Current Integrative Engineering
Volume 2, Issue 1, 15-30, *ISSN: 2995-6307*
DOI: 10.59762/cie570390542120240205133154

Analytical Hierarchy Process (AHP) and Superdecisions to Select Building Material for Housing Construction at New Capital Nusantara (IKN), East Kalimantan, Indonesia

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1. Abstract

AHP by Saaty and Super Decisions decided on eight criteria for five alternative building materials in Bew Capital Nusantara. It is designed to facilitate decision-making processes using multi-criteria decision analysis (MCDA) methods. MCDA methods are used when decisions involve multiple criteria or factors. Weighting by these two tools has been able to explain to construction actors that for a housing project location which is 99km from Samarinda to IKN by land, about 1,343 km from Surabaya by land, and 74.6 km from Balikpapan, which can be reached by land. Selection through weighting on both tools, AHP and Super Decision, ensuring that a total of 11,880 housing units with a total budget of IDR 45.2 trillion use materials that meet the requirements for cost, easy-to-work-with, performance, and physical properties.

Keywords: AHP, Hierarchical structure, Decision-making processes, (MCDA) methods.

2. Introduction

In the 1970s, there was a framework formed by Thomas L. Saaty based on decision-making with the name Analytic Hierarchy Process (AHP) (Saaty, 1977). It is a structured method used to analyze complex decisions involving multiple criteria or factors.

2.1. Analytic Hierarchy Process (AHP)

2.1.1. Definition

The Analytic Hierarchy Process (AHP) is a mathematical and systematic approach that helps individuals or groups make decisions by structuring and quantifying the relative importance of various criteria and alternatives.

2.1.2. Main Characteristics:

1. Hierarchical Structure:

AHP breaks down complex decisions into a hierarchical structure composed of criteria, sub-criteria, and alternatives. This hierarchical structure allows decision-makers to analyze and compare elements at different levels of importance.

2. Subjective Judgment:

AHP acknowledges that decision-making involves subjective judgment. It allows decision-makers to express their preferences and judgments based on their expertise and knowledge of the problem domain.

3. Mathematical Model:

AHP employs a mathematical model to calculate priority weights for criteria and alternatives based on pairwise comparison judgments. This model helps in synthesizing the subjective judgments into a coherent decision.

2.1.3. Classification

Analytic Hierarchy Process (AHP) falls under the broader category of MCDM methods. Used when decisions need to be made considering multiple criteria or factors. AHP is specifically designed to handle decision problems with a hierarchical structure, making it suitable for complex decision scenarios. It is widely applied in various fields, including business, engineering, project manage-

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Received: June-20-2023 Revised: Dec-05-2023 Accepted: Jan-15-2024

ment, and policy-making, to aid in decision-making processes where multiple factors need to be considered and prioritized (Kar & Jha, 2022).

2.2. SuperDecisions Software

SuperDecisions is a decision support software developed by the Creative Decisions Foundation. It is designed to facilitate decision-making processes using multi-criteria decision analysis (MCDA) methods. MCDA methods are utilized when decisions involve multiple criteria or factors (Kar & Jha, 2022).

2.2.1. Definition

SuperDecisions is decision support software that provides a platform for implementing and conducting multi-criteria decision analysis. It aims to assist decision-makers in structuring complex decision problems, analyzing criteria and alternatives, and making informed choices based on quantitative assessments (Altaie & Dishar, 2024).

2.2.2. Main Characteristics:

1. Multi-Criteria Decision Analysis (MCDA): SuperDecisions focuses on MCDA. It provides a structured framework for systematically assessing and comparing alternatives (Altaie & Dishar, 2024).

2. Hierarchy-based Approach:
Similar to other decision support systems, SuperDecisions employs a hierarchical structure to break down complex decisions into manageable components. It allows users to define criteria, sub-criteria, and alternatives, establishing a clear hierarchy for evaluation.

3. Pairwise Comparisons:
SuperDecisions incorporates pairwise comparisons to capture the relative importance or preference of criteria and alternatives. Decision-makers provide judgments on pairwise comparisons, enabling the software to calculate priority weights for elements in the hierarchy (Alkharasani, 2023).

4. Decision Visualization:
SuperDecisions offers visualization tools to aid decision-makers in understanding and interpreting the results. It provides graphical representations, such as decision trees, bar charts, and sensitivity analysis, to help users gain insights into the decision-making process.

2.2.3. Classification

SuperDecisions can be classified as decision support software within the field of multi-criteria decision analysis (MCDA). MCDA methods are commonly used in various domains, including business, engineering, public policy, and environmental management (Cardona-Trujillo et al., 2023). SuperDecisions specifically focuses on facilitating the application of MCDA techniques by providing a user-friendly interface and analytical tools for decision-making processes (Altaie & Dishar, 2024).

In determining a mass construction project in a remote location, architects and civil engineers must consider construction costs, ease of construction, material performance, and physical property. Of these four criteria, as shown in Figure 1, each main criterion has a second derivative criterion, namely, cost consisting of material cost and shipment cost. The easy-to-work-with criterion consists of 2 derivative criteria, namely, 'heavy equipment to install' and construction period. The performance criterion consists of 2 derivative criteria, namely, lifetime and comfortable or comfort to live in due to surface heat propagation. The physical property criterion consists of 2 derivative criteria, namely, density and weight of wall element per house, which will have an impact on the size of the foundation (Altaie & Dishar, 2024).

Housing development in the capital of the archipelago, IKN; Penajam Paser, East Kalimantan, is considered very urgent. This multi-time building project requires measurable studies, both qualitative and quantitative, so that the main types of materials for residential building structures can be determined (Afzali Borujeni et al., 2024). "A total of 2,585 units are proposed to be built using the state budget with an estimated cost of IDR 9.4 trillion. Then 9,295 units are planned to be built through the PPP scheme (Government Cooperation with Business Entities with an estimated cost of IDR 35.8 trillion," a statement on the official website of the Ministry of PUPR quoted Friday (31/3/2023). Five thousand one hundred ten units of flats are also needed to be held through private investment schemes/housing developers with an estimated cost of IDR 6.2 trillion. (Emir Yanwardhana, 2023). This number does not include staff and employees

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GOAL	CRITERIA	ALTERNATIVES
Selected Material	Material Cost	Concrete Precast
	Shipment Cost	LBW
	Heavy Equipment	AAC Panel
	Construction Period	EPS Panel
	Life Time	Sandwich Panel
	Comfortable	
	Density	
	Total Weight	

	Cost		Easy-to-work-with		Performance		Physical property	
	Material cost (IDR/sqm)	Shipment cost (IDR)	Heavy equipment to install	Construction period (week/s)	Life time (year/s)	Comfortable	Density (Kg/cum)	Weight 0f Wall Element per house (Kg)
Wall concrete precast	364.000	77.760.000	yes	8	30	no	2400	364.000
Load Bearing Wall AAC	75.000	50.176.800	no	4	30	yes	500	75.000
Wall Panel AAC	250.000	72.254.592	no	3	30	yes	800	250.000
EPS Panels (Expanded Polystyrene)	113.333	5.017.680	no	2	10	yes	50	113.333
Calcium Silicate-EPS-Cement Panels	97.000	80.282.880	no	3	10	yes	500-1000	97.000

Figure 1.
Material criteria and alternatives

of private institutions. There are 8 criteria and 5 alternative types of materials that have been verified by the Center for Building and Settlement Research - Department of Public Works, Republic of Indonesia (Puslitbangkim – PUPR) to be calculated using AHP and SuperDecision software. Shipment Cost is a significant value because there is no nearby building materials industry in IKN. Density refers to density; specific gravity will also affect the ease of implementation, mobilization and demobilization (mob-demob) tools used, and wages. Total weight will affect the design of the foundation and the type of material fittings or connectors. The five alternative materials are materials that have passed the Center for Building and Settlement Research - Department of Public Works, Republic of Indonesia (Puslitbangkim -PUPR), have been used in many projects, and can be accepted by users with or without certain conditions (Afzali Borujeni et al., 2024).

Shipment cost is calculated on a port-to-door basis from Surabaya, Java island, to IKN, Kalimantan island. The 'shipment cost' of 'wall concrete precast' is calculated from the 'batching plant' located in Samarinda or Balikpapan, which is almost the same distance to IKN, sent by inland transportation (Afzali Borujeni et al., 2024). The types of materials shown in Figure 2 have different characteristics, performance, and physical properties.

Figure 2.
Alternative Materials

Thus, 8 variable criteria were obtained to be compared, namely, 'material cost,' 'shipment cost,' 'heavy equipment,' 'construction period,' 'lifetime,' 'comfortable,' 'density, and 'weight of wall element' for one house. These eight criterion variables are calculated to determine the right type of main material. It is known that the cost per m2 (IDR/m2) is based on the specific gravity (Kg/m3) of each material selected; 'wall concrete precast,' Load Bearing Wall AAC,' Wall Panel AAC,' EPS Panel, and EPS-Cement Panel; is as described in Figure 3 below.

Structural System	Density (Kg/m3)	Size per unit (cm)	Cost (Rp)	unit	Cost per sqm (Rp)	Life Time (year/s)
Wall concrete precast	2400	full size	3.640.000	per cum	364.000	50
Load Bearing Wall AAC	500	60x20x15	750.000	per cum	75.000	30
Wall Panel AAC	800	300x10x60	2.500.000	per cum	250.000	30
EPS Panels (Expanded Polystyrene)	50	(300-600)x100x10	340.000	per lembar 300x100x10	113.333	10
Calcium Silicate-EPS-Cement Panels	500-1000	300x60x10	291.000	per lembar 300x60x10	97.000	10

Figure 3.
Material Cost per m2

While the cost of material delivery per unit of type 36 house; AAC Load Bearing Wall', AAC Wall Panel,' EPS Panel, and EPS-Cement Panel; from the nearest industry, namely Surabaya, and the shipping cost of wall concrete precast from the nearest batching plant, Samarinda, is shipped by inland transportation as described in figure 4 below:

Surabaya-Samarinda, Sea Freight	Density (Kg/m3)	Size per unit (cm)	Weight Of Wall Element per house (Kg)	Sea Freight Cost by Indah Cargo (Rp)	Sea Freight Cost by PT Pos Indonesia (Rp)
Wall concrete precast*	2400	full size	25.920	30.000.000	
Load Bearing Wall AAC	500	60x20x15	5.400	50.176.800	59.520.422
Wall Panel AAC	720	300x10x60	7.776	72.254.592	85.709.411
EPS Panels (Expanded Polystyrene)	50	(300-600)x100x10	540	5.017.680	5.952.042
Calcium Silicate-EPS-Cement Panels	500-1000	300x60x10	8.640	80.282.880	95.232.679

* inland shipment Samarinda-IKN (Penajam Paser), 170 km included mob-demob using mobile crane

sea freight port-to-door

Figure 4.
The cost of delivery of materials per unit of the house

3. Research Method

The determination of the main material to be selected is calculated through the AHP (Analytical Hierarchy Process) method. The process is carried out in the following order:

3.1. Proses Analytical Hierarchy Process (AHP)

Compiling pairwise comparisons is the first step in determining the priority scale against the criteria that have been arranged; in each sub-hierarchical system, comparisons are carried out in the value of criteria into the form of pairs as a whole (Afzali Borujeni et al., 2024). For its numerical analysis, a comparative transformation into matrix form is carried out (Hsino & Jasiczak, 2023). The value used for all comparisons is obtained based on the value of the comparison scale between values 1 to 9 (Saaty Scale)

3.2. Consistency Test

In the Analytical Hierarchy Process (AHP) model, consistency testing is one of the main analyses in. The maximum eigenvalue is the basis of consistency testing in the comparison matrix. The comparison matrix can be minimized through maximum eigenvalues by considering the inconsistencies in the results of the answers that have been given (Alamdari et al., 2023). The breakdown of the consistency index formula is as follows:

$$CI = (\lambda_{max} - n) / (n - 1)$$

dengan :
CI : indeks konsistensi
λ_{max} : eigenvalue maks.
n : orde matriks

After that, the value of the results of the respondent consistency test in filling out the question-

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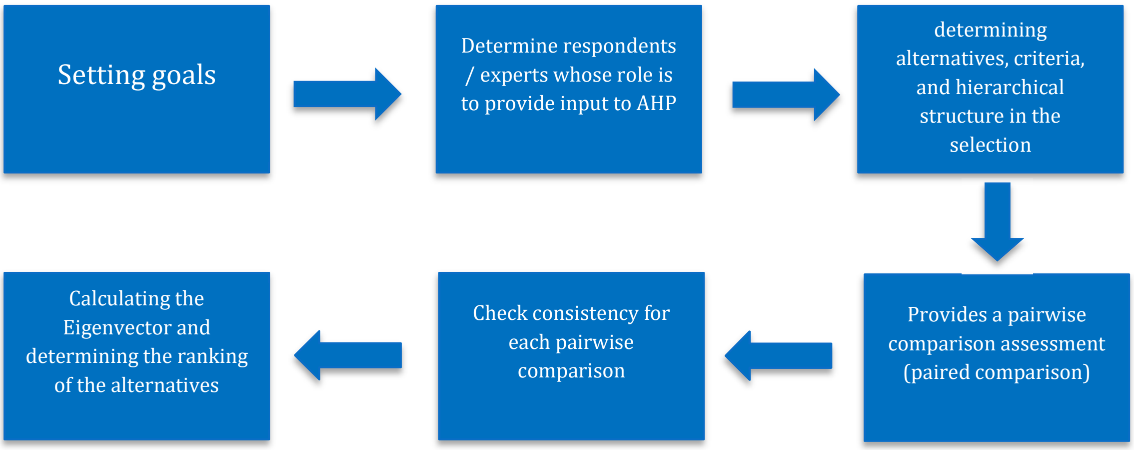


Figure 5.
AHP process

Matrik Perbandingan Berpasangan

S	A_1	A_2	...	A_n
A_1	a_{11}	a_{12}	...	a_{1n}
A_2	a_{21}	a_{22}	...	a_{2n}
⋮	...	...	...	⋮
A_m	a_{m1}	a_{m2}	...	a_{mn}

Sumber : Sugiyarto, 2015

Figure 6.
Pairwise comparison matrix

Skala Prof. Thomas Lorie Saaty

Intensitas Kepentingan	Definisi/Keterangan	Penjelasan
1	Sama penting	A dan B sama penting
3	Sedikit lebih penting	A sedikit lebih penting dari B
5	Agak lebih penting	A agak lebih penting dari B
7	Jauh lebih penting	A jauh lebih penting dari B
9	Mutlak/benar-benar lebih penting	A mutlak / benar-benar lebih penting dari B
Catatan		
Nilai 2,4,6,8	Nilai antara dua angka di atas	Ragu-ragu dalam menentukan skala. Misal nilai 6 antara 5 dan 7
Resiprocal	Jika A/B=9 maka B/A=1/9	Asumsi masuk akal

Figure 7.
Prof. Scale Thomas Lorie Saaty

naire was measured (Alamdari et al., 2023). Measurement of the value of the results of the consistency test aims to obtain the value of the inconsistency of the results of the answers that respondents have given. The CR value allowed by Prof. Thomas Lorie S. is CR < 0.1.

3.3. Multi-Participant Comparison Assessment

There are n answers in each pair generated by geometric mean theory, which explains if there are respondents who perform pairwise comparative analysis. All values must be multiplied by one another; this aims to produce a certain value, and then the appointment is done by 1/n. So that the following formula describes the mathematical calculation:

$$a_{ij} = (Z_1, Z_2, Z_3, \ldots\ldots\ldots\ldots Z_n)^{1/n}$$

Whereas:
Adj = paired comparison value between Ai and Aj criteria for n respondents.
Z_i = the pairwise comparison value between the criteria of Ai and Aj for respondents i, with i is 1,2,3, ... *n*.
n = respondent's number.

4. Result and Discussion

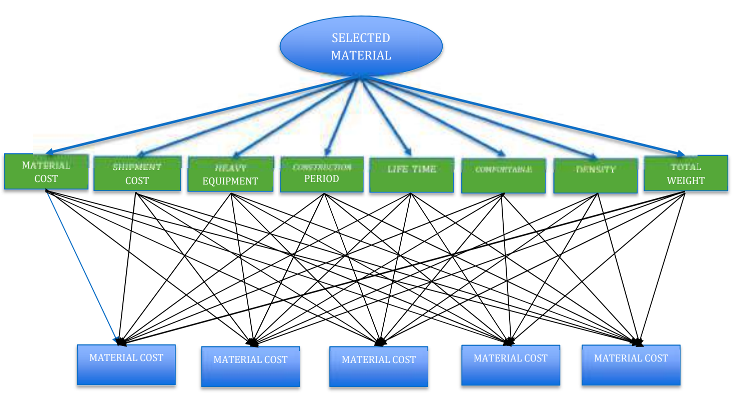
4.1. Criterion Weight Calculation

To choose the most suitable type of material for IKN,SELECTED; with 8 criteria;'material cost,' 'shipment cost,'heavy equipment,'construction period,' 'lifetime,'comfortable,'density,' and total weight';to choose one of five types of materials that meet PUPR requirements;'precast concrete,'Load Bearing Wall,'AAC Wall Panel,' EPS Panel,and Sandwich Panel EPS Cement; From the Pairwise comparison method: The ratio matrix is created by involving pairwise comparisons for each criterion and alternative. The scale is used to make comparisons in pairs and then calculate the weights (Alamdari et al., 2023). Then, it is calculated according to the calculation procedure in Figure 9 below.Furthermore, weighting is made according to Figure 10 and Figure 11 to determine the Eigen Vector or the weight of each criterion as follows: From the weighting results above, then we need to check the consistency as follows:

Since a CR of < 0.1 means that the preference obtained is consistent.

4.2. Calculation of Evaluation Factors for All Criteria

Next,wetesteachtypeofmaterial,precastconcrete, AAC load-bearing wall, AAC wall panel, EPS panel, and EPS-cement panel, against each of the criteria. Conclusion of weighting calculation using the AHP method; Analytical Hierarchy Process; as follows:
i The most important variable is the 'comfortable' criterion, the value is 0.1856 or 18.56%;



Intensity of importance	Definition	Explanantion
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or Slight	
3	Moderate Importance	Experience and judgment slightly favor one activity over another
4	Moderate Plus	
5	Strong Importance	Experience and judgment strongly favor one activity over another
6	Strong Plus	
7	Very Strong	An activity is favored very strongly over another
8	Very, very Strong	
9	Extreme Importance	The evidence favoring one activity over another is of the highest possible order of affirmation

Figure 8.
Salty's 1-9 Scale of pairwise comparisons

ii The second most important variable is the criterion 'lifetime,' which refers to strength or 'durability'; the weight is 0.175 or 17.5%;
iii The criterion of 'material cost' weight is 0.047 or 4.7%
iv The criterion of 'shipment cost' weights 0.051 or 5.1%
v The criterion of 'heavy equipment' weighs

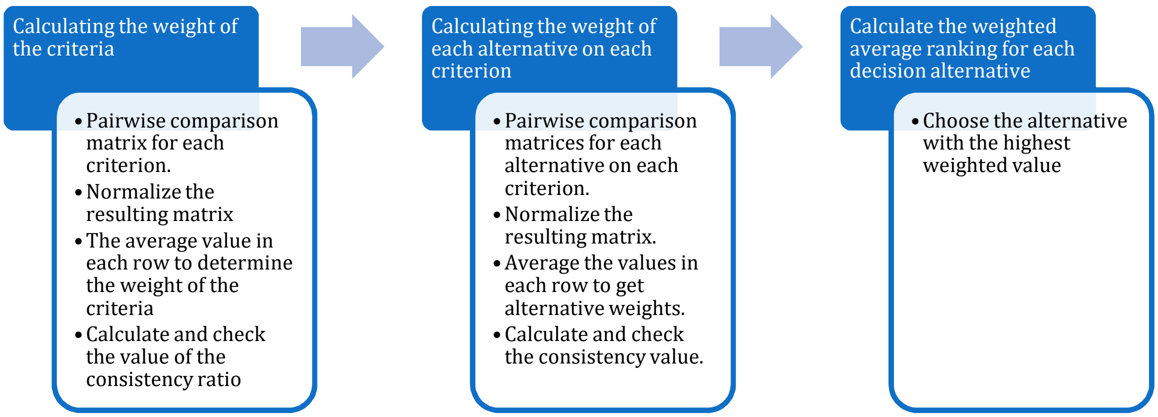


Figure 9.
Calculation procedure

PAIRWISE COMPARISON	Material cost	Shipment cost	Heavy equipment to install	Construction period	Life time	Comfortable	Density	Weight Of Wall Element per house
Material cost	1	1,00	0,33	0,33	0,25	0,25	0,33	0,50
Shipment cost	1	1	0,50	0,33	0,33	0,33	0,50	0,25
Heavy equipment to install	3	2	1	0,33	0,33	0,33	1,00	1,00
Construction period	3	3	3	1	0,33	0,33	0,25	0,25
Life time	4	3	3	3	1	1,00	0,50	1,00
Comfortable	4	3	3	3	1	1	1,00	1,00
Density	3	2	1	4	2	1	1	1,00
Weight Of Wall Element per house	2	4	1	4	1	1	1	1
	21,0	19,0	12,8	16,0	6,3	5,3	5,6	6,0

Figure 10.
Calculation of the weight of the hierarchy criteria

MATRIX NORMALISATION	Material cost	Shipment cost	Heavy equipment to install	Construction period	Life time	Comfortable	Density	Weight Of Wall Element per house	EIGENVECTOR (criterion weight)
Material cost	0,05	0,05	0,03	0,02	0,04	0,05	0,06	0,08	0,047
Shipment cost	0,05	0,05	0,04	0,02	0,05	0,06	0,09	0,04	0,051
Heavy equipment to install	0,14	0,11	0,08	0,02	0,05	0,06	0,17	0,17	0,101
Construction period	0,14	0,16	0,23	0,07	0,05	0,06	0,09	0,04	0,106
Life time	0,19	0,16	0,23	0,21	0,16	0,19	0,09	0,17	0,175
Comfortable	0,19	0,16	0,23	0,21	0,16	0,19	0,17	0,17	0,186
Density	0,14	0,11	0,08	0,14	0,32	0,19	0,17	0,17	0,165
Weight Of Wall Element per house	0,10	0,21	0,08	0,29	0,16	0,19	0,17	0,17	0,170
	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	

Conclusion: the most important comfortable variable, the second is life time variable

CHECK CRITERIA CONSISTENCY	Material cost	Shipment cost	Heavy equipment to install	Construction period	Life time	Comfortable	Density	Weight Of Wall Element per house	WEIGHT SUM VALUE	CRITERION WEIGHT	EIGENVALUE (weight sum/weight of criteria
Material cost	0,05	0,05	0,03	0,04	0,04	0,05	0,05	0,08	0,3970	0,0473	8,3998
Shipment cost	0,05	0,05	0,05	0,04	0,06	0,06	0,08	0,04	0,4288	0,0509	8,4247
Heavy equipment to install	0,14	0,10	0,10	0,04	0,06	0,06	0,16	0,17	0,8342	0,1006	8,2929
Construction period	0,14	0,15	0,30	0,11	0,06	0,06	0,08	0,04	0,9475	0,1063	8,9163
Life time	0,19	0,15	0,30	0,32	0,17	0,19	0,08	0,17	1,5750	0,1749	9,0046
Comfortable	0,19	0,15	0,30	0,32	0,17	0,19	0,16	0,17	1,6573	0,1856	8,9284
Density	0,14	0,10	0,10	0,21	0,35	0,19	0,16	0,17	1,4266	0,1647	8,6627
Weight Of Wall Element per house	0,09	0,20	0,10	0,43	0,17	0,19	0,16	0,17	1,5188	0,1697	8,9474

n	1	2	3	4	5	6	7	8	9	10
IR	0,00	0,00	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49

$$\lambda \text{ max} = \frac{8{,}3998+8{,}4247+8{,}2929+8{,}9163+9{,}0046+8{,}9284+8{,}6627+8{,}9474}{8} \qquad 8{,}69710247$$

CHECK CONSISTENCY

$$CI = \frac{\lambda \text{ max} - n}{n-1.} = \frac{8{,}6971-8}{8-1} \qquad CI = 0{,}09958607$$

$$CR = CI/IR \qquad CR = 0{,}07062842 < 0{,}1\text{; consistence}$$

0.101 or 1.01%

vi The criterion of ‘construction period’ weights 0.106 or 1.06%

vii The criterion of ‘density’ weighs 0.165 or 1.65%

viii The criterion of ‘weight of wall element per house’ weighs 0.170 or 1.7%

Then, we calculate the weighting for alternative types of building materials as follows:

	Cost		Easy-to-work-with		Performance		Physical property	
	Material cost (IDR/sqm)	Shipment cost (IDR)	Heavy equipment to install	Construction period (week/s)	Life time (year/s)	Comfortable	Density (Kg/cum)	Weight Of Wall Element per house (Kg)
Wall concrete precast	364.000	30.000.000	yes	8	30	no	2400	364.000
Load Bearing Wall AAC	75.000	50.176.800	no	4	30	yes	500	75.000
Wall Panel AAC	250.000	72.254.592	no	3	30	yes	800	250.000
EPS Panels (Expanded Polystyrene)	113.333	5.017.680	no	2	10	yes	50	113.333
Calcium Silicate-EPS-Cement Panels	97.000	80.282.880	no	3	10	yes	500-1000	97.000

PAIRWISE COMPARISON	Material cost	Shipment cost	Heavy equipment to install	Construction period	Life time	Comfortable	Density	Weight Of Wall Element per house
Material cost	1	1,00	0,33	0,33	0,25	0,25	0,33	0,50
Shipment cost	1	1	0,50	0,33	0,33	0,33	0,50	0,25
Heavy equipment to install	3	2	1	0,33	0,33	0,33	1,00	1,00
Construction period	3	3	3	1	0,33	0,33	0,50	0,25
Life time	4	3	3	3	1	1,00	0,50	1,00
Comfortable	4	3	3	3	1	1	1,00	1,00
Density	3	2	1	2	2	1	1	1,00
Weight Of Wall Element per house	2	4	1	4	1	1	1	1

MATRIX NORMALISATION	Material cost	Shipment cost	Heavy equipment to install	Construction period	Life time	Comfortable	Density	Weight Of Wall Element per house	EIGENVECTOR (bobot kriteria)
Material cost	0,05	0,05	0,03	0,02	0,04	0,05	0,06	0,08	0,047
Shipment cost	0,05	0,05	0,04	0,02	0,05	0,06	0,09	0,04	0,051
Heavy equipment to install	0,14	0,11	0,08	0,02	0,05	0,06	0,17	0,17	0,101
Construction period	0,14	0,16	0,23	0,07	0,05	0,06	0,09	0,04	0,106
Life time	0,19	0,16	0,23	0,21	0,16	0,19	0,09	0,17	0,175
Comfortable	0,19	0,16	0,23	0,21	0,16	0,19	0,17	0,17	0,186
Density	0,14	0,11	0,08	0,14	0,32	0,19	0,17	0,17	0,165
Weight Of Wall Element per house	0,10	0,21	0,08	0,29	0,16	0,19	0,17	0,17	0,170
	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	

Kesimpulan: Variabel 'Comfortable' yang paling penting, yang kedua variable 'Life time'

Conclusion of weighting material types according to AHP; Analytical Hierarchy Process; are as follows: The material that has the greatest weight to choose from is ‘wall concrete precast,’ with a value of 0.303;

i The criterion with the greatest weight is the ‘comfortable’ criterion, with a value of 0.2639. The second criterion is the ‘weight of wall element,’ with a value of 0.2361;

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Volume 2, Issue 1, 15-30, *ISSN: 2995-6307*
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ii 2 types of materials and structural systems are widely chosen, namely 'wall concrete precast' and 'EPS Panels (Expanded Polystyrene),' The material 'precast concrete' meets the criteria of 'material cost,' construction period,' 'lifetime,' and 'density.' The material 'EPS panel' meets the criteria of 'shipment cost,' heavy equipment,' comfort,' and total wall weight (Alkharasani, 2023).

Calculation of Evaluation Factors for Material Cost Criteria		S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	EIGENVECTOR
Wall concrete precast*	S1	1	4	2	3	3	0,41	0,52	0,44	0,33	0,27	0,3961
AAC Load Bearing Wall; LBW	S2	0,25	1	0,5	2	4	0,10	0,13	0,11	0,22	0,36	0,1859
AAC wall panel	S3	0,5	2	1	2	2	0,21	0,26	0,22	0,22	0,18	0,2182
EPS Panels (Expanded Polystyrene)	S4	0,33	0,5	0,5	1	1	0,14	0,06	0,11	0,11	0,09	0,1031
Calcium Silicate-EPS-Cement Panels; sandwich panel	S5	0,33	0,25	0,5	1	1	0,14	0,03	0,11	0,11	0,09	0,0967
		2,42	7,75	4,5	9	11	1,00	1,00	1,00	1,00	1,00	0,2000

λ maximum = 2,42 x 0,3961+7,75x0,1859+4,5x2182+9x0,1031+11x0,09676 / 5 = 5,37

CI = λ max - n / n-1. = 5,37 - 5 / 5-1 CI= 0,09 CR = CI/IR 0,083 <0,1; Konsisten

n	1	2	3	4	5	6	7	8	9	10
IR	0,00	0,00	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49

Calculation of Evaluation Factors for Shipment Cost Criteria		S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	EIGENVECTOR
Wall concrete precast*	S1	1	2	3	0,33	3	0,41	0,26	0,67	0,04	0,27	0,3296
AAC Load Bearing Wall; LBW	S2	0,25	1	3	0,25	3,0	0,10	0,13	0,67	0,03	0,27	0,2399
AAC wall panel	S3	0,25	0,3	1	0,25	1	0,10	0,04	0,22	0,03	0,09	0,0975
EPS Panels (Expanded Polystyrene)	S4	2,00	3,00	3,00	1	0,25	0,83	0,39	0,67	0,11	0,02	0,4030
Calcium Silicate-EPS-Cement Panels; sandwich panel	S5	0,33	0,3	0,5	0,25	1	0,14	0,04	0,11	0,03	0,09	0,0821
		3,83	6,67	10,50	2,08	8,25	1,59	0,86	2,33	0,23	0,75	0,2304

λ maximum = 3,83X0,3296+6,67X0,2399+10,5X0,0975+2,08X0,4030+8,25X0,0821 / 5 = 5,40

CI = λ max - n / n-1. = 5,40 - 5 / 5 - 1 CI= 0,10 CR = CI/IR 0,090 <0,1; Konsisten

Calculation of Evaluation Factors for Heavy Equipment Criteria		S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	EIGENVECTOR
Wall concrete precast*	S1	1	2	3	0,25	0,5	0,41	0,26	0,67	0,03	0,05	0,2824
AAC Load Bearing Wall; LBW	S2	0,5	1	2	1	2	0,21	0,13	0,44	0,11	0,18	0,2147
AAC wall panel	S3	0,33	1	1	1	1	0,14	0,06	0,22	0,11	0,09	0,1253
EPS Panels (Expanded Polystyrene)	S4	3,00	1,00	1,00	1	2	1,24	0,13	0,22	0,11	0,18	0,3771
Calcium Silicate-EPS-Cement Panels; sandwich panel	S5	0,50	0,25	0,25	0,5	1	0,21	0,03	0,06	0,06	0,09	0,0882
		5,33	4,75	7,25	3,75	6,5	2,21	0,61	1,61	0,42	0,59	0,2175

λ maximum = 5,33x0,2824+4,75x0,2147+7,25x0,1253+3,75x0,3771+6,5x0,0882 / 5 = 5,42

CI = λ max - n / n-1. = 5,42. - 5 / 5 - 1 CI= 0,11 CR = CI/IR 0,094 <0,1; Konsisten

Calculation of Evaluation Factors for Construction Period Criteria		S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	EIGENVECTOR
Wall concrete precast*	S1	1	2	3	4	4	0,41	0,26	0,67	0,44	0,36	0,4293
AAC Load Bearing Wall; LBW	S2	0,5	1	2	0,5	3	0,21	0,13	0,44	0,06	0,28	0,2223
AAC wall panel	S3	0,33	0,5	1	0,33	1	0,14	0,06	0,22	0,04	0,09	0,1104
EPS Panels (Expanded Polystyrene)	S4	0,25	2	0,5	1	2	0,10	0,26	0,11	0,11	0,18	0,1531
Calcium Silicate-EPS-Cement Panels; sandwich panel	S5	0,25	0,33	1	0,5	1	0,10	0,04	0,22	0,06	0,09	0,1029
		2,33	5,83	7,5	6,33	11,03	0,97	0,75	1,67	0,70	1,00	0,2036

λ maximum = 2,33x0,4293+5,83x0,2223+7,5x0,1104+6,33x0,1531+11,03x0,1029 / 5 = 5,23

CI = λ max - n / n-1. = 5,23. - 5 / 5 - 1 CI= 0,06 CR = CI/IR 0,051 <0,1; Konsisten

Calculation of Evaluation Factors for Life Time Criteria		S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	EIGENVECTOR
Wall concrete precast*	S1	1	2	2	3	3	0,41	0,26	0,44	0,33	0,27	0,3445
AAC Load Bearing Wall; LBW	S2	0,5	1	1	3	3	0,21	0,13	0,22	0,34	0,28	0,2341
AAC wall panel	S3	1	1	1	3	2	0,41	0,13	0,22	0,33	0,18	0,2560
EPS Panels (Expanded Polystyrene)	S4	0,33	0,33	0,33	1	1	0,14	0,04	0,07	0,11	0,09	0,0910
Calcium Silicate-EPS-Cement Panels; sandwich panel	S5	0,33	0,33	0,5	1	1	0,14	0,04	0,11	0,11	0,09	0,0985
		3,16	4,66	4,83	11,03	10,03	1,31	0,60	1,07	1,23	0,91	0,2048

λ maximum = 3,16x0,3445+4,66x0,2341+4,83x0,2560+11,03x0,0910+10,03x0,0985 / 5 = 5,41

CI = λ max - n / n-1. = 5,41 - 5 / 5 - 1 CI= 0,102 CR = CI/IR 0,091 <0,1; Konsisten

Calculation of Evaluation Factors for Comfortable Criteria		S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	EIGENVECTOR
Wall concrete precast*	S1	1	0,33	0,5	0,25	0,33	0,41	0,04	0,11	0,03	0,03	0,1251
AAC Load Bearing Wall; LBW	S2	3	1	1	0,50	2	1,24	0,13	0,22	0,06	0,18	0,3660
AAC wall panel	S3	2	0,5	1	0,33	3	0,83	0,06	0,22	0,04	0,27	0,2847
EPS Panels (Expanded Polystyrene)	S4	4,00	0,5	2	1	0,25	1,66	0,06	0,44	0,11	0,02	0,4596
Calcium Silicate-EPS-Cement Panels; sandwich panel	S5	0,33	0,5	0	0,5	1	0,14	0,06	0,07	0,06	0,09	0,0842
		10,33	2,83	4,83	2,58	6,58	4,27	0,37	1,07	0,29	0,60	0,2639

maximum = 10,33x0,1251+2,83x0,3660+4,83x0,2847+2,58x0,4596+6,58x0,0842 / 5 = 5,44

CI = λ max - n / n-1. = 5,44. - 5 / 5 - 1 CI= 0,11 CR = CI/IR 0,099 <0,1; Konsisten

Evaluation Factor Calculation for Density Criteria		S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	EIGENVECTOR
Wall concrete precast*	S1	1	3	2	4	3	0,41	0,39	0,44	0,44	0,27	0,3925
AAC Load Bearing Wall; LBW	S2	0,33	1	0,5	0,33	0,5	0,14	0,13	0,11	0,04	0,05	0,0920
AAC wall panel	S3	0,5	2	1	3	1	0,21	0,26	0,22	0,33	0,09	0,2223
EPS Panels (Expanded Polystyrene)	S4	0,25	3	0,33	1	4	0,10	0,39	0,07	0,11	0,36	0,2087
Calcium Silicate-EPS-Cement Panels; sandwich panel	S5	0,33	2	1	0,25	1	0,14	0,26	0,22	0,03	0,09	0,1474
		2,42	11,03	4,83	8,58	9,5	1,00	1,42	1,07	0,95	0,86	0,2126

λ maximum = 2,42x0,3925+11,03x0,0920+4,83x0,2223+8,58x0,2087+9,5x0,1474 / 5 = 6,23

CI = λ max - n / n-1. = 6,23 - 5 / 5 - 1 CI= 0,31 CR = CI/IR 0,274 <0,1; Konsisten

Calculation of Evaluation Factors for Total Weight of Wall Criteria		S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	EIGENVECTOR
Wall concrete precast*	S1	1	0,33	0,5	0,25	0,5	0,41	0,04	0,11	0,03	0,05	0,1281
AAC Load Bearing Wall; LBW	S2	2	1	1	0,33	0,5	0,83	0,13	0,22	0,04	0,05	0,2522
AAC wall panel	S3	0,5	1	1	0,5	1	0,21	0,13	0,22	0,06	0,09	0,1409
EPS Panels (Expanded Polystyrene)	S4	3	0,5	2	1	1	1,24	0,06	0,44	0,11	0,09	0,3905
Calcium Silicate-EPS-Cement Panels; sandwich panel	S5	2	2	0,5	0,5	1	0,83	0,26	0,11	0,06	0,09	0,2686
		8,50	4,83	5	2,58	4	3,52	0,62	1,11	0,29	0,36	0,2361

maximum = 8,5X0,1281+4,83X0,2522+5X0,1409+2,58X0,3905+4X0,2686 / 5 = 5,09

CI = λ max - n / n-1. = 5,09 - 5 / 5 - 1 CI= 0,02 CR = CI/IR 0,021 <0,1; Konsisten

n	1	2	3	4	5	6	7	8	9	10
IR	0,00	0,00	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49

		Material cost	Shipment cost	Heavy equipment to install	Construction period	Life time	Comfortable	Density	Weight Of Wall Element per house	EIGENVECTOR
		0,2000	0,2304	0,2175	0,2036	0,2048	0,2639	0,2126	0,2361	
		M1	M2	M3	M4	M5	M6	M7	M8	
Wall concrete precast*	S1	0,3961	0,3296	0,2824	0,4293	0,3445	0,1251	0,3925	0,1281	0,303
Load Bearing Wall AAC	S2	0,1859	0,2399	0,2147	0,2223	0,2341	0,3660	0,0920	0,2522	0,226
Wall Panel AAC	S3	0,2182	0,0975	0,1253	0,1104	0,2560	0,2847	0,2223	0,1409	0,182
EPS Panels (Expanded Polystyrene)	S4	0,1031	0,4030	0,3771	0,1531	0,0910	0,4596	0,2087	0,3905	0,273
Calcium Silicate-EPS-Cement Panels	S5	0,0967	0,0821	0,0882	0,1029	0,0985	0,0842	0,1474	0,2686	0,121

		Material cost	Shipment cost	Heavy equipment to install	Construction period	Life time	Comfortable	Density	Weight Of Wall Element per house
PRIORITY SEQUENCE MATRIX		M1	M2	M3	M4	M5	M6	M7	M8
The first sequence	#1	S1	S4	S4	S1	S1	S4	S1	S4
The second sequence	#2	S3	S1	S1	S2	S3	S2	S3	S5
The third sequence	#3	S2	S2	S2	S4	S2	S3	S4	S2

The weighting conclusions according to SuperDecisions
are as follows:

Conclusion

Analytic Hierarchy Process (AHP) Pros:IStructured Decision-Making: AHP provides a systematic and structured approach to decision-making by breaking down complex problems into a hierarchical structure of criteria, sub-criteria, and alternatives.

i Flexibility: AHP allows decision-makers to incorporate subjective judgments and preferences into the decision-making process, accommodating a wide range of decision scenarios and problem domains.

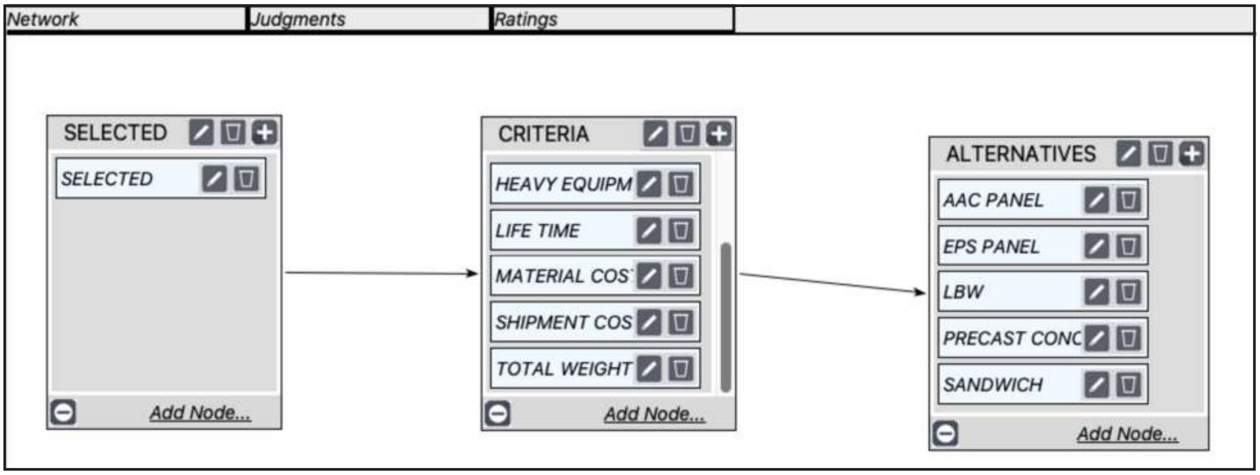
ii Prioritization of Criteria: AHP enables decision-makers to prioritize criteria and alternatives by assigning numerical values to their relative importance. This helps in focusing attention on the most critical factors in the decision.

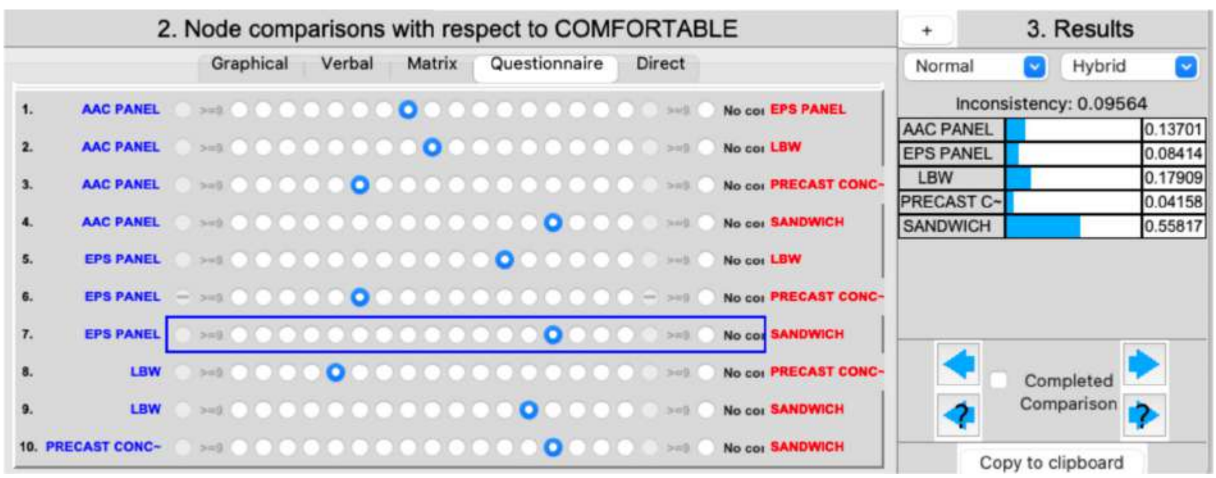
iii Mathematical Model: AHP utilizes a mathematical model to calculate priority weights based on pairwise comparisons, which adds rigor and consistency to the decision-making process.

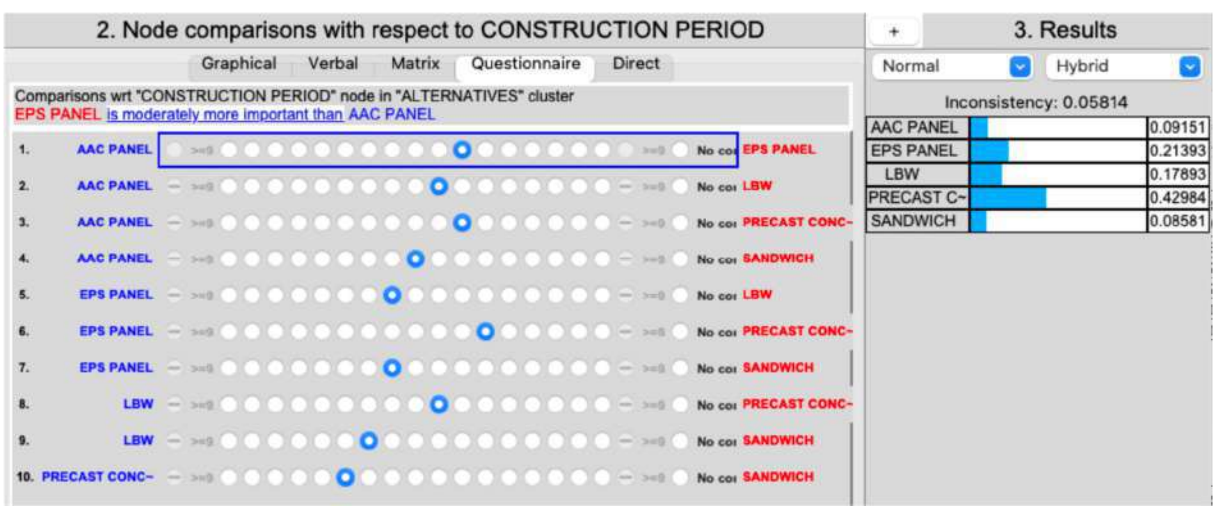
SuperDecisions Software Pros:

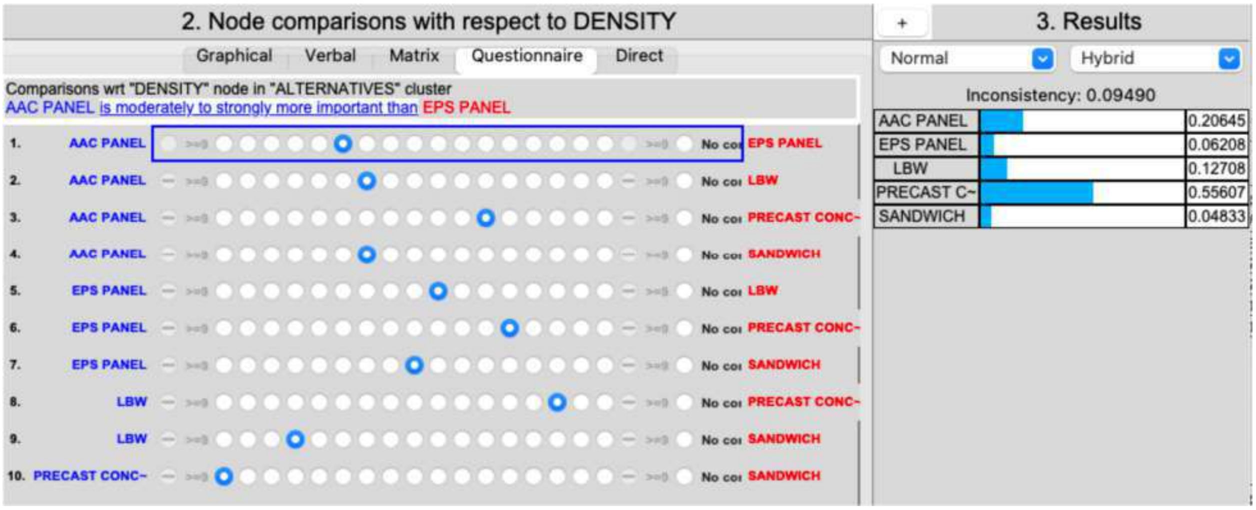
User-Friendly Interface: SuperDecisions provides a user-friendly interface that simplifies the implementation of multi-criteria decision analysis. It offers intuitive tools and visualizations to assist decision-makers in understanding and interpreting the results. Decision Visualization: SuperDecisions software offers graphical representations and visualization tools that help decision-makers visualize the decision hierarchy, compare alter

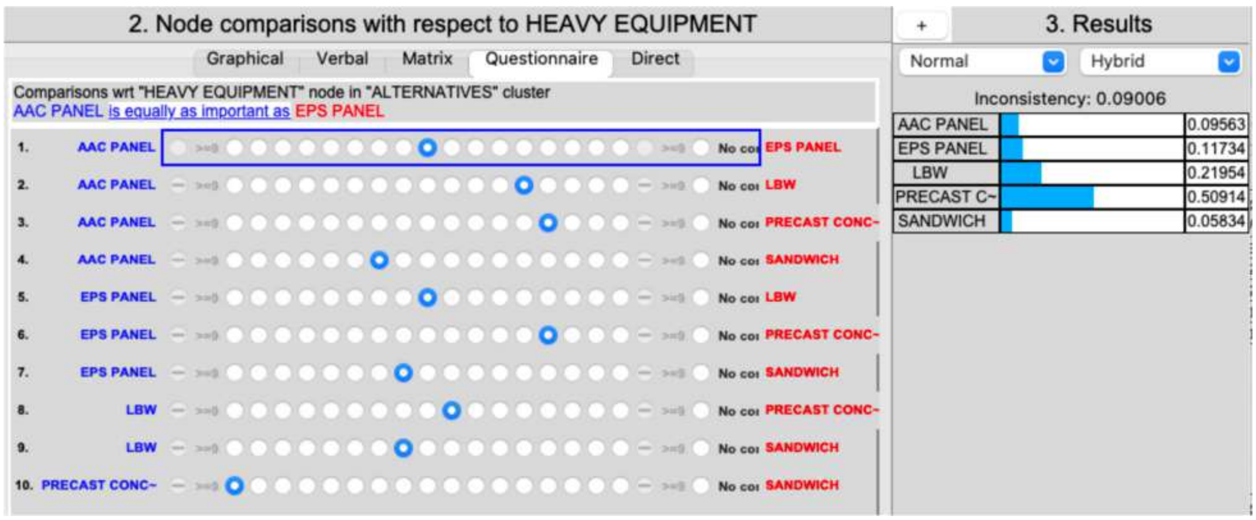
Current Integrative Engineering
Volume 2, Issue 1, 15-30, *ISSN: 2995-6307*
DOI: 10.59762/cie570390542120240205133154

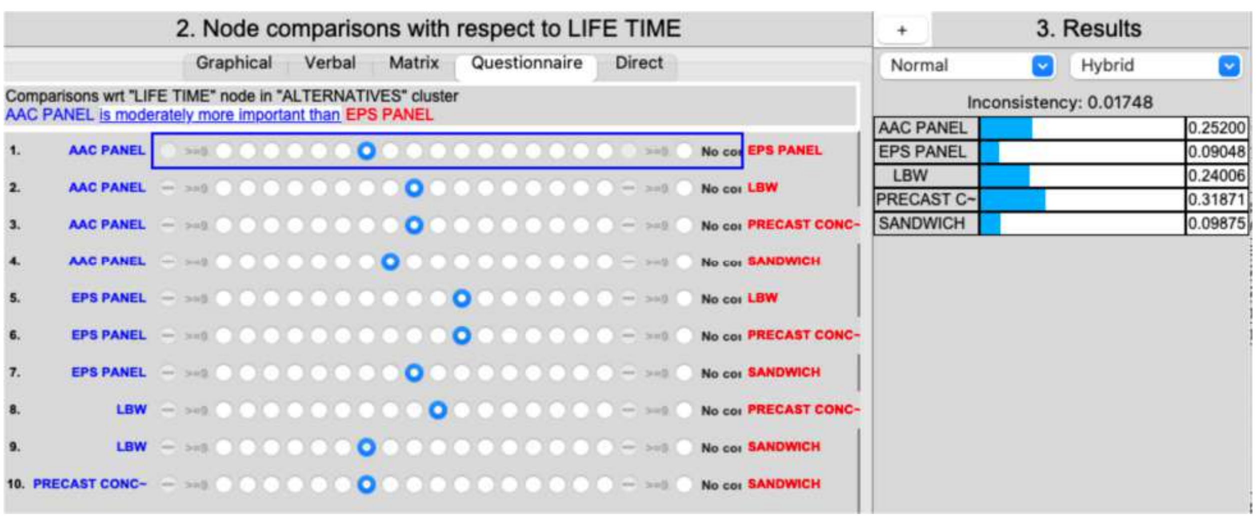







2. Node comparisons with respect to DENSITY
Graphical
Verbal
Matrix
Questionnaire
Direct
Comparisons wrt "DENSITY" node in "ALTERNATIVES" cluster
AAC PANEL is moderately to strongly more important than EPS PANEL
1. AAC PANEL EPS PANEL
2. AAC PANEL LBW
3. AAC PANEL PRECAST CONC~
4. AAC PANEL SANDWICH
5. EPS PANEL LBW
6. EPS PANEL PRECAST CONC~
7. EPS PANEL SANDWICH
8. LBW PRECAST CONC~
9. LBW SANDWICH
10. PRECAST CONC~ SANDWICH
3. Results
Normal
Hybrid
Inconsistency: 0.09490
AAC PANEL 0.20645
EPS PANEL 0.06208
LBW 0.12708
PRECAST C~ 0.55607
SANDWICH 0.04833


2. Node comparisons with respect to HEAVY EQUIPMENT
Graphical
Verbal
Matrix
Questionnaire
Direct
Comparisons wrt "HEAVY EQUIPMENT" node in "ALTERNATIVES" cluster
AAC PANEL is equally as important as EPS PANEL
1. AAC PANEL EPS PANEL
2. AAC PANEL LBW
3. AAC PANEL PRECAST CONC~
4. AAC PANEL SANDWICH
5. EPS PANEL LBW
6. EPS PANEL PRECAST CONC~
7. EPS PANEL SANDWICH
8. LBW PRECAST CONC~
9. LBW SANDWICH
10. PRECAST CONC~ SANDWICH
3. Results
Normal
Hybrid
Inconsistency: 0.09006
AAC PANEL 0.09563
EPS PANEL 0.11734
LBW 0.21954
PRECAST C~ 0.50914
SANDWICH 0.05834


2. Node comparisons with respect to LIFE TIME
Graphical
Verbal
Matrix
Questionnaire
Direct
Comparisons wrt "LIFE TIME" node in "ALTERNATIVES" cluster
AAC PANEL is moderately more important than EPS PANEL
1. AAC PANEL EPS PANEL
2. AAC PANEL LBW
3. AAC PANEL PRECAST CONC~
4. AAC PANEL SANDWICH
5. EPS PANEL LBW
6. EPS PANEL PRECAST CONC~
7. EPS PANEL SANDWICH
8. LBW PRECAST CONC~
9. LBW SANDWICH
10. PRECAST CONC~ SANDWICH
3. Results
Normal
Hybrid
Inconsistency: 0.01748
AAC PANEL 0.25200
EPS PANEL 0.09048
LBW 0.24006
PRECAST C~ 0.31871
SANDWICH 0.09875

Current Integrative Engineering
Volume 2, Issue 1, 15-30, *ISSN: 2995-6307*
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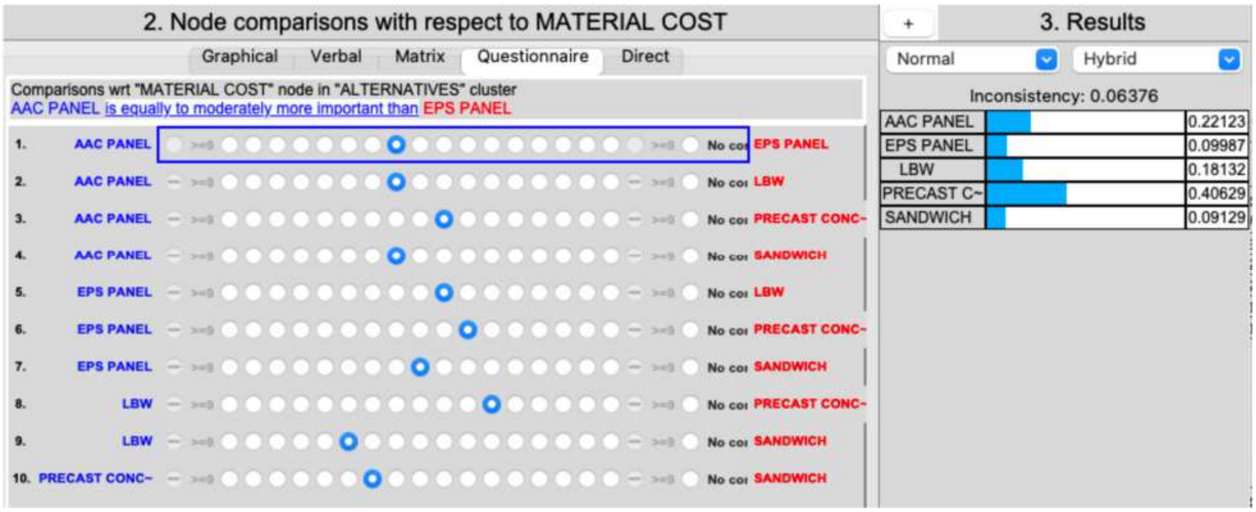

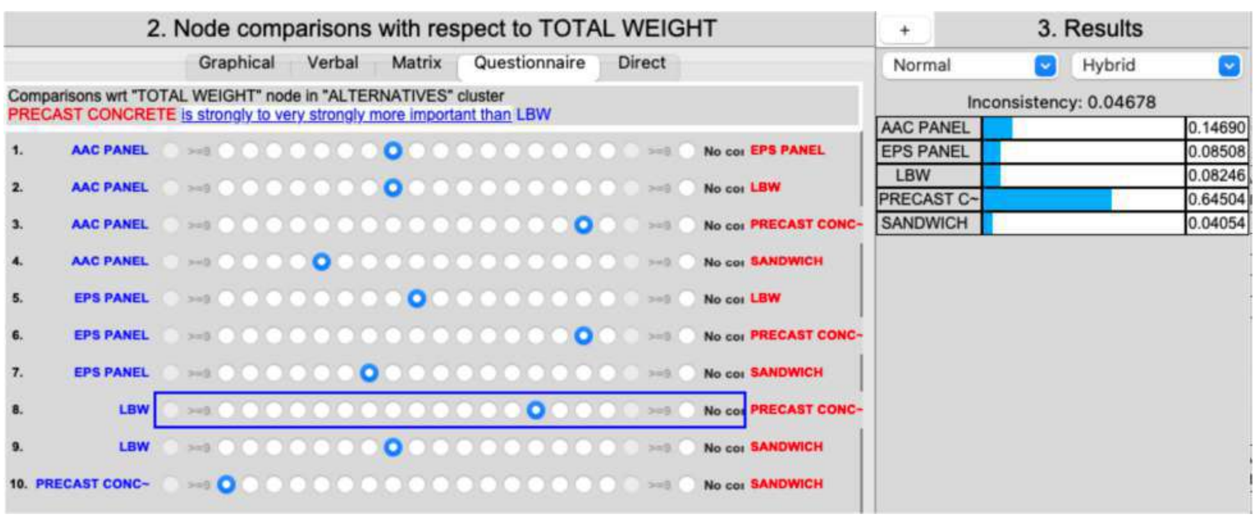

		Concrete precast	LBW	AAC panel	EPS panel	Sandwich panel
		S1	S2	S3	S4	S5
Material cost	A1	0,4063				0,9129
Shipment cost	A2				0,4973	0,0514
Heavy equipment to install	A3	0,5091				0,0583
Construction period	A4	0,4298				0,0858
Life time	A5	0,3187			0,0905	
Comfortable	A6	0,0416				0,5582
Density	A7	0,5561				0,0483
Weight 0f Wall Element per house	A8	0,6450				0,0405
		the highest				**the lowest**

natives, and understand the impact of different criteria on the final decision.

i Data Management: SuperDecisions provides a platform for managing and organizing decision-related data, making it easier to store and retrieve information. This can be particularly helpful when dealing with complex decision problems involving numerous criteria and alternatives.

Analytic Hierarchy Process (AHP) Cons: Subjective Judgments: AHP heavily relies on subjective judgments and pairwise comparisons provided by decision-makers. This reliance on individual opinions can introduce bias or inconsistency if the judgments are not well-informed or properly calibrated.

i Complexity: AHP, especially for larger and more complex decision problems, can become time-consuming and challenging to implement. The process of constructing the hierarchy, performing pairwise comparisons, and synthesizing results can be intricate and demanding.

SuperDecisions Software Cons:

i Learning Curve: Like any software, SuperDecisions may have a learning curve, particularly for users who need to become more familiar with multi-criteria decision analysis or decision support systems. It may require some initial time and effort to understand and utilize the software effectively.

ii Limited Customization: The capabilities and features of SuperDecisions may be limited to the functionality provided by the software. Users may encounter limitations in customizing certain aspects of the decision-making process to suit their specific needs or preferences.

It's important to note that the pros and cons listed here are general considerations and may vary depending on specific use cases and individual preferences. Users should evaluate their specific requirements and consider the suitability of AHP and SuperDecisions software in their decision-making processes. Within certain cases, decision-makers delivered data that is not completed, and numerous reasons are present related to this; these are (Harker, 1987):

(1) Lease amount of time for making a decision
(2) Reluctance to show the opinion
(3) Opinion's Uncertainty

Furthermore, the results of the AHP and Super Decisions calculation above are as follows:

i Material cost is ex-factory material price, the highest price of 'concrete precast,' lowest price of sandwich panel;

ii Shipment Cost is the cost of shipping from the nearest building materials industry to IKN. Highest cost EPS Panel, lowest cost sandwich panel;

iii Heavy equipment is the level of heavy equipment requirements, both for erections and for mob demos. The material that most needs heavy equipment assistance is 'concrete precast.' While the least necessary heavy equipment for mob-demob is the 'sandwich panel';

iv The longest construction period is concrete precast, 8 weeks per housing unit. The fastest is the 'sandwich panel,' which is 2 weeks per housing unit.

v Lifetime, the longest building area is concrete precast, 40 years. The shortest building life is EPS panel, 10 years;

vi Comfortable: The most comfortable place to live is the sandwich panel. The most uncomfortable is precast concrete;

vii The highest density is precast concrete, and the lowest one is sandwich panel. The density value refers to durability;

viii The total weight of the building is precast concrete; the lowest total weight of the building is sandwich panel;

5. Thank you note

The new capital of the archipelago (IKN = Capital of the Archipelago) is both an opportunity and a challenge. The opportunity to create a new center for Indonesia's economic growth while at the same time offering a construction challenge that must be realized in the near future, with very limited local resources. These building material choices can be determined through AHP and SuperDecision. I would like to thank A.A. Bagus Dinariyana Putranto for enabling the above objectives to be answered through the Quantitative Methods course at Ten November Institute of Technology, Surabaya. Thus, choosing the right building materials can save costs, shorten the construction period, and create thousands of durable, comfortable house constructions to live in.

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