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DESIGN OF A CONSTRUCTION PROJECT RISK MONITORING AND CONTROL FRAMEWORK THROUGH A SYNTHESIS OF LITERATURE AND PRACTICE

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ABSTRACT

Construction projects operate under high uncertainty and remain vulnerable to cost, time, quality, and occupational safety issues. Although risk management is commonly applied, risk monitoring and control in practice often remain fragmented, with indicator tracking, follow-up actions, and reporting not always connected in a clear operational flow. This study aims to develop an initial design of a construction project risk monitoring and control framework that is practical, systematic, and easy to implement. The study adopts a design-study approach using secondary data derived from international standards and guidelines, scientific literature, and Indonesian construction risk management references, which were synthesized to identify the key process, information, and tool requirements of the framework. The proposed design integrates an iterative monitoring and control workflow, structured risk information including Early Warning Signs (EWS), Key Risk Indicator (KRI) grouping, metrics and thresholds, and action effectiveness evaluation, as well as semi-automated spreadsheet-based tools to support risk recording, evaluation, updating, and reporting. The contribution of this study lies in translating risk monitoring and control principles into a connected operational design that can support more consistent, traceable, and system-based project risk management practice. As a literature- and practice-based initial design, this framework is intended to serve as a foundation for further expert validation and implementation in construction projects.

Keywords: *Construction Project; Early Warning Signs; Framework Design; Key Risk Indicator; Risk Monitoring and Control.*

1. INTRODUCTION

Construction projects operate in dynamic environments filled with uncertainty, making risk management a crucial knowledge area to ensure project objectives are achieved. Risk management is a systematic process to identify, analyze, respond to, and monitor and control uncertainties so that positive opportunities can be maximized and negative impacts minimized [1], [2], [3].

However, in practice, the risk monitoring and control stage often becomes a weak point. A systematic review on risk monitoring and control reported that fewer than 15 studies were identified during 2011–2015, and the number declined to around five studies after 2015, indicating that this topic has received relatively limited attention in project management research [4]. At the same time, the practical consequences of weak project control remain substantial in Indonesia. For example, a study of 70 Indonesian toll road projects reported cost overruns ranging from –34.43% to 356.54%, with an average of 14.83% [5]. These conditions suggest that the challenge extends beyond identifying risks at the beginning of a project, and also concerns how monitoring can be sustained, how response effectiveness

can be evaluated, how newly emerging risks can be detected, and how updated risk status can be communicated in a structured and traceable manner.

Various guidelines have offered improvement alternatives such as SOPs/checklists, periodic evaluation-reporting meetings, audits/inspections, and system/software support. [6], [2], [1], [7] emphasize iterative monitoring-review, recording-reporting, risk tracking, monitoring of response implementation, identification of new risks, and evaluation of treatment effectiveness. In the Indonesian construction context, risk monitoring and control practice is also reflected in formal documents and systems used by [8], [7], [9], [10], which generally emphasize the use of risk registers or risk profiles as the main risk documents, periodic monitoring, follow-up of control actions, evaluation of control effectiveness, and periodic reporting. Even so, these standards and organizational references still tend to remain principle-oriented, and they do not yet explain in a sufficiently connected way how project teams can integrate monitoring data, early warning interpretation, follow-up decisions, risk updates, and reporting into one implementable workflow. A similar concern is also reflected in audit and oversight reports outside the project management literature, which continue to highlight weaknesses in construction management, documentation, and control processes [11], [12].

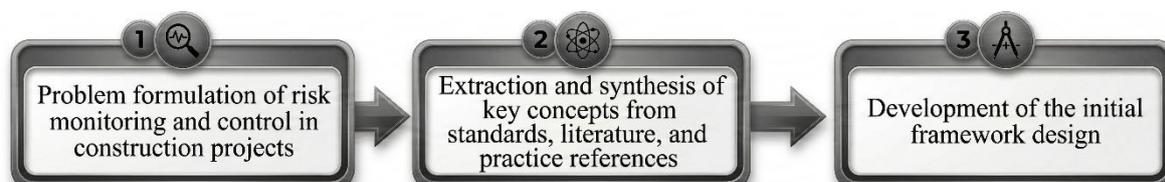
Against this background, this study designs an initial risk monitoring and control framework that unifies the process into a single connected decision flow: updating the risk register, monitoring indicators (KRI/EWS), evaluation, determining follow-up actions and improvements, managing new, secondary, and residual risks, reassessment, and finally reporting and lessons learned. The framework emphasizes proactive monitoring through early warning [13], [14], [8] as well as the use of KRIs as quantitative measures of risk tolerance. In this way, the study translates monitoring and control principles into an integrated workflow, structured indicator information, and semi-automated spreadsheet-based tools, so that the process becomes more systematic, traceable, and implementable in construction project practice. Rather than merely restating general guidance, the study is directed toward showing how these principles can be organized into work steps, required information, and traceable outputs at the project level.

Accordingly, this study presents an initial construction project risk monitoring and control framework developed through a synthesis of literature and practice, as a basis for implementing monitoring and control that is more operational, consistent, documented, and system-based.

2. RESEARCH METHOD

This study adopts a design-study approach because the research focus is to develop a solution design to address practical problems, rather than to test the framework in the field at this stage. The design was developed through the synthesis of standards, scientific literature, and guidelines relevant to construction project risk management.

As shown in Figure 1, the study was conducted in three main steps. First, the practical problem of risk monitoring and control in construction projects was formulated based on the need for a more consistent and operational approach. Second, key concepts were extracted and synthesized from the selected standards, literature, and practice references. Third, these extracted concepts were translated into the initial framework design in the form of an integrated monitoring and control workflow, a structured risk indicator information layer, and semi-automated spreadsheet-based implementation tools.



Source: Author's Processing (2026)

Figure 1. Research Stages

The data used in this study are secondary data drawn from three reference groups: (1) international standards and guidelines, (2) scientific literature, and (3) Indonesian guidelines and practice references. These reference groups were used to ensure that the proposed design aligns with general risk management principles, is supported by scientific findings, and remains relevant to practical implementation needs in the Indonesian construction context. To make the basis of source selection explicit, Table 1 summarizes the reference groups, the selection criteria applied to each group, the selected core reference documents, the number of selected core references, and the main extracted outputs used in the framework development process. The selected sources focused on references that explicitly discuss risk monitoring and control processes, monitor-risks logic, early warning and key risk indicators, metrics and thresholds, effectiveness evaluation, reassessment, and reporting or documentation practices relevant to construction projects.

Table 1. Main Reference Sources in Framework Development

Reference group	Selection criteria	Selected reference documents	Number of selected core references	Main extracted outputs
International standards and guidelines	References explaining general risk management principles and monitor-risks logic, especially monitoring, review, risk updating, and reporting processes	ISO 31000 (2018); PMBOK Guide (2017); APM Body of Knowledge (2012)	3	Monitoring and review logic; risk updating; reporting and documentation principles
Scientific literature	Studies explicitly discussing risk monitoring and control, KRI, EWS, thresholds, effectiveness evaluation, reassessment, implementation barriers, or operational practices in construction projects	Cakmak & Texel (2019); Almutahir & Wiguna (2024); Hillson (2017); Aven (2016); Zwikael & Ahn (2011); Obondi (2022)	6	Indicator concepts; early warning logic; thresholds; effectiveness evaluation; implementation barriers; operational needs
Indonesian guidelines and practice references	References reflecting governance, documentation, and monitoring practices used in the Indonesian construction context	BPKP (2018); Kementerian PUPR (2024); Hutama Karya (2024); Adhi Karya (2024)	4	Risk documentation structure; periodic monitoring practices; follow-up of control actions; evaluation and reporting requirements

Source: Author's Processing (2026)

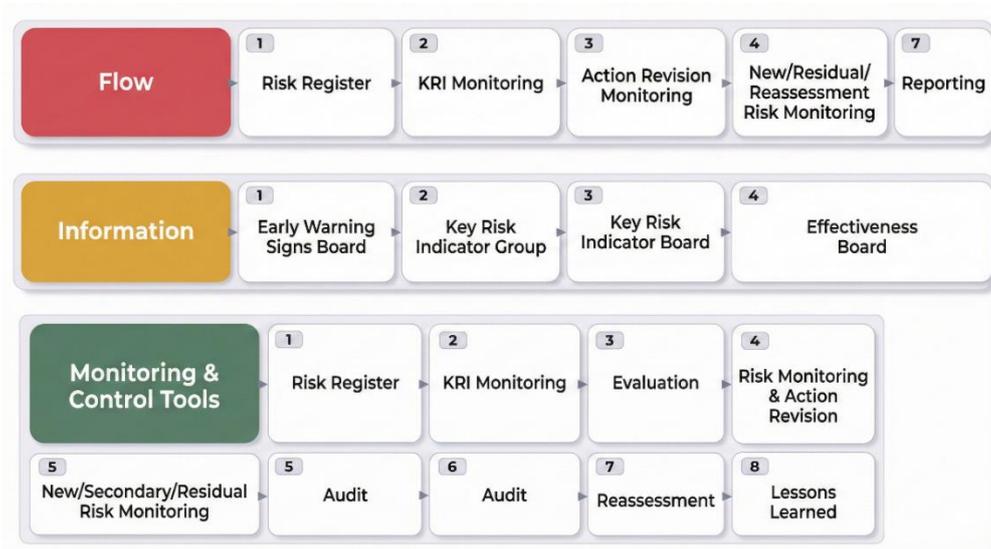
The synthesis process was therefore not limited to summarizing literature, but was directed toward transforming selected concepts and practical references into connected framework elements. The workflow element was derived from the logic of monitoring identified risks, tracking response implementation, identifying new risks, evaluating effectiveness, and updating risk information. The information element was derived from the need to make monitoring measurable and operational through components such as Early Warning Signs (EWS), Key Risk Indicators (KRI), metrics, triggers, thresholds, and reassessment criteria. The tools element was derived from the need to operationalize these components into spreadsheet-based modules that support consistent recording, evaluation, updating, and reporting.

Accordingly, this methodology provides the basis for developing an initial framework design consisting of a connected workflow, structured indicator information, and implementation tools that can support more operational, consistent, and documented risk monitoring and control in construction projects.

3. RESULT AND DISCUSSION

3.1. Result

The proposed framework consists of three interrelated layers: an iterative monitoring and control workflow, a structured risk indicator information layer, and semi-automated spreadsheet-based implementation tools [2], [1], [7]. This arrangement was selected because weaknesses in practice do not arise solely from the absence of risk documentation, but also from the lack of connection between monitoring activities, indicator interpretation, follow-up decisions, risk updating, and reporting [15], [7], [8]. The proposed framework design is shown in Figure 2 to illustrate the relationship between the monitoring and control process, the indicators monitored, and the outputs generated.



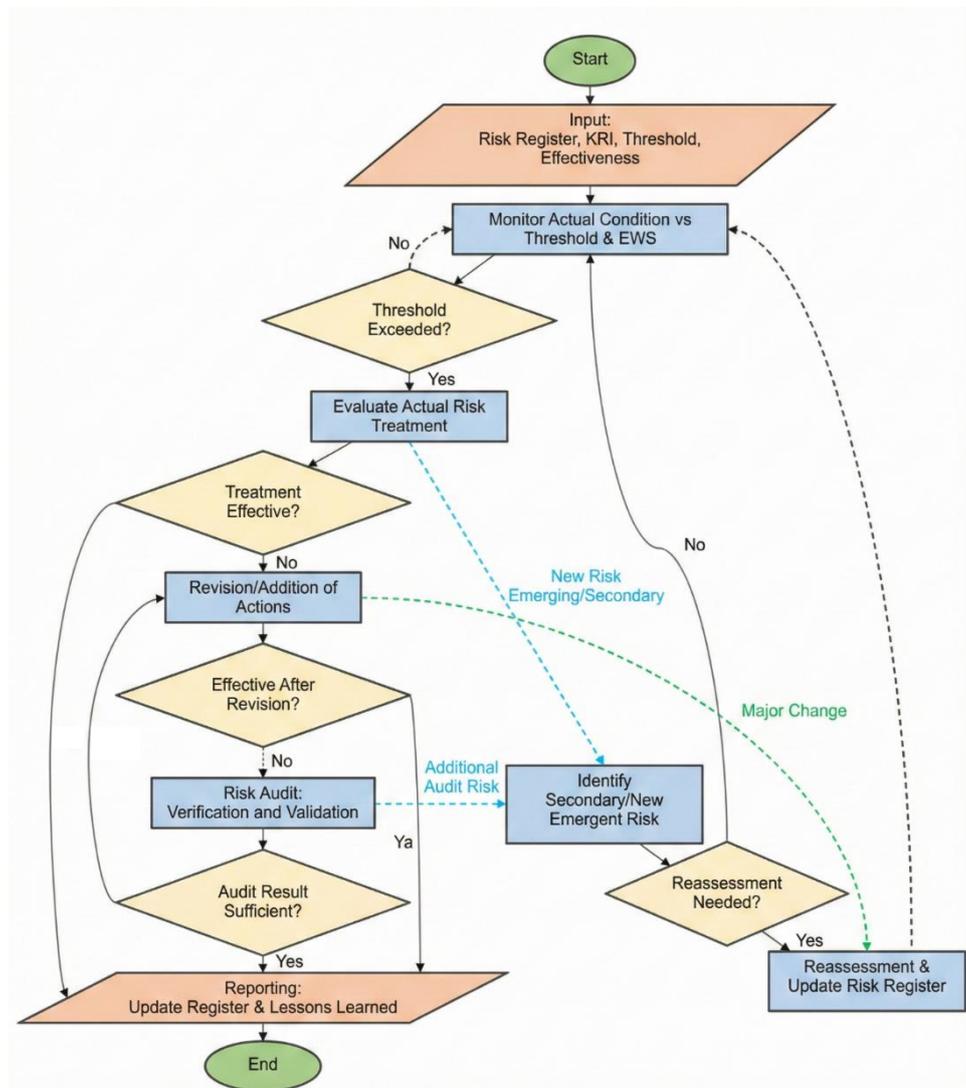
Source: Author's Processing (2026)

Figure 2. Proposed Construction Project Risk Monitoring and Control Framework Based On Literature and Practice

Figure 2 shows that monitoring does not stop at recording, but is directed to generate periodic status evaluations, follow-up actions, risk data updates, and reporting summaries [2], [1], [7]. The initial framework was derived from the monitor risks logic that includes risk tracking, response monitoring, identification of new risks, effectiveness evaluation, and updating risk documents [2], [1]. In this framework, these elements are not presented as separate activities, but are organized into a connected operational cycle so that monitoring outputs can be translated into decisions and updates more consistently [15], [7]. The operational workflow was also shaped by the need for early warning, effectiveness evaluation, updating of the risk database, and accountable risk status reporting [7], [8], [1].

The workflow layer consists of several main components. The risk register and its updating function were retained as the backbone of risk documentation, because monitoring results must be reflected in the current risk record [2], [1], [7]. KRI/EWS monitoring was included to support proactive detection of changing conditions through measurable indicators and early signals [13], [14], [8]. Action

effectiveness evaluation was incorporated because monitoring is not complete if actions are only recorded without assessing whether they actually reduce risk exposure [2], [7], [17]. New, secondary, and residual risks, together with reassessment, were included because project conditions may change during execution and risk profiles cannot be assumed to remain static [1], [18]. Dashboard, reporting, and lesson learned functions were retained to support escalation, accountability, and organizational learning [7], [8], [1]. Each of these components was therefore included on a functional basis, not merely as an additional procedural step, so that the framework can support continuity from monitoring to follow-up, updating, and learning [2], [1], [15].



Source: Author's Processing (2026)

Figure 3. Risk Monitoring and Control Workflow in The Proposed Framework

Figure 3 summarizes the connected decision flow of the framework. With this workflow, indicator monitoring results can be directly translated into risk status and follow-up decisions, then traced through data updates and implementation records [2], [1], [7]. Compared with fragmented monitoring practices, this arrangement is intended to ensure that monitoring outputs do not end at observation, but continue to evaluation, corrective response, updating of risk information, and reporting [2], [1], [8]. In this way, the framework supports greater traceability across monitoring periods and provides a clearer basis for escalation, action revision, and reassessment [1], [7], [15].

To make the workflow operational, the framework also defines a structured risk indicator information layer. The indicator information structure includes an EWS database, KRI grouping, KRI metrics and thresholds, and action effectiveness evaluation [13], [14], [7]. This layer is essential because a monitoring process can only function consistently when the required information is defined in advance, standardized, and linked to decision rules [1], [2]. The Early Warning Signs (EWS) database is used to standardize early signs so that detection does not rely solely on intuition. The minimum content includes a description of the early sign, observation method, data source, recording PIC, and monitoring frequency [8], [7]. EWS is derived from the monitoring objective of providing early warning and ensuring the effectiveness of risk handling before impacts escalate [13], [8]. The literature also emphasizes EWS as a leading indicator that helps predict potential problems earlier than indicators that tend to be reactive [14], [11].

KRI grouping is derived from the concept that KRIs are measurable indicators that show a project’s position relative to risk tolerance, enabling proactive control [13], [8]. This principle is aligned with governance practices that require indicators for proactive risk monitoring [7], [8]. KRI metrics and thresholds are required to ensure consistent interpretation of risk conditions. Triggers and thresholds transform KRI/EWS into consistent decision metrics so that follow-up actions do not depend only on perception but on monitoring data [2], [14], [1]. The green-yellow-red status is adopted as a standardized interpretation of conditions to facilitate escalation and action recommendations [7], [8]. The effectiveness component is explicitly retained because the framework is not limited to showing whether a risk is being monitored, but also whether the selected response remains adequate [2], [17], [7]. For consistency, the term effectiveness board is used to refer to the evaluation of mitigation effectiveness.

Table 2. Risk Indicator Information Structure and Its Role in Monitoring and control

Information element	Stored data content	Required outputs	Main function
EWS database	List of early signs, observation method, data source, checking frequency	List of EWS by risk/category	Early detection before impacts occur
KRI grouping	List of KRIs by category and priority	List of priority KRIs by category	More focused monitoring
KRI metrics & thresholds	Metric definition, formula, unit, normal/alert/critical limits	Indicator status + action trigger	Faster and more consistent decisions
Effectiveness board	List of actions, implementation status, results, effectiveness rating, recommendations	Effective/moderately effective/not effective + revision	Ensures controls actually work

Source: Author’s Processing (2026)

Table 2 shows that each information element supports a different monitoring function. The EWS database supports early detection before impacts occur, KRI grouping supports more focused monitoring, KRI metrics and thresholds support faster and more consistent decision making, and the effectiveness board supports evaluation of whether controls actually work [13], [7], [8]. Accordingly, the strength of this layer lies not in the quantity of stored information, but in its role in reducing subjectivity and improving consistency across monitoring cycles [1], [2].

To enable routine and well-documented implementation, the design is also equipped with semi-automated spreadsheet-based tools. The tools help the project team enter site data, calculate indicators, display risk status, record follow-up actions, and prepare reporting summaries. Semi-automated means some outputs are generated automatically, while the main inputs still come from the user [7], [8]. These tools were selected not merely as a software preference, but because many project monitoring activities

are operationalized through working sheets, forms, and tabular records. Organizing them into linked spreadsheet modules provides a practical way to improve consistency and traceability without requiring a complex information system [7], [9], [10].

Table 3. Semi-Automated Spreadsheet Tools and Generated Outputs

Tools	Main inputs	Main outputs	Role
Risk Register	Risk list, initial level, PIC	Updated risk database	Source of risk data and status
KRI Monitoring	KRI values per period, EWS notes	Indicator recap per period	Monitoring evidence (values and early signs)
Risk Evaluation	Indicator recap + thresholds	Normal/alert/critical status	Basis for control decisions
Action Revision	Ongoing actions, effectiveness results	New/revised actions + targets	Adaptive control
New/Secondary Risks	New risk findings, risks due to actions	List of new/secondary risks	Keeps the risk register relevant
Risk Audit	Input completeness, schedule compliance	Audit findings + improvements	Ensures process discipline
Reassessment	Major project changes	Latest risk level	Adjusts priorities
Dashboard	Status summary, indicator trends	Priority & trend view	Supports management decisions
Reporting	Dashboard summary + action list	Concise risk report	Risk communication
Lesson Learned	Action outcomes & lessons	Improvement recommendations	Project learning

Source: Author’s Processing (2026)

Table 3 shows that each tool is linked to a specific purpose and output within the monitoring cycle. The Risk Register functions as the source of risk data and status, KRI Monitoring provides monitoring evidence through indicator values and early signs, Risk Evaluation supports control decisions, Action Revision supports adaptive control, New/Secondary Risks and Reassessment keep the risk database relevant, Risk Audit supports process discipline, Dashboard supports management decisions, Reporting supports risk communication, and Lesson Learned supports project learning [2], [7], [8]. The practical advantage of this arrangement is that each module does not stand alone; instead, outputs from one sheet become the basis for evaluation, revision, reassessment, or reporting in the next sheet [15], [7].

To illustrate the implementation form of the tools layer, example views of the semi-automated spreadsheet tools are shown in Figures 4–6. Figure 4 presents the database and monitoring components, Figure 5 presents risk changes and process control, and Figure 6 presents management outputs and learning documentation. These figures show that the framework is designed not only to record risk conditions, but also to maintain continuity from monitoring, evaluation, and updating to managerial communication and organizational learning [1], [7], [8].

Risk ID	Monitoring Date	KRI	Threshold			Actual Value	Color Status	Next Step
			Safe	Warning	Danger			
Auto	Fill in according to the monitoring date	Select one KRI measurement metric from the dropdown list below (see guidance on the sheet.	Auto	Auto	Auto	Auto-filled with the actual calculation result	Auto	Auto
R1		Schedule Performance Index				0.7	Safe	2_KRI_Monitoring
		Schedule Performance Index (SPI)						
		Finish Date Variance (FDV)						
		Critical Path Completion Rate						
		Labor Productivity Index (LPI)						
		Overall Equipment Effectiveness (OEE)						
		Key Labor Fulfillment Rate						
		Equipment Availability / Uptime						
		Critical Material Availability Rate						
		RFI Cycle Time (Average)						
		On-Time Document Approval Rate						
		Team Communication Quality Index						
		Frequency of Effective Coordination Meetings						

Risk ID	Evaluation	Previous Color	Before Value	Response	Current Color	After Value	Effectiveness	Revised?	Next Step
Auto	Fill in according to the evaluation date	See KRI Board	Fill in according to the actual condition	Fill in according to the actual condition	See KRI Board	Fill in according to the actual condition	Auto	Select whether corrective action has been implemented or not	Auto
R1		Yellow	3		Green	1	Effective	No	9_Pelaporan

Risk ID	Revision Source	Revision Date	New Action	Person in Charge	Target Date	Major Change?	Implementation Status	Next Step
Auto	Enter the source of improvement suggestions (from Evaluation/Audit)	Enter the actual condition	Select Yes/No (see guidance on the Change Board sheet)	Select one from the dropdown list	Auto			
	Evaluation					Yes	Implemented	7_Reassessment
	Evaluation							
	Audit							

Source: Author’s Processing (2026)

Figure 4. Sequence Of Semi-Automated Spreadsheet Tool Views (part 1: database and monitoring)

Figure 4 shows how the initial risk data recorded in the Risk Register become the basis for KRI monitoring and evaluation. The sequence indicates that monitoring data can generate risk status and trigger documented follow-up [2], [7]. What is important in this part is not only the existence of individual sheets, but the linkage among them, which allows monitoring evidence to be translated into action and recorded consistently [15], [8]. To clarify how each component of the semi-automated spreadsheet tool is practically used during project execution, the following section outlines the step-by-step inputs and corresponding next steps for each tool component within the risk monitoring and control workflow.

1) Risk Register

Steps

- Fill in the white columns: ID, description, category, work item, cause, impact, EWS, action plan, PIC.
- Determine the initial probability–impact value (based on project data/Risk Heatmap) and risk status.
- Check the grey (automated) columns such as risk level/status and recommendations.

Next Step

- Active → proceed to the monitoring process (indicator setting/KRI monitoring).
- Closed → go to Dashboard → Lesson Learned.
- Escalated → follow the project escalation mechanism.

2) KRI Monitoring

Steps

- Ensure the Risk ID appears automatically from the Risk Register.
- Enter the monitoring date and select the KRI indicator (dropdown).
- Enter the actual KRI value based on site realization and select the color status (safe/alert/danger).

Next Step

- Safe → continue routine monitoring in KRI Monitoring.
- Alert/Danger → proceed to Evaluation.

3) Evaluation

Steps

- The Risk ID is filled automatically from KRI Monitoring/Action Revision.
- Enter the evaluation date, the color status before–after, and the action taken.
- Check the automatic effectiveness and fill in the “revised?” status (yes/no).

Next Step

- Effective/Highly effective → Reporting.
- Moderately effective/Not effective & not yet revised → Action Revision.
- Not effective & already revised → Audit.

4) Action Revision

Steps

- The Risk ID is filled automatically from Evaluation/Audit.
- Select the revision source, enter the revision date, the new action, the PIC, and the target time.
- Determine whether the change constitutes a major change (yes/no).

Next Step

- If a risk level update is needed → Reassessment (to update the risk score before returning to monitoring).

Through the sequence in Figure 4, recorded indicator data can produce risk status and drive documented follow-up. In addition to indicator monitoring, risks may evolve, requiring recording of new/secondary risks and checking process consistency. An example view of this part is shown in Figure 5.

Risk ID	Source of Occurrence	Risk Description	Impact	Impact Score	Probability	Probability Score	Updated Risk Score	Updated Risk Level	Initial Action Plan	Dominant Risk?	Added to Register?	Next Step
Enter the new risk code	Enter the risk source	Enter the actual condition	Enter the impact description	Enter the impact score (1-5; see Risk Heatmap)	Enter a description of the likelihood of occurrence	Enter the probability score (1-5; see Risk Heatmap)	Auto	Auto	Enter the initial action plan	Select Yes/No	Select Yes/No (already added to 1_Risk_Register or not)	Auto
R20	Response									No	Yes	1_Risk_Regist
	Response Failed											
	New Risk											
	Secondary Risk											

Risk ID	Audit Date	Audit Aspect	Audit Findings	Audit Result	Recommendation	Next Step
Auto	Fill in according to the actual condition	Fill in according to the actual condition	Fill in according to the actual condition	Enter the audit result	Fill in according to the actual condition	Auto
				New Risk Identified		5_Risiko_Baru
				Adequate		
				New Risk Identified		
				Follow-up Required		

Risk ID	Reason for Reassessment	Updated Probability	Updated Impact	Updated Risk Score	Updated Risk Level	Next Step
Auto	Enter the reason for reassessment	Enter the probability score (1-5; see Risk Heatmap)	Enter the impact score (1-5; see Risk Heatmap)	Auto	Auto	Auto
	Major Change					
	Major Change					
	New Risk Dominant					
	Response Failed Repeatedly					

Source: Author’s Processing (2026)

Figure 5. Sequence of Semi-Automated Spreadsheet Tool Views (part 2: risk changes and process control)

Figure 5 shows how the framework accommodates changing risk conditions through the identification of new, secondary, and residual risks, as well as through audit and reassessment [1], [18]. This part helps keep the risk list relevant and ensures that the monitoring process is conducted with discipline, especially when significant changes occur [7], [8]. This element distinguishes the framework from more static approaches, because it explicitly accommodates the dynamic nature of project risks and the possibility that controls may produce new consequences [1], [18].

5) New / Secondary / Residual Risks

Steps

- Enter the risk ID and select the emergence source (new risk/secondary/failed treatment).
- Enter the description, probability–impact (refer to the Risk Heatmap), and the initial action plan.
- Determine whether the risk is dominant and needs to be included in the register (yes/no).

Next Step

- Dominant & included in register → Reassessment.
- Not dominant but included in register → Risk Register.
- Not dominant & not included in register → return to KRI Monitoring.

6) Audit

Steps

- The Risk ID is filled automatically from Evaluation (that requires an audit).
- Enter the audit date, audit aspect, audit findings, and recommendations.
- Select the audit result (adequate/new risk identified/follow-up required).

Next Step

- Adequate → Reporting.
- New risk identified → New/Secondary/Residual Risks.
- Follow-up required → Action Revision.

7) Reassessment

Steps

- The Risk ID is filled automatically from Action Revision/New Risks.
- Select the reassessment reason, then enter the latest probability–impact (refer to the Risk Heatmap).
- Check the latest risk level as the reassessment result.

Next Step

- Reassessment result → Update Risk Register (latest probability–impact–level).

The section in Figure 5 helps keep the risk list relevant and ensures the monitoring process is conducted with discipline, especially when significant changes occur. To make monitoring results easy to understand for management and stakeholders, summaries and learning documentation are needed. Example views of summaries, reporting, and lessons learned are presented in Figure 6.



Source: Author's Processing (2026)

Figure 6. Sequence of Semi-Automated Spreadsheet Tool Views (Part 3: Management and Learning Outputs)

Figure 6 shows how monitoring results are translated into dashboard summaries, reporting outputs, and lesson learned documentation. As shown in this sequence, risk communication becomes faster, decisions are easier to trace, and project experience becomes input for improvement [7], [8], [1]. This closing stage is important because it ensures that monitoring and control are not treated only as operational checking activities, but also as a source of managerial communication and continuous improvement [1], [17].

8) Dashboard

Steps

- Use the summary view (mostly automated) to see the number/trend of risk statuses.
- Apply filters if needed for review/reporting purposes.
-

Next Step

- Dashboard output → used as input for Reporting and a summary of risk conditions.

9) Reporting

Steps

- The Risk ID is filled automatically from Risk Register/Evaluation/Audit.
- Enter the risk description and reporting date.
- Select the final status (active/closed/escalated) and effectiveness (effective/not effective).
-

Next Step

- Closed → go to Lesson Learned.
- Active → return to the monitoring cycle.
- Escalation → follow the project escalation mechanism.

10) Lesson Learned

Steps

- Fill in all columns manually: critical issue, root cause, actual impact, corrective/preventive actions.
- Document the lessons as a reference for future improvements.

Next Step

- Serves as an organizational learning basis for improving risk monitoring & control in subsequent projects.

As shown in Figure 6, risk communication becomes faster, decisions are easier to trace, and project experience becomes input for improvement. The sequence of views shows that the tools are interconnected following the monitoring and control workflow. The linkage between the process, indicators, and tools is summarized in Table 4.

Table 4. Linkage Matrix of Workflow–Indicator Information–Tools (Framework Core)

Workflow stage	Key information	Main tools	Periodic outputs
Define priority risks	Risk list + priorities	Risk Register	Priority risk list
Define indicators	EWS, KRI grouping	EWS database & KRI list	Priority indicator list
Routine monitoring	KRI values, EWS notes	KRI Monitoring	Indicator recap
Condition evaluation	Thresholds, indicator status	Risk Evaluation	Normal/alert/critical status
Follow-up actions	Action effectiveness	Action Revision + Effectivity Board	Action list + revisions
New/secondary risks	Risk classification	New/Secondary Risks	List of new risks
Process audit	Input & follow-up compliance	Risk Audit	Audit findings
Reassessment	Re-score when major changes occur	Reassessment	Latest risk level
Dashboard & reporting	Status summaries and trends	Dashboard + Reporting	Concise report
Lessons learned	Learning	Lesson Learned	Improvement recommendations

Source: Author’s Processing (2026)

Table 4 summarizes the relationship among workflow stages, key information, tools, and outputs. Define priority risks is linked with the Risk Register and produces a priority risk list. Define indicators is linked with the EWS database and KRI list and produces a priority indicator list. Routine monitoring is linked with KRI Monitoring and produces indicator recaps. Condition evaluation is linked with Risk Evaluation and produces normal, alert, or critical status. Follow-up actions are linked with Action Revision and the effectiveness board and produce action lists and revisions. New or secondary risks are linked with the New/Secondary Risks sheet, process audit is linked with Risk Audit, reassessment is linked with the Reassessment sheet, dashboard and reporting are linked with Dashboard and Reporting, and lessons learned are linked with the Lesson Learned sheet [2], [7], [8]. This matrix clarifies that each workflow stage is supported by specific information requirements and implementation tools, thereby reducing dependence on ad hoc judgment and isolated records [1], [15].

To conduct routine monitoring, a minimum checklist is needed for each period, namely: select the priority risks to be monitored; enter KRI values and record EWS; compare indicators with thresholds to set the status; assess action effectiveness; define follow-up actions or action revisions; record new or secondary risks if any; update the risk register; and prepare dashboard and reporting summaries [2], [7], [8]. To further clarify the monitoring logic, an integrated illustration of monitoring a delay risk is presented in Table 5.

Table 5. Illustration Example of Monitoring a Delay Risk

Component	Content (example)	Monitoring implication / next step
Risk	Delay in structural work	Remains under active monitoring
Risk owner	Site Engineer / Planner	Responsible for monitoring and escalation
KRI	Weekly progress deviation (%) from plan	Main measurable indicator
EWS	Late material delivery; sudden decrease in workforce	Early signs supporting proactive detection
Threshold	Deviation > 5% = alert; > 10% = critical	Basis for status interpretation
This period data	Progress deviation = 7%	Indicates alert condition
Status	Alert	Requires evaluation and response
Action	Reschedule supply; add 1 shift for critical work	Corrective action initiated
PIC & target	Logistics (2 days); Site Manager (1 week)	Follow-up accountability
Update / next step	Tighter monitoring in the next period; risk level reviewed if condition persists	Links action to update and reassessment

Source: Author's Processing (2026)

This illustration shows the logical relationship among indicator value, interpreted status, action, accountability, and update implication within one monitoring cycle [2], [7]. By presenting these elements in one integrated example, the framework demonstrates how monitoring data can be translated into follow-up decisions and subsequent risk updating more clearly and without duplication [1], [8].

Overall, the proposed framework shows that risk monitoring and control can be made more operational when process logic, indicator structure, and implementation tools are designed as an integrated system [2], [1], [7]. Its main strengths lie in proactive detection through EWS and KRI, more consistent interpretation through metrics and thresholds, traceable follow-up through linked tools, and stronger continuity from monitoring to reporting and lesson learned [13], [8], [15]. These characteristics indicate that the framework has practical implementation potential for construction projects that require periodic, data-based, and documented risk monitoring without relying on overly complex digital systems [7], [9], [10].

3.2. Discussion

This study produces an initial design of a construction project risk monitoring and control framework that is procedural and operational, meaning it organizes risk monitoring and control principles into a clear workflow that can be applied at the project level. This initial design is derived from the concept of monitoring and review as an iterative process to track risk changes, assess control implementation, and update risk information throughout the project life cycle [1], [2], [7]. Unlike standard references that are still general and emphasize principles and basic stages [1], [2], [7], this design emphasizes how those principles are operationalized into work steps, required information, and traceable outputs. This finding also closes a gap in some previous studies that often discuss risk monitoring partially, so the relationships among monitoring, evaluation, and risk updating activities are not depicted as one complete work cycle [4], [15].

The linkage to theory is seen in positioning the risk register as the center of risk information management that is updated periodically. The risk register is understood as the main document containing risks, responses, and monitoring results, thus functioning as the link between risk identification and risk monitoring [2], [7]. In addition, the initial design incorporates indicators to strengthen more proactive monitoring, in line with the idea that continuous monitoring helps maintain project stability amid uncertainty [3]. In this context, using risk indicators as early signals is also consistent with risk monitoring principles that emphasize the role of indicators in detecting changes in the risk profile earlier [13], [14], [8]. Conceptually, the initial design also accommodates the dynamic nature of risks by

allowing risk updates throughout project execution, consistent with literature that emphasizes the need for mechanisms that can capture changes, including new risks and residual risks [1], [18].

The main interpretation of the initial design findings is that problems in risk monitoring and control in construction projects cannot be addressed sufficiently merely by adding documents or certain activities; instead, they require a connected process from monitoring through updating risk information. This initial design emphasizes process consistency and data traceability, so monitoring activities do not stop at recording but generate outputs that systematically support follow-up actions and risk information updates [1], [2]. Thus, the contribution of this study at the initial design stage is to provide an operational structure that bridges risk management principles with implementation needs at the project level, without replacing existing concepts [1], [2].

The limitation of this study at this stage is that the initial design remains conceptual-operational based on a synthesis of literature and practice; therefore, the effectiveness, clarity, and applicability of each component across various project types cannot yet be evaluated in this section of the research. In addition, this study has not discussed the results of refining the design through expert assessment or testing applicability in a case-study project, so generalization of the design's performance cannot yet be concluded at this stage. The scientific implication of this initial design is that it provides a concrete example of how monitoring and control principles can be translated into an operational work structure, and it opens opportunities for future research to test, validate, and evaluate the impact of applying the design in different project contexts [1], [2].

4. CONCLUSION

This study presents a literature- and practice-based design of a construction project risk monitoring and control framework that integrates a connected monitoring and control workflow, a structured risk indicator information layer comprising Early Warning Signs, Key Risk Indicator grouping, metrics and thresholds, and mitigation effectiveness evaluation, as well as semi-automated spreadsheet-based tools to support risk recording, evaluation, updating, and reporting. By linking these elements into a single operational design, the framework provides a more systematic, traceable, and system-based approach to project risk management practice. However, the framework remains an initial conceptual-operational design, and therefore should be regarded as a basis for subsequent expert validation and further application in construction projects.

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