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Identifying Risk Factors in Storage Tank Construction Projects: A Systematic Review and Validation Through Aiken's V Method

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Abstract: This study identifies and validates critical risk factors in storage tank construction projects through a Systematic Literature Review (SLR) and expert judgment using Aiken's V method. Initially, 103 journal articles were screened, with 43 selected for in-depth analysis, revealing 33 causal factors and six key risk categories. A Focus Group Discussion (FGD) involving industry professionals (project managers, QA personnel, safety officers) enriched the findings by incorporating practical insights missing in academic literature. Eight experts then evaluated these factors using Aiken's V, validating 13 causal factors and four risk factors as highly significant. Key causal factors included Structure Design, Material Delivery, and Foundation Design, while major risk factors were financial loss, non-compliance, workplace accidents, and poor-quality outcomes. The study establishes a structured risk model for storage tank projects, supporting future quantitative risk analysis and mitigation strategies.

Keywords: Storage Tank Construction, Risk Factors, Aiken's V Method, Systematic Literature Review (SLR), Expert Judgment.

1. Introduction

Construction projects involving storage tanks are among the most critical and complex undertakings in industrial infrastructure development, particularly within the oil, gas, chemical, and energy sectors [1], [2]. These projects demand high safety, quality, and reliability standards due to their direct impact on environmental sustainability, operational continuity, and public safety [3], [4]. However, storage tank construction projects are also prone to risks that can lead to cost overruns, schedule delays, structural failures, and regulatory non-compliance[5], [6].

Understanding and managing these risks requires identifying underlying causal factors contributing to project failures[7], [8], [9], [10]. While numerous studies have explored general construction risks [11], [12], [13], [14], relatively few have focused specifically on the unique characteristics and challenges associated with storage tank construction [1], [15]. This gap in the literature highlights the need for a structured synthesis of existing knowledge and a validated framework for risk factor identification tailored to such projects.

This study employs a Systematic Literature Review (SLR) and Focus Group Discussion (FGD) to comprehensively identify and synthesize risk factors associated with storage tank construction to address this need. A total of 43 journal articles were initially collected, and 33 were selected based on relevance and quality screening criteria. These studies extracted 33 causal factors and six grouped risk factors.

To ensure the validity of the synthesized factors, this study integrates expert judgment through Aiken's V method [16], involving eight experienced professionals in the construction and engineering risk domain. This validation phase aims to assess the clarity and relevance of each identified factor, strengthening the foundation for further risk modeling or mitigation planning.

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2. Methods

This study was conducted in two main phases: (1) the Systematic Literature Review (SLR) and Focus Group Discussion (FGD) for the identification and synthesis of risk factors relevant to storage tank construction, and (2) expert validation using Aiken's V method to assess the relevance of the identified factors. Integrating these methods ensures the final risk factor list is evidence-based and practically validated.

2.1. Systematic Literature Review

The SLR approach was selected to systematically extract, analyze, and synthesize existing knowledge on risk factors in storage tank construction projects. This method follows a transparent, replicable process that minimizes bias and ensures comprehensive coverage of the literature [17]. Systematic Literature Review (SLR) allows researchers to comprehensively identify, evaluate, and synthesize relevant literature using transparent and replicable procedures [17]. In construction risk research, SLR has proven useful for mapping risk factors across different project types and enhancing theoretical frameworks[17][12].

The literature search was conducted across several academic databases, including ScienceDirect, Google Scholar, and Web of Science (WoS), using a combination of keywords such as "storage tank construction," "project risk," and "construction risk factors." To ensure the relevance and contemporaneity of the findings, the search was limited to journal articles published within the last six years. From an initial pool of 103 articles, 43 studies were selected based on strict inclusion criteria: they must discuss risk factors specifically related to storage tank construction, present empirical findings or validated risk models, be peer-reviewed, and be published in reputable academic journals, as represented in Figure 1.

In addition to the literature review, a Focus Group Discussion (FGD) was conducted to capture expert perspectives and field-based insights that may not be adequately documented in published sources. This step was particularly important for identifying practical factors that emerge in local or project-specific contexts [18], [19]. The FGD involved a structured dialogue with industry professionals, including project managers, quality control officers, and HSE engineers with extensive experience in storage tank construction. The outcomes of the FGD were used to cross-validate the literature-derived factors and to ensure that the preliminary list of risks was comprehensive and reflective of real-world practices. The literature review and FGD combination provided a strong basis for subsequent expert validation using Aiken's V method.

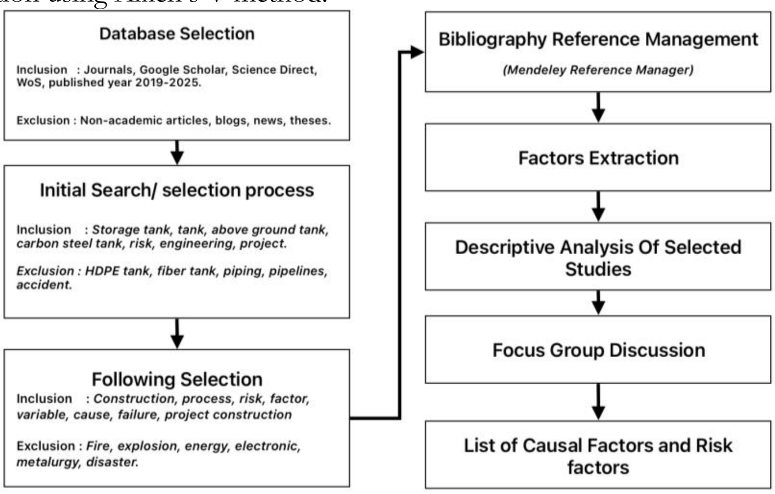

Figure 1. Bibliometric Review Methodology.

Relevant data were extracted from the selected articles, including descriptions of individual risk factors, grouping or categorizing risks (technical, managerial, environmental, etc.), context, and the project phase where each factor typically occurs. A total of 33 causal risk factors and six risk categories were synthesized through thematic coding. This process laid the foundation for the next phase of validation.

2.2 Expert Validation Using Aiken's V

Aiken's V method was employed to ensure the relevance and clarity of the synthesized risk factors. Aiken's V is a widely recognized statistical approach used to quantify the degree of expert agreement regarding the content validity of an instrument or list of items [20], [21].

Eight subject matter experts were purposively selected based on the following criteria: a minimum of 12 years of experience in industrial or storage tank construction projects, involvement in project risk assessment, management, or quality control, and a professional background in civil engineering, construction management, or related fields.

$$\boldsymbol{V} = \frac{\sum \boldsymbol{S}}{\boldsymbol{n}(\boldsymbol{c} - \boldsymbol{1})} \quad (1)$$

Description:

V = Expert agreement index regarding item validity
r = Score assessment that given by expert-n on item-n
l = Lowest score in the scoring category
n = Number of experts
S = r - l
c = Number of choice scores

Each expert was provided with a validation form listing the 33 synthesized risk factors and asked to evaluate each factor's relevance to storage tank construction projects using a 5-point Likert scale, where 1 = not relevant at all and 5 = highly relevant. Aiken's V coefficient for each factor was calculated using the following formula [16] with r as the rating given by each expert and l as the lowest rating point (in this case, 1), n = number of experts/ raters, c= number of possible rating values (in this case, 5).

No. of Items (m) or Raters (n)	Number of Rating Categories (c)											
	2		3		4		5		6		7	
	V	p	V	p	V	p	V	p	V	p	V	p
2							1.00	.040	1.00	.028	1.00	.020
3							1.00	.008	1.00	.005	1.00	.003
3			1.00	.037	1.00	.016	.92	.032	.87	.046	.89	.029
4					1.00	.004	.94	.008	.95	.004	.92	.006
4			1.00	.012	.92	.020	.88	.024	.85	.027	.83	.029
5			1.00	.004	.93	.006	.90	.007	.88	.007	.87	.007
5	1.00	.031	.90	.025	.87	.021	.80	.040	.80	.032	.77	.047
6			.92	.010	.89	.007	.88	.005	.83	.010	.83	.008
6	1.00	.016	.83	.038	.78	.050	.79	.029	.77	.036	.75	.041
7			.93	.004	.86	.007	.82	.010	.83	.006	.81	.008
7	1.00	.008	.86	.016	.76	.045	.75	.041	.74	.038	.74	.036
8	1.00	.004	.88	.007	.83	.007	.81	.008	.80	.007	.79	.007
8	.88	.035	.81	.024	.75	.040	.75	.030	.72	.039	.71	.047
9	1.00	.002	.89	.003	.81	.007	.81	.006	.78	.009	.78	.007
9	.89	.020	.78	.032	.74	.036	.72	.038	.71	.039	.70	.040
10	1.00	.001	.85	.005	.80	.007	.78	.008	.76	.009	.75	.010
10	.90	.001	.75	.040	.73	.032	.70	.047	.70	.039	.68	.048
11	.91	.006	.82	.007	.79	.007	.77	.006	.75	.010	.74	.009
11	.82	.033	.73	.048	.73	.029	.70	.035	.69	.038	.68	.041
12	.92	.003	.79	.010	.78	.006	.75	.009	.73	.010	.74	.008
12	.83	.019	.75	.025	.69	.046	.69	.041	.68	.038	.67	.049
13	.92	.002	.81	.005	.77	.006	.75	.006	.74	.007	.72	.010
13	.77	.046	.73	.030	.69	.041	.67	.048	.68	.037	.67	.041
14	.86	.006	.79	.006	.76	.005	.73	.008	.73	.007	.71	.009
14	.79	.029	.71	.035	.69	.036	.68	.036	.66	.050	.66	.047
15	.87	.004	.77	.008	.73	.010	.73	.006	.72	.007	.71	.008
15	.80	.018	.70	.040	.69	.032	.67	.041	.65	.048	.66	.041
16	.88	.002	.75	.010	.73	.009	.72	.008	.71	.007	.70	.010
16	.75	.038	.69	.046	.67	.047	.66	.046	.65	.046	.65	.046
17	.82	.006	.76	.005	.73	.008	.71	.010	.71	.007	.70	.009
17	.76	.025	.71	.026	.67	.041	.66	.036	.65	.044	.65	.039
18	.83	.004	.75	.006	.72	.007	.71	.007	.70	.007	.69	.010
18	.72	.048	.69	.030	.67	.036	.65	.040	.64	.042	.64	.044
19	.79	.010	.74	.008	.72	.006	.70	.009	.70	.007	.68	.009
19	.74	.032	.68	.033	.65	.050	.64	.044	.64	.040	.63	.048
20	.80	.006	.72	.009	.70	.010	.69	.010	.68	.010	.68	.008
20	.75	.021	.68	.037	.65	.044	.64	.048	.64	.038	.63	.041
21	.81	.004	.74	.005	.70	.010	.69	.008	.68	.010	.68	.009
21	.71	.039	.67	.041	.65	.039	.64	.038	.63	.048	.63	.045
22	.77	.008	.73	.006	.70	.008	.68	.009	.67	.010	.67	.008
22	.73	.026	.66	.044	.65	.035	.64	.041	.63	.046	.62	.049
23	.78	.005	.72	.007	.70	.007	.68	.007	.67	.010	.67	.009
23	.70	.047	.65	.048	.64	.046	.63	.045	.63	.044	.62	.043
24	.79	.003	.71	.008	.69	.006	.68	.008	.67	.010	.66	.010
24	.71	.032	.67	.030	.64	.041	.64	.035	.62	.041	.62	.046
25	.76	.007	.70	.009	.68	.010	.67	.009	.66	.009	.66	.009
25	.72	.022	.66	.033	.64	.037	.63	.038	.62	.039	.61	.049

Figure 2. Aiken's V rating and raters categories table

Interpretation of Aiken's V coefficient involves comparing the obtained value with a predetermined threshold. This threshold is specified in Aiken's V rating and rater categories table in Figure 2. The first column in Aiken's V table shows the number of raters, where the minimum value of the V index will vary depending on the number of raters. In general, the more raters involved, the lower the minimum Aiken's V value needed to declare an item valid.

In theory, the minimum number of raters is two people [20], but in this case, the resulting V value must reach the maximum value (i.e., 1) for the item to be accepted.

Meanwhile, the number of rating categories refers to the number of scales used in the assessment. For example, when the scale consists of four levels, such as very irrelevant, irrelevant, relevant, and very relevant, then the number of categories is four. The table also provides two alternative significance values (p): if the researcher sets a significance level of $p < 0.01$ (1% chance of error), then the minimum V value is seen from the first row for each number of raters. On the other hand, if a significance level of $p < 0.05$ is used (5% chance of error), then the V value is seen in the second row.

Integrating SLR and Aiken's V ensures comprehensive identification of risk factors grounded in scholarly evidence and confirms each factor's practical relevance and clarity through expert validation [16]. This dual approach strengthens the validity of the final output. It ensures that the resulting set of risk factors is theoretically justified and field-relevant, thus making it suitable for further application in probabilistic modeling, risk prioritization, or mitigation strategy design.

3. Result

The initial phase of the research involved a comprehensive search of academic databases using selected keywords related to risk in storage tank construction. A total of 103 articles were identified through this process. These articles were screened based on titles, abstracts, duplication, and full-text availability. After applying inclusion and exclusion criteria, 43 articles were selected for full-text review. This step ensured that only peer-reviewed journal articles directly addressing construction project risk—particularly in industrial or infrastructure contexts—were retained. Of the 43 full-text articles, 33 were highly relevant to the research focus. These articles were analyzed in depth to extract explicit mentions of risk factors. Through qualitative thematic analysis, 33 unique risk-causing factors and six risk factors were synthesized in Tables 1 and 2. These factors spanned across categories such as design issues, material delays, human resource competence, inspection, safety procedures, and environmental uncertainties.

Table 1. Instrument items in causal factors.

Item Code	Causal Factor
FP 1	Structure Design
FP 2	Material
FP 3	Foundation Design
FP 4	Incomplete permits and technical requirements
FP 5	Site conditions
FP 6	project schedule
FP 7	Cost / Budget
FP 8	Social Condition
FP 9	Welding Process
FP 10	Marking Process
FP 11	Cutting Process
FP 12	Blasting and painting Process
FP 13	Tools and equipment
FP 14	Material handling procedures
FP 15	Design changes in the middle of construction
FP 16	Engineering drawings specification documents
FP 17	Hydrotest regulations
FP 18	Final inspection of tank equipment
FP 19	Test Commisoning
FP 20	Manipulation of NDT test results
FP 21	Progress payments
FP 22	Team Allocation and Task Assignment System
FP 23	Daily log and periodic progress report
FP 24	Material and Equipment delivery
FP 25	Communication and coordination between stakeholders
FP 26	OHS (Occupational Health and Safety) system
FP 27	HSE documents/permits
FP 28	Work accidents
FP 29	Quality Control

Item Code	Causal Factor
FP 30	Safety/HSE Officer
FP 31	Project Manager
FP 32	Operators and workers certification
FP 33	Weather and climate

Table 2. Instrument items in risk factors.

Item Code	Risk Factor
FR 1	Project was not finished on schedule
FR 2	Project financial losses
FR 3	The outcomes do not align with the specifications/requirements
FR 4	Workplace accidents occurred
FR 5	The quality of the work was below expectations.
FR 6	Issues arose during the warranty period.

Eight professionals with experience in storage tank construction participated in an expert judgment process to validate the relevance of the 33 synthesized causal factors and six risk factors. Each expert assessed the significance of each risk factor using a 5-point Likert scale. Aiken's V analysis was conducted, and each item's coefficient was calculated. The results are presented in Tables 3 and 4.

Table 3. Validity Assessment of Causal Factors Using Aiken's V Method.

Item Code	Experts								Σr	Σl	Σs	V	Category Of Validity
	R1	R2	R3	R4	R5	R6	R7	R8					
FP 1	5	5	5	5	5	5	5	5	40	8	32	1,00	Valid
FP 2	5	4	4	5	5	4	4	5	36	8	28	0,88	Valid
FP 3	5	4	4	5	5	4	5	5	37	8	29	0,91	Valid
FP 4	4	4	4	4	5	3	4	5	33	8	25	0,78	Not Valid
FP 5	4	5	4	3	5	2	3	5	31	8	23	0,72	Not Valid
FP 6	5	4	4	3	5	3	5	3	32	8	24	0,75	Not Valid
FP 7	4	5	5	4	5	4	4	4	35	8	27	0,84	Valid
FP 8	3	4	4	5	5	3	4	4	32	8	24	0,75	Not Valid
FP 9	4	3	3	4	5	4	5	5	33	8	25	0,78	Not Valid
FP 10	3	3	4	4	5	3	5	5	32	8	24	0,75	Not Valid
FP 11	3	3	4	4	5	3	5	4	31	8	23	0,72	Not Valid
FP 12	2	3	3	3	5	2	4	4	26	8	18	0,56	Not Valid
FP 13	4	4	4	3	4	2	4	5	30	8	22	0,69	Not Valid
FP 14	4	4	3	4	5	3	4	4	31	8	23	0,72	Not Valid
FP 15	3	5	3	3	4	3	5	5	31	8	23	0,72	Not Valid
FP 16	3	4	4	4	5	3	5	4	32	8	24	0,75	Not Valid
FP 17	4	4	4	4	5	3	5	4	33	8	25	0,78	Not Valid
FP 18	4	4	4	5	5	3	5	5	35	8	27	0,84	Valid
FP 19	4	5	4	5	5	3	5	5	36	8	28	0,88	Valid
FP 20	4	4	4	5	5	3	5	3	33	8	25	0,78	Not Valid
FP 21	3	5	4	2	4	3	5	5	31	8	23	0,72	Not Valid
FP 22	3	4	4	3	4	3	4	5	30	8	22	0,69	Not Valid
FP 23	3	4	3	3	4	2	4	4	27	8	19	0,59	Not Valid
FP 24	4	5	5	3	5	4	5	5	36	8	28	0,88	Valid
FP 25	3	4	4	3	5	3	4	5	31	8	23	0,72	Not Valid
FP 26	4	4	3	5	5	3	5	5	34	8	26	0,81	Valid
FP 27	4	5	3	4	5	3	5	5	34	8	26	0,81	Valid
FP 28	4	5	4	5	5	3	5	5	36	8	28	0,88	Valid
FP 29	4	5	4	5	5	3	5	5	36	8	28	0,88	Valid
FP 30	4	5	3	4	5	3	5	5	34	8	26	0,81	Valid
FP 31	3	5	5	4	5	4	4	5	35	8	27	0,84	Valid
FP 32	3	4	3	5	5	3	5	5	33	8	25	0,78	Not Valid
FP 33	3	4	4	4	4	4	4	5	32	8	24	0,75	Not Valid

Table 4. Validity Assessment of Risk Factors Using Aiken's V Method.

Item Code	Experts								Σr	Σl	Σs	V	Category Of Validity
	R1	R2	R3	R4	R5	R6	R7	R8					
FR 1	5	4	4	3	5	3	4	5	33	8	25	0,78	Not Valid
FR 2	5	5	4	4	5	3	4	5	35	8	27	0,84	Valid
FR 3	5	4	4	4	5	4	4	5	35	8	27	0,84	Valid
FR 4	5	5	4	5	5	3	5	5	37	8	29	0,91	Valid
FR 5	5	4	4	5	5	3	4	5	35	8	27	0,84	Valid
FR 6	5	4	3	4	5	3	4	4	32	8	24	0,75	Not Valid

Based on the validation threshold (Aiken's V ≥ 0.81), only 13 causal factors and four risk factors met the required content validity level and were retained for further use (Tables 5 and 6). These validated factors are considered theoretically significant and practically applicable within the context of storage tank construction projects.

Table 5. Validated causal factors.

Item Code	Causal Factor
FP 1	Structure Design
FP 2	Material
FP 3	Foundation Design
FP 7	Cost / Budget
FP 18	Final inspection of tank equipment
FP 19	Test Commisoning
FP 24	Material and Equipment delivery
FP 26	OHS (Occupational Health and Safety) system
FP 27	HSE documents/permits
FP 28	Work accidents
FP 29	Quality Control
FP 30	Safety/HSE Officer

Table 6. Validated risk factors.

Item Code	Risk Factor
FR 2	Project financial losses
FR 3	The outcomes do not align with the specifications/requirements
FR 4	Workplace accidents occurred
FR 5	The quality of the work was below expectations

These validated factors represent the most relevant and influential risks in the context of storage tank construction projects. The key causal factors include Structure Design, Material, Foundation Design, Cost / Budget, Final inspection of tank equipment, Test Commissioning, Material and Equipment delivery, OHS (Occupational Health and Safety) system, HSE documents/permits, Work accidents, Quality Control, Safety/HSE Officer, and Project Manager for the risk factors include project financial losses, outcomes do not align with the specifications/requirement, workplace accidents occurred and the quality of the work was below expectations. Experts consistently rated these factors as highly relevant and critical to project performance, suggesting they should be prioritized in future risk mitigation strategies and quantitative modeling efforts.

4. Discussion

This study aimed to identify and validate key causal and risk factors specific to storage tank construction projects by combining a Systematic Literature Review (SLR) with expert validation using Aiken's V method. From an initial pool of 103 articles, 43 were found to be highly relevant, resulting in the synthesis of 33 distinct causal factors and six risk factors. These factors reflected a broad range of concerns, including technical issues (e.g., design accuracy), management-related risks (e.g., safety, inspection, and supervision), and logistical challenges (e.g., material delivery). The SLR process helped ensure that the identified factors were grounded in scholarly evidence and representative of recurring themes in the literature.

In Contrast, not all literature-derived factors are equally relevant in practice. Expert validation was conducted with eight professionals actively involved in construction and project risk management to test their applicability. Each risk factor was evaluated for relevance using a 5-point Likert scale and analyzed using Aiken's V. The results showed that only 13 of the 33 and four of the six factors reached the validity threshold (Aiken's V ≥ 0.81) in Table 7. This finding illustrates the importance of expert judgment in narrowing down theoretical models to factors that impact real-world construction outcomes most. It also confirms that risk perception is highly contextual—some risks frequently cited in literature may not hold the same priority in specific project types, such as storage tanks.

Table 7. Summary of factor reduction process.

Stages	Number of Items
Initial articles identified	103
Articles selected for full-text review	43
Articles deemed relevant after screening	33
Causal factors synthesized from literature	33
Causal factors validated via Aiken's V ≥ 0.81	13
Risk factors synthesized from literature	6
Risk factors validated via Aiken's V ≥ 0.81	4

The 13 validated causal factors and four risk factors refined set offers practical value for researchers and practitioners. For researchers, these variables can serve as core inputs for developing probabilistic models to predict and simulate risk behavior. For practitioners, the results offer a more focused approach to risk mitigation, helping project managers prioritize resources toward risks most likely to affect cost, time, or quality outcomes. Ultimately, integrating literature synthesis and expert validation in this study reinforces the need for balanced methodological approaches when designing effective project risk management tools.

5. Conclusion

This research successfully identified and validated critical risk factors specific to storage tank construction projects. The systematic literature review provided a theoretical foundation, while expert validation ensured practical relevance. Of the 33 causal factors identified, 13 were confirmed valid through Aiken's V analysis, and of the six risk factors identified, four were confirmed valid through Aiken's V analysis. These findings contribute a focused set of risk variables suitable for application in further risk modeling and inform more precise risk management strategies in the field. Subsequent studies should apply these validated factors in probabilistic models to simulate risk impact. Researchers may also expand expert validation across multiple regions or industries to improve generalizability.

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