MORFAI JOURNAL Multidiciplinary Output Research For Actual and International Issue
Multidisciplinary Output Research For Actual and International Issue (MORFAI Journal) ISSN (e): 2808-6635
Volume 6 No. 2 (2026)

CONTRACTOR DECISION MAKING ON CONTINUING A SUSPENDED PROJECT USING AHP-TOPSIS (A CASE STUDI OF THE NINES PLAZA & RESIDENCE BSD PROJECT)

Jiwo Waskito[1], Endah Kurniyaningrum[2]
Master of Civil Engineering Study Program, Faculty of Civil Engineering and Planning, Universitas Trisakti
E-mail: 151012400030@std.trisakti.ac.id[1], kurnianingrum@trisakti.ac.id[2]

Received	: 20 November 2025	Published	: 18 January 2026
Revised	: 01 December 2025	DOI	: https://doi.org/10.54443/morfai.v6i2.5011
Accepted	: 30 December 2025	Publish Link	: https://radjapublika.com/index.php/MORFAI/article/view/5011

Abstract

Suspended construction projects pose multidimensional challenges and necessitate accountable follow-up decision-making from the contractor's perspective. This study develops a multi-criteria decision making (MCDM) framework to determine the most appropriate alternative for continuing a suspended high-rise building project, using the Nines Plaza and Residence BSD as a case study. The Analytic Hierarchy Process (AHP) is applied to derive priority weights for nine decision criteria, while the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is used to rank four decision alternatives for project continuation. Decision robustness is examined through contextual scenario variations, respondent clustering based on expertise, and sensitivity analysis of criterion dominance. The results indicate that cost and financing are the most influential criteria, and continuing the project through a strategic partnership (joint venture) emerges as the best alternative. Robustness testing confirms that the decision outcome is stable and not driven by a single dominant criterion, demonstrating that the integrated AHP–TOPSIS approach is a suitable decision-support tool for contractors dealing with suspended construction projects.

Keywords: Suspended Construction Project; Multi-Criteria Decision Making; AHP–TOPSIS; Strategic Partnership In Construction; Decision Model Robustness.

INTRODUCTION

A construction project is an organized and temporary endeavor undertaken to deliver a unique physical facility (International Project Management Association, 2016). Such project are inherently complex, involving technical interdependencies, multiple stakeholders, and high levels of uncertainty. Consequently, cross-functional coordination is required throughout its life cycle (from initiation, planning, execution, commissioning/turnover, ~~to~~and operation), which is lengthy and highly interdependent (Begić et al., 2022; Lafhaj et al., 2024). A key indicator of project success is timely completion; however, in reality, construction project delays are a chronic problem in many countries. Such delays lead to cost overruns through domino effects on the critical path, changes in work sequences, and extended overhead costs (Çevikbaş & Işık, 2021). High-prevalence triggering factors (materials, equipment, finance, management, design, and labor) require schedule control from the early stages of the project life cycle (Rauzana & Dharma, 2022).

Among the disruptions encountered in construction projects, work suspension or termination is one of the risks with the most serious impact on time performance (Bunni, 2005). Temporary or permanent suspension may occur due to a combination of funding constraints, scope changes, procurement delays, declining productivity, weak coordination, and policy or regulatory changes. The impacts extend to cost, schedule, quality, and contractual risks for both contractors and owners (Adepu et al., 2023; Rauzana & Dharma, 2022). From an operational perspective, a suspended project is characterized by the accumulation of unfinished work and uninstalled materials/equipment, while contractual obligations continue to apply (Bartholomew, 2022). The consequences of project suspension include protecting the work from damage, managing uninstalled materials, and controlling safety in incomplete areas during the suspension period (Bunni, 2005; Construction Leadership Council, 2020). One of the building projects in BSD, namely Nines Plaza and Residence (Vasaka Nines), demonstrates this phenomenon. Based on the latest S-Curve, project progress has remained unchanged since February 2022 and has stalled at 82.784%. This condition is consistent with the operational characteristics of a suspended project, in which contractual obligations, according to the planned progress, indicate that the work should have been fully completed (100%). This situation requires accountable follow-up strategies, as each alternative action carries different implications across performance dimensions (time, cost, quality, occupational health and safety, environment, stakeholder satisfaction, and commercial value). Therefore, decision evaluation must be based on holistic parameters (Ofori, 2023). From a project economics perspective, managerial flexibility in taking action (postponing, stopping, or adjusting the scale) in response to a suspended project has its own value. Options regarding time (when to act) and scale (how much to act) will affect the economic value under conditions of irreversible investment and high uncertainty (Pindyck, 1993). Furthermore, recent perspectives suggest that waiting in the early phase and acting when information availability is high can improve decision quality; however, prolonged delays risk eroding the value of these options (Sund et al., 2022).

Multi-Criteria Decision Making (MCDM) is a commonly used approach to structure complex problems to ensure that decision-making mechanisms become transparent and measurable. In practice, the Analytic Hierarchy Process (AHP) can be used to derive priority weights for decision criteria, while the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is used to rank decision alternatives (Behzadian et al., 2012; Darko et al., 2019). The integration of AHP–TOPSIS has been applied in various construction contexts (Chen, 2020; Park et al., 2025). Reviews of MCDM in the construction field indicate the widespread adoption of integrated approaches, including AHP–TOPSIS. However, few studies have specifically documented decision-making related to the continuation of suspended high-rise building projects in Indonesia. Accordingly, the development of this framework is expected to provide both conceptual contributions and practical benefits.

METHODS

Research Location

The study was conducted at the Nines Plaza & Residence (Vasaka Nines) project located in the BSD Sunburst area, South Tangerang, Banten Province, Indonesia. The project consists of two 36-storey apartment towers with five podium levels and three basement levels. It is currently partially suspended state, making it a relevant case for developing a decision-support model for stalled high-rise building projects. The research location is situated within a planned urban environment, relatively complete utility networks, good logistical accessibility, proximity to the BSD consumer market, and supporting infrastructure such as arterial roads and public transportation. These characteristics influence market and logistics indicators as part of the evaluation criteria (Khairurizqi, 2024).

Figure 1. Current Existing Project Conditions

Research Design and Data

This study adopts a descriptive–analytical quantitative approach based on Multi-Criteria Decision Making (MCDM). The Analytic Hierarchy Process (AHP) is employed to derive criteria weights from expert preferences (with consistency ratio CR $\leq$ 0.10) while the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is used to measure the closeness of alternatives to the ideal solution and to generate their rankings. The research design is a cross-sectional case study of a suspended high-rise building project involving multiple criteria to determine follow-up strategy alternatives. The study incorporates two categories of variables: primary and auxiliary variables. Primary variables consist of dependent variables (relative closeness (Ci) and ranking of alternatives) and independent variables (priority weights of criteria and performance scores of alternatives). Auxiliary variables are employed to assess the robustness of the final alternative rankings. The data comprise primary data from expert judgments (pairwise comparison matrices for AHP and alternative performance scoring at the sub-criteria level based on brief structured interviews/questionaire) as well as secondary data derived from project documents and external contextual data.

Data Analysis

As previously explained, this study employed an applied quantitative approach supported by descriptive analysis. Expert data were processed to obtain priority weights (AHP), while alternative data on sub-criteria were analyzed to produce relative closeness and ranking (TOPSIS). Additional tests included robustness and instrument/source validation to ensure the reliability of the results.

AHP Formula

AHP analysis aims to derive priority weights based on the principal eigenvectors of the pairwise comparison matrix. Consistency is tested using λmax, CI, CR, and RI (Saaty & Vargas, 2012). The calculation algorithm then uses the power method to numerically obtain the principal eigenvectors (Jäntschi, 2023). Subsequently, expert judgments were aggregated using the geometric mean and the weighted geometric mean.

TOPSIS Formula

The analysis procedure involves constructing a normalized decision matrix, weighting it using the AHP-derived criteria weights, identifying the positive ideal solution (PIS) and negative ideal solution (NIS), calculating the Euclidean distances to the ideal and anti-ideal solutions, and subsequently computing the relative closeness coefficient (Ci) to rank the alternatives from the highest to the lowest Ci value (Chakraborty, 2022; Hwang & Yoon, 1981).

Data aggregation was applied not only at the AHP stage but also in the TOPSIS stage when alternative performance scores were derived from multiple sources (e.g., questionnaires). Inter-rater assessments for each alternative–sub-criterion pair were aggregated using mean operators. By default, the arithmetic mean (AM) was used due to its simplicity and suitability in the absence of outliers or skewness. When score distributions exhibited skewness or extreme values, the geometric mean (GM) was applied, as it is less sensitive to outliers and provides a more representative measure of central tendency (Petrović et al., 2023)

Content Validity Formula

Content validity was employed to ensure the relevance of the assessed items, including criteria and sub-criteria definitions, indicators, and scale wording. An expert panel rated each item using a four-point relevance scale (1 = not relevant to 4 = highly relevant). Ratings were dichotomized into relevant (3–4) and not relevant (1–2) categories to compute the Item-Level Content Validity Index (I-CVI) and the Scale-Level Content Validity Index–Average (S-CVI/Ave) (Polit & Beck, 2006).

RESULTS AND DISCUSSION

Content Validity of The Instrument Results

Four experts from the construction sector, each with a minimum of 15 years of professional experience, were purposively selected to provide expert judgments through a questionnaire for the content validity assessment, as presented in Tabel 1.

Table 1. Profil of Validity Test Respondents

Initial	Role	Experience (Years)	Educational Background
R-01	Director	35	B.Eng;
R-02	Project Manager	17	B.Eng; Ir. (ID)
R-03	Project Manager	16	B.Eng
R-04	QHSE Manager	32	B.Eng; Ir. (ID)

Table B shows that several sub-criteria have an Item-Level Content Validity Index (I-CVI) of less than 1, whereas for four experts an I-CVI value of 1 is considered acceptable. Consequently, these sub-criteria were excluded from the alternative scoring assessment. The Scale-Level Content Validity Index (S-CVI/Ave) was equal to 1, indicating that the instrument demonstrates strong content validity (S-CVI/Ave $\geq$ 0.9).

Table 2. Validity Test Results

Dimension (Main Criteria)	Measurable Sub-Criteria	I-CVI	S-CVI
Time / Schedule	Project Completion Duration	1,00	1,00
	Ready-to-Start Index	1,00	
Cost & Financing	Completion Cost	1,00	
	Availability of Funding Sources	1,00	
	Monthly Holding Cost	1,00	
	Performance Bond Cost	1,00	
Technical / Existing Condition	Water Tightness	0,75	
	MEP System Readiness	0,25	
	Rework Risk	1,00	
Market & Sales	Comparable Project Take-up Rate	1,00	
	Net Selling Price Projection	1,00	
Legal / Contractual	Claim Status / Contractual Risk	1,00	
	Potential Liquidated Damages (LDs)	0,75	
	Obligations to Buyers	1,00	
HSE & Environment	Potential Hazards due to Incomplete Work Areas	1,00	
	Readiness of Safe Work Plan	1,00	
Logistics & Supply Chain	Labor Availability	1,00	
	Critical Material Lead Time	1,00	
	Equipment Availability	1,00	
	Subcontractor Readiness	1,00	
Reputation & Stakeholders	Reputation Exposure	1,00	
	Contractor Confidence	1,00	
	Media Sentiment	1,00	
Managerial Flexibility	Ease of Phased/Staged Implementation	1,00	
	Allowable Delay Period	0,75	
	Strategic Partner Opportunity	1,00	
	Decision Reversibility	1,00	

AHP Process Results

Consistency Check Results

The Analytic Hierarchy Process (AHP) was initiated by assessing the consistency ratio of each pairwise comparison questionnaire completed by individual respondents. As shown in Table 3, the consistency ratios (CR) of the pairwise comparison questionnaires completed by all 12 respondents met the acceptable threshold, indicating that the data can proceed to the aggregation process.

Table 3. Individual AHP Questionaire Consistency

Initial	P-01	P-02	P-03	P-04	E-01	E-02	P-01	P-02	Q-01	Q-02	M-01	M-02
CR	7.16 %	6.22 %	7.27 %	9.99 %	7.88 %	9.63 %	6.67 %	4.64 %	9.06 %	6.09 %	5.28 %	6.54 %
Desc.	C	C	C	C	C	C	C	C	C	C	C	C

Aggregation and Consistency Ratio Calculation

The pairwise comparison questionnaires from the 12 respondents that met the consistency ratio (CR) requirement were aggregated, as presented in Table 4. Subsequently, analysis using the power method was conducted to obtain the maximum eigenvalue (λmax), consistency index (CI), random index (RI), and consistency ratio (CR), as shown in Table 5.

Table 4. Aggregated Pairwise Comparison Matrix of 12 Respondents

Criteria	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	**1.00**	0.27	0.55	0.52	0.48	1.54	0.34	0.27	0.43
2	3.64	**1.00**	2.67	3.48	2.90	4.33	2.73	1.78	3.00
3	1.83	0.37	**1.00**	1.67	1.62	2.44	0.59	0.63	0.65
4	1.91	0.29	0.60	**1.00**	1.10	3.10	0.62	0.50	0.68
5	2.10	0.34	0.62	0.91	**1.00**	2.48	0.69	0.51	0.77
6	0.65	0.23	0.41	0.32	0.40	**1.00**	0.35	0.35	0.52
7	2.92	0.37	1.69	1.62	1.46	2.88	**1.00**	0.85	1.32
8	3.72	0.56	1.58	2.02	1.96	2.88	1.18	**1.00**	2.38
9	2.30	0.33	1.54	1.48	1.30	1.92	0.76	0.42	**1.00**

Table 5. Results of AHP Analysis

λmax	9.19
CI	0.02
RI	1.45
CR	1.60% (passed)

Aggregated AHP Weights

The AHP weights represent the final priority vector (*v*) values obtained after convergence and are presented in Table 6.

Table 6. Aggregated AHP Weights

Criteria	**Weight**
Time / Schedule	0.049
Cost & Financing	0.255
Technical / Existing Condition	0.098
Market & Sales	0.082
Legal / Contractual	0.083
HSE & Environment	0.042
Logistics & Supply Chain	0.128
Reputation & Stakeholders	0.161
Managerial Flexibility	0.101

TOPSIS Process Results

TOPSIS Decision Matrix

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) begins with the process of assigning sub-criteria scores to each alternative, which are then formed into a TOPSIS decision matrix in Table 1.

Table 7. TOPSIS Decision Matrix

Dimension (Main Criteria)	Measurable Sub-Criteria	Direction	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Time / Schedule	Project Completion Duration	Cost	2930	5417	0	5417
	Ready-to-Start Index	Benefit	96.18	72.30	0	72.30
Cost & Financing	Completion Cost	Cost	50,991.34	168,419.09	0	168,419.09
	Availability of Funding Sources	Benefit	2	1	3	2
	Monthly Holding Cost	Cost	46,500,000.00	–	46,500,000.00	–
	Performance Bond Cost	Cost	2,540,496,070	–	27,930,187,365	–
Technical / Existing Condition	Rework Risk	Cost	2.13	2.69	4.31	2.69
Market & Sales	Comparable Project Take-up Rate	Benefit	15.65%	15.65%	0%	15.65%
	Net Selling Price Projection	Benefit	364.69	729.38	–	729.38
Legal / Contractual	Claim Status / Contractual Risk	Benefit	5	4	2	5
	Obligations to Buyers	Benefit	1	1	0	1
HSE & Environment	Potential Hazards due to Incomplete Work Areas	Cost	16	21	1	21
	Readiness of Safe Work Plan	Benefit	3.75	2.75	1	2
Logistics & Supply Chain	Labor Availability	Benefit	40%	50%	35%	40%
	Critical Material Lead Time	Cost	47	84	0	84
	Equipment Availability	Benefit	52.78%	27.78%	100.00%	27.78%
	Subcontractor Readiness	Benefit	20.00	35.00	35.00	35.00
Reputation & Stakeholders	Reputation Exposure	Benefit	2.64	2.64	2.86	3.40
	Contractor Confidence	Benefit	4.00	4.20	4.32	4.20
	Media Sentiment	Cost	16	16	0	16
Managerial Flexibility	Ease of Phased/Staged Implementation	Benefit	2	2	2	5
	Strategic Partner Opportunity	Benefit	25%	5%	0%	25%
	Decision Reversibility	Benefit	1	1	5	3

Decision Matrix Normalization

The next process is to normalize the decision matrix (vector normalization). The normalized decision matrix is shown in Table 8.

Table 8. Normalized Decision Matrix

Dimension (Main Criteria)	Measurable Sub-Criteria	Direction	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Time / Schedule	Project Completion Duration	Cost	0.357	0.660	0.000	0.660
	Ready-to-Start Index	Benefit	0.685	0.515	0.000	0.515
Cost & Financing	Completion Cost	Cost	0.209	0.691	0.000	0.691
	Availability of Funding Sources	Benefit	0.471	0.236	0.707	0.471
	Monthly Holding Cost	Cost	0.707	0.000	0.707	0.000
	Performance Bond Cost	Cost	0.091	0.000	0.996	0.000
Technical / Existing Condition	Rework Risk	Cost	0.347	0.439	0.704	0.439
Market & Sales	Comparable Project Take-up Rate	Benefit	0.577	0.577	0.000	0.577
	Net Selling Price Projection	Benefit	0.333	0.667	0.000	0.667
Legal / Contractual	Claim Status / Contractual Risk	Benefit	0.598	0.478	0.239	0.598
	Obligations to Buyers	Benefit	0.577	0.577	0.000	0.577
HSE & Environment	Potential Hazards due to Incomplete Work Areas	Cost	0.474	0.622	0.030	0.622
	Readiness of Safe Work Plan	Benefit	0.727	0.533	0.194	0.388
Logistics & Supply Chain	Labor Availability	Benefit	0.481	0.601	0.421	0.481
	Critical Material Lead Time	Cost	0.368	0.658	0.000	0.658
	Equipment Availability	Benefit	0.441	0.232	0.835	0.232
	Subcontractor Readiness	Benefit	0.313	0.548	0.548	0.548
Reputation & Stakeholders	Reputation Exposure	Benefit	0.455	0.455	0.493	0.586
	Contractor Confidence	Benefit	0.478	0.502	0.516	0.502
	Media Sentiment	Cost	0.577	0.577	0.000	0.577
Managerial Flexibility	Ease of Phased/Staged Implementation	Benefit	0.329	0.329	0.329	0.822
	Strategic Partner Opportunity	Benefit	0.700	0.140	0.000	0.700
	Decision Reversibility	Benefit	0.167	0.167	0.833	0.500

Weighted Normalized Decision Matrix

The results of the weighted calculation of the normalized decision matrix are shown in Table 9.

Table 9. Weighted Normalized Decision Matrix

Dimension (Main Criteria)	Measurable Sub-Criteria	Direction	Weight (W)	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Time / Schedule	Project Completion Duration	Cost	0.025	0.009	0.016	0.000	0.016
	Ready-to-Start Index	Benefit	0.025	0.017	0.013	0.000	0.013
Cost & Financing	Completion Cost	Cost	0.064	0.013	0.044	0.000	0.044
	Availability of Funding Sources	Benefit	0.064	0.030	0.015	0.045	0.030
	Monthly Holding Cost	Cost	0.064	0.045	0.000	0.045	0.000
	Performance Bond Cost	Cost	0.064	0.006	0.000	0.064	0.000
Technical / Existing Condition	Rework Risk	Cost	0.098	0.034	0.043	0.069	0.043
Market & Sales	Comparable Project Take-up Rate	Benefit	0.041	0.024	0.024	0.000	0.024
	Net Selling Price Projection	Benefit	0.041	0.014	0.027	0.000	0.027
Legal / Contractual	Claim Status / Contractual Risk	Benefit	0.041	0.025	0.020	0.010	0.025

	Obligations to Buyers	Benefit	0.041	0.024	0.024	0.000	0.024
HSE & Environment	Potential Hazards due to Incomplete Work Areas	Cost	0.021	0.010	0.013	0.001	0.013
	Readiness of Safe Work Plan	Benefit	0.021	0.015	0.011	0.004	0.008
Logistics & Supply Chain	Labor Availability	Benefit	0.032	0.015	0.019	0.013	0.015
	Critical Material Lead Time	Cost	0.032	0.012	0.021	0.000	0.021
	Equipment Availability	Benefit	0.032	0.014	0.007	0.027	0.007
	Subcontractor Readiness	Benefit	0.032	0.010	0.018	0.018	0.018
Reputation & Stakeholders	Reputation Exposure	Benefit	0.054	0.024	0.024	0.027	0.032
	Contractor Confidence	Benefit	0.054	0.026	0.027	0.028	0.027
	Media Sentiment	Cost	0.054	0.031	0.031	0.000	0.031
Managerial Flexibility	Ease of Phased/Staged Implementation	Benefit	0.034	0.011	0.011	0.011	0.028
	Strategic Partner Opportunity	Benefit	0.034	0.024	0.005	0.000	0.024
	Decision Reversibility	Benefit	0.034	0.006	0.006	0.028	0.017

Positive and Negative Ideal Solutions (PIS & NIS)

After the normalized decision matrix is weighted, the next step is to determine the values of the Positive Ideal Solution and the Negative Ideal Solution (A^+ and A^-). The PIS and NIS values are shown in Table 10.

Table 10. PIS and NIS Values

Dimension (Main Criteria)	Measurable Sub-Criteria	Direction	Alt. 1	Alt. 2	Alt. 3	Alt. 4	A^+	A^-
Time / Schedule	Project Completion Duration	Cost	0.009	0.016	0.000	0.016	0.000	0.016
	Ready-to-Start Index	Benefit	0.017	0.013	0.000	0.013	0.017	0.000
Cost & Financing	Completion Cost	Cost	0.013	0.044	0.000	0.044	0.000	0.044
	Availability of Funding Sources	Benefit	0.030	0.015	0.045	0.030	0.045	0.015
	Monthly Holding Cost	Cost	0.045	0.000	0.045	0.000	0.000	0.045
	Performance Bond Cost	Cost	0.006	0.000	0.064	0.000	0.000	0.064
Technical / Existing Condition	Rework Risk	Cost	0.034	0.043	0.069	0.043	0.034	0.069
Market & Sales	Comparable Project Take-up Rate	Benefit	0.024	0.024	0.000	0.024	0.024	0.000
	Net Selling Price Projection	Benefit	0.014	0.027	0.000	0.027	0.027	0.000
Legal / Contractual	Claim Status / Contractual Risk	Benefit	0.025	0.020	0.010	0.025	0.025	0.010
	Obligations to Buyers	Benefit	0.024	0.024	0.000	0.024	0.024	0.000
HSE & Environment	Potential Hazards due to Incomplete Work Areas	Cost	0.010	0.013	0.001	0.013	0.001	0.013
	Readiness of Safe Work Plan	Benefit	0.015	0.011	0.004	0.008	0.015	0.004
Logistics & Supply Chain	Labor Availability	Benefit	0.015	0.019	0.013	0.015	0.019	0.013
	Critical Material Lead Time	Cost	0.012	0.021	0.000	0.021	0.000	0.021
	Equipment Availability	Benefit	0.014	0.007	0.027	0.007	0.027	0.007
	Subcontractor Readiness	Benefit	0.010	0.018	0.018	0.018	0.018	0.010
Reputation & Stakeholders	Reputation Exposure	Benefit	0.024	0.024	0.027	0.032	0.032	0.024
	Contractor Confidence	Benefit	0.026	0.027	0.028	0.027	0.028	0.026
	Media Sentiment	Cost	0.031	0.031	0.000	0.031	0.000	0.031
Managerial Flexibility	Ease of Phased/Staged Implementation	Benefit	0.011	0.011	0.011	0.028	0.028	0.011
	Strategic Partner Opportunity	Benefit	0.024	0.005	0.000	0.024	0.024	0.000
	Decision Reversibility	Benefit	0.006	0.006	0.028	0.017	0.028	0.006

Alternative Ranking

After the PIS and NIS have been determined, the next step is to calculate the S_i^+ and S_i^- values, which represent the Euclidean distance from each alternative to the PIS and NIS, respectively. From these Euclidean distances, the closeness coefficient (*Ci*) is calculated. The results of this calculation can be seen in Table 11.

Table 11. Alternative Ranking

Value	Alternative 1	Alternative 2	Alternative 3	Alternative 4
$\Sigma (v_{ij} - v_j^+)^2$	0.0050	0.0064	0.0107	0.0047
$S_i^+ = \sqrt{\Sigma (v_{ij} - v_j^+)^2}$	0.0706	0.0798	0.1035	0.0683
$\Sigma (v_{ij} - v_j^-)^2$	0.0084	0.0091	0.0056	0.0103
$S_i^- = \sqrt{\Sigma (v_{ij} - v_j^-)^2}$	0.0919	0.0952	0.0749	0.1016
C_i (Preference Value)	0.5654	0.5440	0.4200	0.5982
Rank	2	3	4	1

From Table 11, it can be seen that the calculated *Ci* values can be ranked by sorting them from the largest value as rank 1 (first rank) to the smallest value as rank 4 (last rank). Therefore, the alternatives are ranked as follows:
1. Alternative 4 (Strategic Partnership/Joint Venture): First
2. Alternative 1 (Partial Continuation of Tower 1 and Podium)
3. Alternative 2 (Full Remobilization of Towers 1 & 2 and Podium)
4. Alternative 4 (Protected Delay): Last

Alternative Robustness Test Results
Respondent Characteristics (Expertise Cluster)

The questionnaire results from 12 respondents were grouped according to each respondent's expertise cluster as follows:
1. PM-01 to PM-02: Project Management (4 respondents)
2. ENG-01 to ENG-02: Engineering (2 respondents)
3. PL-01 to PL-02: Procurement and Logistics (2 respondents)
4. QHSE-01 to QHSE-02: QHSE (2 respondents)
5. MEP-01 to MEP-02: MEP (2 respondents)

Next, aggregation was performed using the geometric mean and the consistency ratio was checked, as shown in Table 6.

Table 12. Weight and CR Per Expertise Cluster

No.	Criteria	Project Management	Engineering	Procurement & Logistics	QHSE	MEP
1	Time / Schedule	0.034	0.041	0.086	0.040	0.045
2	Cost & Financing	0.264	0.068	0.300	0.317	0.341
3	Technical / Existing Condition	0.105	0.140	0.083	0.059	0.068
4	Market & Sales	0.064	0.138	0.077	0.086	0.048
5	Legal / Contractual	0.073	0.175	0.074	0.064	0.039
6	HSE & Environment	0.026	0.227	0.047	0.024	0.018
7	Logistics & Supply Chain	0.154	0.036	0.133	0.115	0.192
8	Reputation & Stakeholders	0.176	0.107	0.137	0.178	0.135
9	Managerial Flexibility	0.105	0.069	0.064	0.116	0.113
Total		**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
Consistency Ratio (CR)		**2.64%**	**4.64%**	**2.49%**	**4.54%**	**4.97%**

As seen in Table 12, the consistency ratio for the five respondent expertise clusters is ≤ 10%. Therefore, the geometric mean is sufficient for aggregation, and the resulting weights can be used in the subsequent TOPSIS process. Next, the TOPSIS process is recalculated per expertise cluster using the weights listed in Table 13.

Table 13. TOPSIS Results Per Expertise Cluster

PM	**Alternative**			
	1	**2**	**3**	**4**
Ci	0.5533	0.5296	0.4349	0.5853
Rank	2	3	4	1
ENG	**Alternative**			
	1	**2**	**3**	**4**
Ci	0.6385	0.5510	0.3848	0.5448
Rank	1	2	4	3
PL	**Alternative**			
	1	**2**	**3**	**4**
Ci	0.5767	0.5559	0.4245	0.5894
Rank	2	3	4	1
QHSE	**Alternative**			
	1	**2**	**3**	**4**
Ci	0.5480	0.5459	0.4254	0.6058
Rank	2	3	4	1
MEP	**Alternative**			
	1	**2**	**3**	**4**
Ci	0.5476	0.5323	0.4444	0.5852
Rank	2	3	4	1

Table 13 presents the TOPSIS results for each expertise cluster, showing that the alternative rankings are consistent with the combined rankings of all respondents in the Project Management, Procurement and Logistics, QHSE, and MEP clusters. However, for the Engineering expertise cluster, the rankings differ, with Alternative 1 ranked highest, followed by Alternative 2, Alternative 4, and Alternative 3.

Contextual Scenario Parameters (Stress Test)

This test simulated realistic changes in conditions and applied them to relevant sub-criteria in the decision matrix. These parameter changes were:

1. Increased market absorption (increasing the market and sales category by +20% compared to the baseline in the benefit category).
2. Tighter financing (increasing the cost sub-criterion score by +15% in the cost category).
3. Supply chain disruption (increasing material lead time by +30 days and reducing labor, equipment, and vendor availability by 25%).

Next, after these parameters were changed, TOPSIS calculations were performed as in the previous TOPSIS steps. Table 14 shows the results of the TOPSIS analysis from the contextual scenario parameter test. The final results of the three contextual changes (increased market absorption, tighter financing, and supply chain disruption) resulted in the same alternative ranking as the alternative ranking without the contextual scenario parameter changes, with alternative 4 as the best alternative, followed by alternative 1, alternative 2, and alternative 3.

Table 14. TOPSIS Results for Contextual Scenario Parameters

MARKET & SALES	**Alternative**			
	1	**2**	**3**	**4**
Ci	0.5654	0.5440	0.4200	0.5982
Rank	2	3	4	1
COST & FINANCING	**Alternative**			
	1	**2**	**3**	**4**
Ci	0.5654	0.5440	0.4200	0.5982
Rank	2	3	4	1
SUPPLY CHAIN DISRUPTION	**Alternative**			
	1	**2**	**3**	**4**
Ci	0.5665	0.5484	0.4151	0.6040
Rank	2	3	4	1

Decision Sensitivity Analysis to Criteria Dominance

A sensitivity analysis of criterion dominance is conducted to evaluate the extent to which each primary criterion individually influences the ranking of decision alternatives, and to assess the stability of decision-making outcomes when the evaluation process is based on only one criterion at a time. At this stage, the TOPSIS method is run separately for each criterion without considering the contribution of other criteria. The analysis results, shown in Table 15, show that alternative rankings vary across criteria, indicating that decisions are sensitive to the evaluation perspective used. Some criteria produce contrasting rankings, while others show relatively small ranking differences, and in some cases, even a tie occurs. This situation reflects the equivalence of alternative performance on certain criteria and the limited discriminatory power of those criteria.

The existence of a tie is a natural characteristic of partial evaluation and indicates a zone of decision indifference, as explained by (Chakraborty, 2022; Jiang et al., 2024). When conceptually compared with multicriteria decision results, it appears that partial rankings tend to be more volatile, so that the superiority of a particular alternative cannot be explained by the dominance of a single criterion. Thus, this analysis confirms that contractor decisions on stalled projects are not driven by a single criterion, but rather by the cumulative contribution of various criteria, and strengthens the justification for using a multi-criteria decision-making (MCDM) approach, specifically AHP–TOPSIS, to address complex decision-making problems in stalled construction projects.

Table 15. TOPSIS Results: Criteria Dominance Sensitivity Analysis

Dimension (Main Criteria)		Alternative 1	Alternative 2	Alternative 3	Alternative 4
Rangking	Time / Schedule	1	3	2	3
	Cost & Financing	3	2	4	1
	Technical / Existing Condition	1	2	4	2
	Market & Sales	3	1	4	1
	Legal / Contractual	1	3	4	1
	HSE & Environment	1	3	2	4
	Logistics & Supply Chain	2	3	1	4
	Reputation & Stakeholders	4	3	1	2
	Managerial Flexibility	2	4	3	1

CONCLUSION

Conclusion

Based on the results of a study of contractor decision-making on continuing suspended project using the AHP-TOPSIS method on the Nines Plaza and Residence project in BSD, along with robustness tests, the following conclusions were obtained:

1. Nine primary criteria were deemed relevant, although four sub-criteria (water tightness, MEP system readiness, potential liquidated damages, and safe delay period) were deemed less valid. The AHP results showed consistent criterion weighting, with cost and funding as the highest priority (w = 0.255) and OHS and environment as the lowest priority (w = 0.042), confirming the dominance of financial considerations in the decision to halt the project.
2. The TOPSIS results indicated Alternative 4 (strategic partnership/joint venture) as the best choice, followed by Alternative 1, Alternative 2, and Alternative 3. The strategic partnership alternative performed closest to the ideal solution based on the combination of weighted criteria.
3. The robustness analysis confirms that the proposed decision model is stable, as variations in contextual parameters did not significantly affect the closeness coefficients or alternative rankings. Consistent rankings were also observed across expertise clusters, although the technical cluster favored Alternative 1. Sensitivity analysis further indicates that the final decision is driven by the combined influence of multiple criteria rather than the dominance of a single criterion. Accordingly, the use of aggregated weights and full criteria integration within the AHP–TOPSIS framework provides a more comprehensive and unbiased evaluation.
4. The study confirms that decisions regarding suspended projects are multidimensional and require a structured, multi-criteria approach. The AHP–TOPSIS integration produced stable, comprehensive, and sector-neutral decisions, demonstrating its suitability as a decision-support tool for contractors.

Recommendations

1. Invalid sub-criteria need to be refined by redefining indicators or adding quantitative data to improve their representativeness.
2. Cost and funding should be a primary focus through strengthening financing strategies and mitigating financial risks.
3. Strategic partnership alternatives are recommended, considering alignment of vision, financial and technical capabilities, and clarity of risk allocation.
4. The decision model needs to be applied dynamically with regular evaluation to remain relevant to changing project conditions.
5. Using combined weights across expertise clusters and integrating all criteria is recommended to avoid sectoral bias and the dominance of a single criterion.
6. Further research is recommended to add contextual variables and integrate fuzzy methods to handle more complex uncertainties.

REFERENCES

Adepu, N., Kermanshachi, S., Pamidimukkala, A., & Loganathan, K. (2023). Analyzing the factors affecting construction project schedules amidst COVID-19 pandemic. *Project Leadership and Society*, *4,* 100100. https://doi.org/10.1016/j.plas.2023.100100

Arfyan, A. R., Kurniyaningrum, E. ., Pontan, D., & Kusumawati, L. (2025). Analysis of Decision Making in Vendor Selection on the TKDN Value Limit Based on the Decree of the Minister of PUPR NO.602/KPTS/M/2023. Eduvest - Journal of Universal Studies, 5(5), 5317–5326. https://doi.org/10.59188/eduvest.v5i5.49995

Bartholomew, S. H. (2022). 16. Delays, Suspensions, and Terminations. In *Construction Contracting*. Virginia Tech Publishing. https://pressbooks.lib.vt.edu/constructioncontracting/chapter/delays-suspensions-and-terminations/

Begić, H., Galić, M., & Dolaček-Alduk, Z. (2022). Digitalization and Automation in Construction Project'S Life-Cycle: a Review. *Journal of Information Technology in Construction*, *27*(October 2021), 441–460. https://doi.org/10.36680/j.itcon.2022.021

Behzadian, M., Khanmohammadi Otaghsara, S., Yazdani, M., & Ignatius, J. (2012). A state-of the-art survey of TOPSIS applications. *Expert Systems with Applications*, *39*(17), 13051–13069. https://doi.org/10.1016/j.eswa.2012.05.056

Bunni, N. G. (2005). *Restraints on the Execution of Works*. https://fidic.org/sites/default/files/37 Restraints on the Execution of Works.pdf

Çevikbaş, M., & Işık, Z. (2021). An overarching review on delay analyses in construction projects. *Buildings*, *11*(3), 109. https://doi.org/10.3390/buildings11030109

Chakraborty, S. (2022). TOPSIS and Modified TOPSIS: A comparative analysis. *Decision Analytics Journal*, *2*, 100021. https://doi.org/10.1016/j.dajour.2021.100021

Chen, C. (2020). A Novel Multi-Criteria Decision-Making Model for Building Material Supplier Selection Based on Entropy-AHP Weighted TOPSIS. *Entropy*, *22*(2), 259. https://doi.org/10.3390/e22020259

Construction Leadership Council. (2020). *Advice on Temporary Suspension of Sites*. https://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2020/03/CLC_Advice-on-temporary-suspension-of-sites1.pdf

Darko, A., Chan, A. P. C., Ameyaw, E. E., Owusu, E. K., Pärn, E., & Edwards, D. J. (2019). Review of application of analytic hierarchy process (AHP) in construction. I*nternational Journal of Construction Management*, *19*(5), 436–452. https://doi.org/10.1080/15623599.2018.1452098

Hwang, C.-L., & Yoon, K. (1981). *Multiple Attribute Decision Making: Methods and Applications: A State-of-the-Art Survey* (1st ed.). Springer-Verlag. https://doi.org/10.1007/978-3-642-48318-9

International Project Management Association. (2016). *Project Excellence Baseline for Achieving Excellence in Projects and Programes Version 1.0*. International Project Management Association (IPMA). https://products.ipma.world/wp-content/uploads/2016/02/IPMA_PEB_1_0.pdf

Jäntschi, L. (2023). Eigenproblem Basics and Algorithms. *Symmetry*, *15*(11), 2046. https://doi.org/10.3390/sym15112046

Khairurizqi, R. (2024). *BSD City: Peluang Emas Investasi Properti di Masa Depan*. Detik.Com.

https://www.detik.com/properti/berita/d-7603203/bsd-city-peluang-emas-investasi-properti-di-masa-depan

Lafhaj, Z., Rebai, S., AlBalkhy, W., Hamdi, O., Mossman, A., & Alves Da Costa, A. (2024). Complexity in Construction Projects: A Literature Review. *Buildings*, *14*(3), 680. https://doi.org/10.3390/buildings14030680

Mahatmantong, S., Moengin, P., Kurniyaningrum, E., & Pontan, D. (2025). Analisis Keputusan Pemilihan Vendor pada Proyek Infrastruktur Kawasan Ibu Kota Negara (IKN) dengan Menggunakan Metode Rank Order Centroid (ROC) dan Simple Multi Attribute Rating Technique (SMART). Syntax Literate: Jurnal Ilmiah Indonesia, Vol. 10(7), pp. 8758-8775

Ofori, G. (2023). Get Construction Project Performance Parameters Right to Attain Sustainable Development Goals. *Sustainability (Switzerland)*, *15*(18), 13360. https://doi.org/10.3390/su151813360

Park, C., Son, M., Kim, J., Kim, B., Ahn, Y., & Kwon, N. (2025). TOPSIS and AHP-Based Multi-Criteria Decision-Making Approach for Evaluating Redevelopment in Old Residential Projects. *Sustainability (Switzerland)*, *17*(15), 7072. https://doi.org/10.3390/su17157072

Petrović, G., Mihajlović, J., Marković, D., Hashemkhani Zolfani, S., & Madić, M. (2023). Comparison of Aggregation Operators in the Group Decision-Making Process: A Real Case Study of Location Selection Problem. *Sustainability (Switzerland)*, 15(10), 8229. https://doi.org/10.3390/su15108229

Pindyck, R. S. (1993). Investments of uncertain cost. *Journal of Financial Economics*, *34*(1), 53–76. https://doi.org/10.1016/0304-405X(93)90040-I

Polit, D. F., & Beck, C. T. (2006). The Content Validity Index: Are You Sure You Know What's Being Reported? Critique and Recommendations. *Research in Nursing & Health*, *29*(5), 489–497. https://doi.org/10.1002/nur.20147

Rauzana, A., & Dharma, W. (2022). Causes of delays in construction projects in the Province of Aceh, Indonesia. *Plos One*, *17*(1), 1–12. https://doi.org/10.1371/journal.pone.0263337

Saaty, T. L., & Vargas, L. G. (2012). Models, Methods, Concepts & Applications of the Analytic Hierarchy Process (2nd ed.). In *International Series in Operations Research & Management Science*. Springer. https://doi.org/10.1007/978-1-4614-3597-6

Sund, S., Sendstad, L. H., & Thijssen, J. J. J. (2022). Kalman filter approach to real options with active learning. *Computational Management Science*, *19*(3), 457–490. https://doi.org/10.1007/s10287-022-00423-1