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A Study on The Influence of Building Construction Project Delays Besed on Delay Factors using The Analytic Hierarchy Process (AHP) and Simple Additive Weighting (SAW) Methods in West Nusa Tenggara Province

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ABSTRACT

Building construction projects involve various complex stages, ranging from planning and material procurement to execution and quality control. This complexity requires effective and efficient project management to ensure that projects are completed according to the established schedule, quality standards, and budget. However, delays remain a common problem in construction project implementation and may result from various technical and nontechnical factors. This study aimed to analyze the factors influencing delays in building construction projects and to determine the severity of delays across several projects in West Nusa Tenggara Province. The study employed the Analytic Hierarchy Process (AHP) to determine the weights and priorities of delay factors and the Simple Additive Weighting (SAW) method to rank the severity of project delays. Data were obtained from respondents with experience and direct involvement in construction project implementation and were supported by actual project execution data from three case studies: Mataram University Hospital, Mandalika Hospital, and the Islamic Center. The AHP weighting results showed varying levels of importance among the delay factors. Criterion C2 had the highest weight (0.17), followed by C14 (0.12), C1 (0.11), and C7 (0.09). The SAW ranking results placed Mandalika Hospital first, the Islamic Center second, and Mataram University Hospital third in terms of delay severity. These findings indicated that project delays were not determined by a single factor but resulted from the cumulative influence of multiple factors with different levels of importance.

INTRODUCTION

The construction of state buildings involves multiple stages, including planning, design, procurement, implementation, supervision, and maintenance. These characteristics make building construction projects complex systems involving numerous resources and stakeholders, as well as a high degree of interdependence among activities. Under such conditions, the achievement of project time targets is determined not only by work productivity within individual activities but also by the project's ability to manage interrelationships among activities and anticipate changes during implementation. In this study, project delay refers to a condition in which work cannot be completed according to the contractual schedule or work plan, resulting in postponed completion, potential cost increases, and disruptions to the intended use of the building (Arifin, 2017).

In building construction projects, deviations from planned schedules may arise from the interaction of various factors, including project planning and control, coordination among stakeholders, labor, materials, equipment, design changes, and external conditions. These factors may accumulate over time and cause project completion to exceed the established schedule. This study examined three case-study projects: the construction of the Mandalika Hospital Inpatient Building, the rehabilitation of the Islamic Center building, and the continuation of construction work on the University of Mataram Hospital (Wijayaningtyas et al., 2023).

Identifying the relative importance of these factors requires a decision-making approach capable of systematically comparing multiple criteria. The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making method used to determine the relative weight of each criterion through pairwise comparisons (Hartoyo, 2013; Saaty, 1993a) . In construction research, AHP has been widely applied to prioritize factors contributing to project delays. (Wijayaningtyas et al., 2023) demonstrated that project management was a high-priority factor, while (Rahman et al., 2024) highlighted the importance of risks associated with material procurement and work supervision. (Syaripudin, 2026) identified delays in material supply, stakeholder coordination, and design changes as factors influencing project delays, whereas (Lestiana et al., 2025) emphasized the role of labor-related factors in construction project delays (Ibrahim & Surya, 2019a; Jasril, 2013a; Salim et al., 2023).

Although AHP can generate relative importance weights for each factor, these weights do not directly indicate which project experiences the greatest degree of delay. Therefore, an additional method is required to evaluate the weighted criteria across multiple project alternatives. Simple Additive Weighting (SAW) is a multi-criteria decision-making method that normalizes criterion values and aggregates them after multiplication by their respective weights. (Gunawan & Priyono D, 2025) applied the SAW method to support a faster and more efficient priority-setting process for paper plan selection (Winanda et al., 2024). Meanwhile, (Ahmad et al., 2023) used the SAW method in a decision support system for selecting Child-Friendly Schools to improve the objectivity of the assessment process. These applications demonstrate that SAW can be used to generate preference scores and rank alternatives based on a defined set of criteria (Virgia, 2022).

This study addressed four research questions: which factors influence construction project delays; how these factors are prioritized and weighted using AHP; what the relative delay levels of the three projects are based on SAW; and how the dominant factors identified through AHP relate to the delay rankings generated by SAW (Ahmad et al., 2023). The objective was not to select an execution method, but rather to rank the relative severity of project delays and provide a technical interpretation of the factors underlying those rankings. Theoretically, this study contributes to the construction project management literature by integrating the Analytic Hierarchy Process (AHP) and Simple Additive Weighting (SAW) as a combined multi-criteria decision-making approach for analyzing delay factors and ranking the relative severity of project delays. Practically, the findings are expected to assist project owners, contractors, supervising consultants, and planning consultants in identifying priority factors contributing to delays and improving project planning, control, and coordination. For policymakers, the study provides input for improving regulations and practices related to construction project management. For academics and researchers, the study may serve as a

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reference for future research on multi-criteria decision-making applications in construction (Saaty, 1993b; Silalahi, 2013b; Subawa, 2015a).

METHOD

Reseach Design an Study Object

This study employed a quantitative descriptive approach within a multi-criteria decision-making framework. The analysis involved identifying delay factors, collecting respondent assessments, aggregating AHP data, constructing pairwise comparison matrices, determining criterion weights, testing consistency, developing the SAW decision matrix, normalizing the data, calculating weighted scores, and determining preference values. The study examined three state building projects in West Nusa Tenggara Province: the Islamic Center, the continuation of construction at the University of Mataram State University Teaching Hospital (RSPTN), and Mandalika Hospital.

Field conditions were used as supporting data for interpreting the analytical results. At Mandalika Hospital, the main issues included schedule extensions, progress deviations, labor shortages, inadequate field management, weak coordination, personnel turnover, and changes in the scope of work. At the Islamic Center, the main issues involved contract adjustments, payments for materials and equipment, dispute resolution, and revisions to the project duration. At the University of Mataram Hospital, the identified issues included additional work, material delays, price increases, discrepancies between the Detailed Engineering Design (DED) and actual site conditions, and delays in the approval of imported materials.

Respondent and Data Collection

The study population comprises stakeholders directly involved in the development of the three projects. Purposive sampling was employed to select respondents, as the research required informants possessing relevant experience and knowledge. A total of 12 respondents were selected, consisting of three Commitment-Making Officials (PPK), three executing contractors, three supervising consultants, and three planning consultants. Respondent criteria included prior or current involvement in building construction projects, relevant construction work experience, and/or holding a stra-tegic position such as director, technical expert, or Commitment-Making Official (PPK) (Jasril, 2013b; Syaripudin, 2026).

Primary data collection was conducted through field observations, questionnaires, and interviews. Questionnaires were used to obtain structured assessments, while interviews served to clarify the reasons and context behind dominant factors. Sec-ondary data were obtained from contract documents, progress reports, contract ad-denda or amendments, journals, similar studies, and literature. All data were com-piled and verified prior to analysis.

The AHP instrument employs a 1–9 pairwise comparison scale based on Saaty's scale. A value of 1 indicates that two elements are equally important, while values of 3, 5, 7, and 9 represent increasing levels of importance ranging from moderate to extreme. For intermediate values, compromise values such as 2, 4, 6, and 8 are used, while the opposite value is used when the element in the comparison column is more dominantInstrumen SAW menggunakan skala 1–5, A score of 1 indicated a very low level of influence, while a score of 5 indicated a very high level of influence. The SAW assessment was conducted for each project across 15 criteria. Thus, each respondent assessed all three project alternatives against all criteria in accordance with the research instrument design.

Data Prosessing Stage

Criteria were formulated as decision elements at a single level, with the primary objective of prioritizing delay factors. Each pair of criteria was compared by 12 respondents. Since the Analytic Hierarchy Process (AHP) utilizes ratio comparisons, group assessments were aggregated using the geometric mean to preserve the multi-plicative nature of the comparisons (Silalahi, 2013a) .

In the SAW phase, the average respondent ratings for each criterion and project serve as the decision matrix. These averages are calculated after grouping the data by project alternative. Attribute classification is determined based on the value's direction relative to the research objective. In this study, a higher score indicates a higher level of problems or delays. Since high scores are the conditions that one would want to identify as high levels of delay, all 15 criteria are treated as benefits. Consequently, there are no "cost" criteria in this study's matrix. This classification does not imply that a "benefit" attribute substantively represents a positive condi-tion; rather, it refers to a mathematical attribute within the SAW method indicating that a larger value translates into a higher preference value. Since the objective of the research is to determine the relative level of delay, the alternative with the largest V_i value is placed in the first rank, namely the project with the highest relative level of delay. This principle aligns with research findings that use the highest preference value as the basis for ranking.

RESULTS AND DISCUSSION

Identifikasi of Delay Criteria

Table 1. Delay criteria identified from literature and project conditions.

Code	Factor/Criteria	Group
C1	Lack of thorough schedule planning	Technical/Managerial
C2	Weak project control by the contractor	Managerial
C3	Ineffective coordination among contractor, consultant, and owner	Non-technical/Managerial
C4	Insufficient labor availability	Technical/Resources
C5	Low labor productivity	Technical/Resources
C6	Labor absenteeism or turnover	Technical/Resources
C7	Delays in material delivery	Technical/Materials
C8	Material quality not meeting specifications	Technical/Materials
C9	Fluctuating or unpredictable material prices	Financial/Materials
C10	Limited availability of construction equipment	Technical/Equipment
C11	Frequent equipment breakdowns	Technical/Equipment
C12	Delays in equipment mobilization/demobilization	Technical/Equipment
C13	Adverse weather conditions	External
C14	Design changes by the owner or consultant	Technical/Planning
C15	Government regulations or permitting issues	Non-technical/External

Source: Primary data, compiled by the researcher (2026)

The fifteen criteria were not established solely based on theory but were adapted to the conditions of the three case study projects. The identification process took into account project documents and respondent assessment results, ensuring that the criteria included in the model are relevant to the phenomenon of delays observed in the research subjects (Arifin, 2017; Hartoyo, 2013; Ibrahim & Surya, 2019b) .

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Pairwise Comparison Matrix and AHP Results

Table 2. Aggregated 15 × 15 pairwise comparison matrix

Code	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
C1	1,00	0,59	1,95	1,50	1,95	2,60	1,00	2,84	3,62	2,53	3,27	3,65	2,00	0,94	2,00
C2	1,70	1,00	2,38	2,71	3,19	4,39	1,94	4,21	5,57	3,49	5,05	5,34	2,79	1,55	3,62
C3	0,51	0,42	1,00	0,54	1,23	1,67	0,79	2,00	2,48	1,33	2,37	2,43	0,65	0,61	1,26
C4	0,67	0,37	1,86	1,00	1,19	1,89	0,68	1,41	2,14	1,41	2,00	2,00	1,00	0,44	1,41
C5	0,51	0,31	0,81	0,84	1,00	1,41	0,53	1,68	2,27	1,00	2,00	1,57	1,00	0,43	1,06
C6	0,39	0,23	0,60	0,53	0,71	1,00	0,40	2,66	1,19	1,50	2,66	0,53	0,56	0,30	0,71
C7	1,00	0,51	1,26	1,46	1,89	2,51	1,00	2,29	3,05	2,07	2,87	2,76	1,41	0,67	2,00
C8	0,35	0,24	0,50	0,71	0,59	0,38	0,44	1,00	1,33	1,00	1,06	0,65	0,56	0,29	0,89
C9	0,28	0,18	0,40	0,47	0,44	0,84	0,33	0,75	1,00	0,66	1,26	1,00	0,43	0,22	0,59
C10	0,39	0,29	0,75	0,71	1,00	0,67	0,48	1,00	1,51	1,00	1,41	1,41	0,71	0,39	1,00
C11	0,31	0,20	0,42	0,50	0,50	0,38	0,35	0,94	0,79	0,71	1,00	1,00	0,50	0,26	0,50
C12	0,27	0,19	0,41	0,50	0,64	1,88	0,36	1,55	1,00	0,71	1,00	1,00	0,44	0,24	0,71
C13	0,50	0,36	1,53	1,00	1,00	1,78	0,71	1,78	2,34	1,41	2,00	2,29	1,00	0,53	1,00
C14	1,06	0,65	1,64	2,29	2,31	3,28	1,50	3,43	4,50	2,53	3,88	4,09	1,89	1,00	2,53
C15	0,50	0,28	0,79	0,71	0,94	1,41	0,50	1,12	1,70	1,00	2,00	1,41	1,00	0,39	1,00
Total	9,44	5,80	16,31	15,46	18,59	26,09	11,01	28,68	34,50	22,36	33,83	31,13	15,94	8,28	20,28

Source: Primary data, compiled by the researcher (2026)

The matrix in Table 2 represents the aggregation of responses from 12 participants using the geometric mean. Mathematically, the diagonal elements have a value of 1 and the opposite elements satisfy the reciprocal property. Variations in values across pairs indicate differing perceptions regarding the level of importance; however, the matrix remains valid for use following a consistency test.

Table 3. AHP priority weights and ranking

Code	Weight	Rank
C2	0.168	1
C14	0.122	2
C1	0.106	3
C7	0.090	4
C4	0.066	5
C13	0.064	6
C3	0.063	7
C5	0.054	8
C15	0.050	9
C6	0.044	10
C10	0.044	11
C12	0.035	12
C8	0.035	13
C9	0.029	14
C11	0.029	15

Source: Primary data, compiled by the researcher (2026)

The weighting results indicate that the structure of importance is concentrated on a few key factors. The top four factors C2, C14, C1, and C7 have a cumulative weight of about 0.486 or 48.6% of the total weight. C2 holds a weight of 0.168, meaning that any change in its normalized value exerts the greatest relative influ-ence on the aggregate SAW score. This result aligns with the nature of delays, which often occur in a chain reaction: weak controls can allow progressive deviations to escalate; design changes can alter work sequences; poorly formulated schedules can result in unrealistic baselines; and material delays can halt activities dependent on those materials.

The consistency test yielded a CI of 0.0205 and a CR of 0.0130. Since the CR is less than 0.10, the group assessment matrix is deemed consistent. Consequently, the AHP weights can be transferred to the SAW stage as a preference weight vector

SAW Attribute Classification and Decision Matrix

Table 4. SAW benefit/cost classification.

Code	Interpretation of scores 1–5	Atribut
C1	The higher it is, the worse it is.	Benefit
C2	The higher it is, the worse it is.	Benefit
C3	The higher it is, the worse it is.	Benefit
C4	The higher it is, the worse it is.	Benefit
C5	The higher it is, the worse it is.	Benefit
C6	The higher it is, the worse it is.	Benefit
C7	The higher it is, the worse it is.	Benefit
C8	The higher it is, the worse it is.	Benefit
C9	The higher it is, the worse it is.	Benefit
C10	The higher it is, the worse it is.	Benefit
C11	The higher it is, the worse it is.	Benefit
C12	The higher it is, the worse it is.	Benefit
C13	The higher it is, the worse it is.	Benefit
C14	The higher it is, the worse it is.	Benefit
C15	The higher it is, the worse it is.	Benefit

Source: Primary data, compiled by the researcher (2026)

Table 4 shows that all criteria fall under the category of "benefit attributes" with-in the mathematical context of the SAW method. This classification must be clearly stated to avoid misinterpreting the term "benefit." In this context, "benefit" does not imply that the factor is advantageous to the project itself; benefit simply means that the higher the problem score, the higher its contribution to the research objective, namely identifying projects with higher relative delay rates.

Table 5. SAW decision matrix based on mean respondent scores.

Code	RS Unram	RS Mandalika	Islamic Center	Atribut	Weight
C1	2.833	3.500	3.417	Benefit	0.106
C2	2.583	3.917	3.583	Benefit	0.168
C3	2.833	3.750	3.417	Benefit	0.063
C4	2.750	3.833	3.417	Benefit	0.066
C5	2.917	3.917	3.333	Benefit	0.054
C6	2.500	3.833	3.083	Benefit	0.044
C7	3.667	3.667	3.333	Benefit	0.090
C8	2.500	2.833	2.500	Benefit	0.035
C9	3.417	2.917	2.750	Benefit	0.029
C10	2.750	3.250	3.833	Benefit	0.044
C11	2.500	2.583	2.750	Benefit	0.029
C12	2.667	3.083	3.583	Benefit	0.035
C13	2.333	2.667	2.583	Benefit	0.064
C14	3.917	3.917	3.250	Benefit	0.122
C15	2.167	2.833	3.833	Benefit	0.050

Source: Primary data, compiled by the researcher (2026)

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The decision matrix reveals distinct patterns across the projects. Mandalika Hos-pital scored relatively high on several management and resource factors, including C2, C3, C4, C5, and C6. Mataram University Hospital scored high on C7 and C14, while the Islamic Center showed high scores on C10, C12, and C15. These differ-ences are significant because the SAW method does not simply seek the project with the highest scores across all criteria; instead, it aggregates the values after applying AHP weights. The data in this matrix is derived from the average assessment scores for each project.

Table 6. Normalized SAW decision matrix.

Code	RS Unram	RS Mandalika	Islamic Center
C1	0.810	1.000	0.976
C2	0.660	1.000	0.915
C3	0.756	1.000	0.911
C4	0.717	1.000	0.891
C5	0.745	1.000	0.851
C6	0.652	1.000	0.804
C7	1.000	1.000	0.909
C8	0.882	1.000	0.882
C9	1.000	0.854	0.805
C10	0.717	0.848	1.000
C11	0.909	0.939	1.000
C12	0.744	0.860	1.000
C13	0.875	1.000	0.969
C14	1.000	1.000	0.830
C15	0.565	0.739	1.000

Source: Primary data, compiled by the researcher (2026)

Since all criteria represent benefits, the value of each project is divided by the maximum value for the same criterion. Normalization eliminates scale differences while preserving the relative positions of the projects. A value of 1,000 indicates that the project is the alternative with the highest score for that criterion.

Table 7. Weighted contributions and final SAW preference values

Code	RS Unram	RS Mandalika	Islamic Center
C1	0.086	0.106	0.103
C2	0.111	0.168	0.153
C3	0.048	0.063	0.058
C4	0.048	0.066	0.059
C5	0.040	0.054	0.046
C6	0.029	0.044	0.035
C7	0.090	0.090	0.082
C8	0.031	0.035	0.031
C9	0.029	0.025	0.023
C10	0.031	0.037	0.044
C11	0.026	0.027	0.029
C12	0.026	0.030	0.035
C13	0.056	0.064	0.062
C14	0.122	0.122	0.101
C15	0.028	0.037	0.050
TOTAL	0.802	0.969	0.913

Based on Table 7, it is evident that the contribution of each criterion varies across the three projects. This variation indicates that each project presents a unique set of issues; consequently, a factor that is dominant in one project does not necessarily contribute to the same extent in another. This distinction is significant because construction project delays generally stem not from a single factor, but rather from the interplay of technical, managerial, resource, and material factors, as well as changes in the scope of work and other external influences.

These values serve as the basis for ranking the three projects according to their level of delay, thereby identifying the project with the highest relative delay based on the combination of criterion weights and actual conditions assessed by the respondents. The ranking is established by ordering the preference values from highest to lowest. In the context of this study, this ranking indicates the relative level of delay; thus, the alternative with the highest preference value is assigned the top rank, representing the project with the most severe delay.

Table 8. Final ranking of relative project delay

Project	**Preference V**	**Rank**
RS Mandalika	0.969	1
Islamic Center	0.913	2
RS Universitas Mataram	0.802	3

Source: Primary data, compiled by the researcher (2026)

Based on the ranking results, Mandalika Hospital ranked first with a preference value of 0.969. This result indicates that Mandalika Hospital exhibited the highest relative level of delay compared to the Islamic Center and Mataram University Hospital, based on the combination of the 15 factors analyzed (Silalahi, 2013a) . This ranking was not determined by a single criterion but resulted from the aggregation of all criteria, accounting for their respective levels of importance as defined by AHP weights.

These results strongly correlate with the actual conditions of the Mandalika Hospital project's execution. The project underwent multiple extensions to its execution period and showed significant progress deviations. Furthermore, issues arose regarding a shortage of field managers and labor, suboptimal coordination, and frequent turnover of foremen and lead craftsmen. Such conditions can render work control processes less effective, as instructions and work targets must be repeatedly communicated to new personnel. These issues subsequently impacted the contractor's ability to catch up on work progress in accordance with the established schedule.

The Islamic Center’s second-place ranking, with a preference value of 0.913, indicates a high relative level of delay, albeit lower than that of Mandalika Hospital. This situation can be attributed to changes in the scope of work and contract value, the addition of materials and equipment, the resolution of contract disputes, and multiple adjustments to the execution period. These changes demonstrate significant dynamic shifts during the project's contract term, particularly regarding scope modifications and schedule adjustments.

Meanwhile, Mataram University Hospital obtained a preference value of 0.802, placing it third. This ranking indicates that, based on the 15 analyzed factors, the project's relative level of delay was lower than that of the other two projects. However, this result does not imply that Mataram University Hospital was free from delay-related issues. The project still faced challenges such as additional work, delayed material deliveries, price increases,

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discrepancies between the Detailed Engineering Design (DED) and existing site conditions, and the approval process for imported materials. While these factors contributed to delays, their aggregate effect resulted in a lower preference value compared to Mandalika Hospital and the Islamic Center.

Technical Interpretation of the AHP–SAW Relationship

The research results reveal that the pattern for the Mandalika Hospital project shows a strong correlation with the dominant AHP factors. Factor C2 contributed 0.168 to the Mandalika project, followed by C14 (0.122), C1 (0.106), and C7 (0.090); these four factors combined account for a contribution of approximately 0.486. This figure indicates that the group of factors with the highest AHP weights constitutes a sub-stantial portion of the Mandalika project's preference value. Technically, this aligns with actual site conditions, which were characterized by weak controls, progress deviations, labor shortages, a lack of field managers, suboptimal coordination, turn-over of foremen or lead craftsmen, and changes in the scope of work (Simanungkalit et al., 2023) .

The Islamic Center project exhibits a different pattern. While C14 contributed 0.101, the project showed relatively high contributions from factors C10, C12, and C15. Issues such as scope changes, the addition of materials or equipment, dispute resolution, and adjustments to the project timeline suggest that delays stemmed from multiple concurrent mechanisms. As its total contribution value was lower than that of the Mandalika project, it ranked second.

The University of Mataram Hospital project showed high contributions from fac-tors C7 (0.090), C14 (0.122), and C2 (0.111). Field conditions in the form of materi-al delays, additional work, price increases, DED discrepancies with existing ones, and approval of imported materials show that the project also experienced important factors. However, its total contribution value of 0.802 was lower. Consequently, a third-place ranking does not imply the project was free from delays; rather, it indi-cates a lower relative level of delay compared to the other two alternatives within the 15-criterion framework used.

From a decision-making perspective, these results demonstrate that AHP and SAW do not function as isolated, independent analyses. AHP serves as the mecha-nism for prioritizing factors, while SAW acts as the mechanism for aggregating project conditions (Subawa, 2015b) . The consistency of the results is reinforced when high-weight factors contribute significantly to projects that empirically show indications of more severe delays.

CONCLUSION

This study identified 15 factors representing project management, planning, coordination, labor, materials, equipment, weather, design changes, and regulatory or permitting issues as criteria for analyzing the severity of delays across three building construction projects in West Nusa Tenggara Province. The criteria were established through a literature review and adjusted to actual project conditions, ensuring that the analytical model was grounded in the empirical context rather than being purely theoretical. The AHP results identified four highest-priority factors: C2, weak project control by the contractor (0.168); C14, design changes initiated by the owner or consultant (0.122); C1, inadequate schedule planning (0.106); and C7, delays in material delivery (0.090). Together, these four factors accounted for approximately 48.6% of the total weight. The Consistency Index (CI) of 0.0205 and Consistency Ratio (CR) of 0.0130 indicated that the pairwise comparison matrix met the consistency requirement, allowing the resulting weights to be used in the subsequent SAW analysis.

The SAW method generated preference values of 0.969 for Mandalika Hospital, 0.913 for the Islamic Center, and 0.802 for Mataram University Hospital. Under the benefit-criterion approach applied in this study, a higher preference value represented a higher relative level of delay. Accordingly, Mandalika Hospital ranked first, followed by the Islamic Center and Mataram University Hospital. These results reflected the aggregated contribution of all 15 criteria rather than the influence of a single factor. The integration of AHP and SAW was evident in the use of AHP-derived criterion weights within the SAW preference calculations, while the extent to which each project was affected by the weighted criteria determined its final preference score. Mandalika Hospital received substantial contributions from several high-priority factors simultaneously, which was consistent with field evidence of progress deviations, schedule extensions, labor shortages, weak project control, insufficient field management, and coordination problems. Consequently, the SAW ranking provided quantitative support for the conclusion that Mandalika Hospital experienced the highest cumulative relative delay among the three case-study projects.

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