeholders from different regions would also improve the generalizability and robustness of the decision model. In addition, comparative studies employing other multi-criteria decision-making methods, such as VIKOR, PROMETHEE, ELECTRE, or fuzzy-based ANP–TOPSIS approaches, are encouraged to validate the consistency of the ranking results under different decision environments. Finally, future investigations should include comprehensive mechanical performance tests of concrete produced using the selected aggregates, such as compressive strength, flexural strength, permeability, and long-term durability, to further verify the practical applicability of the proposed selection model in supporting sustainable ready-mix concrete production.

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