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Analysis of the Cost Structure of the Construction Safety Management System for School Infrastructure Projects Based on Work Breakdown Structure

Yosia Suwadi Siringoringo [1], Rossy Armyn Machfudiyanto [2]
[1), 2)] University of Indonesia (UI)
Corresponding author, e-mail: yosiasuwadi@gmail.com

ABSTRACT
The Rehabilitation and Renovation of School Infrastructure program was initiated by the Indonesian Government through the Ministry of Public Works and Housing in 2019. Within this program, school categorized as low-risk buildings. However, field data show that construction-related accidents still occur frequently during implementation. This phenomenon is presumed to result from inadequate construction safety planning, particularly in the budgeting of Construction Safety Management System (CSMS) components. The main purpose of this research is to create a Work Breakdown Structure (WBS), pinpoint hazards and risks, propose strategies to mitigate these risks, outline objectives and plans, and establish cost factors in order to compute the percentage of CSMS expenditures associated with school restoration and refurbishment projects. A quantitative research method was employed to construct the questionnaire instruments from the initial to the final stage, starting with a literature review. Five construction safety experts validated these instruments. Risk levels were qualitatively assessed (Frequency × Severity) based on the evaluations of 30 respondents. The novelty of this research lies in its specific focus on school infrastructure as the project object. The Ministry of Public Works' school reconstruction and refurbishment initiatives necessitate budget allocations spanning from 2.63% to 4.52% of the Engineer's Estimate for CSMS expenditures.

KEYWORDS
school rehabilitation and renovation, CSMS, cost analysis, risk management, Work Breakdown Structure (WBS)

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1. INTRODUCTION

The Indonesian President instructed the Ministry of Public Works and Public Housing to oversee a national program of repairs and renovations to school facilities, as stipulated by the Republic of Indonesia Regulation Number 43 of 2019, which focuses on aiding 3 specified regions - disadvantaged, frontier, and outermost areas - known as the 3T regions. From 2019 to 2024, the Indonesian Ministry of Public Works and Public Housing, working through its Directorate of Strategic Infrastructure and the Directorate General of Human Settlements, oversaw the execution of 4,479 nationwide school infrastructure rehabilitation and renovation projects over the period from 2019 to 2024, according to the edps-djck.id website report of 2024. The highest number of projects was in West Java, Banten, and East Nusa Tenggara provinces. These rehabilitation and renovation projects are classified as having a low level of construction safety risk in accordance with Minister Regulation Number 10 of 2021, issued by the Ministry of Public Works and Public Housing, considering building floor height and project value. However, field data indicate that work accidents still result in fatalities. According to multiple online media outlets, between 2019 and 2023, at least 13 workers lost their lives and dozens more suffered severe injuries during school construction projects (Adirin, 2023; Mady, 2023; Prasetya, 2023; Simorangkir, 2022; Suladi, 2021; Swasono Widi Handoko, Pengukuran Reliabilitas Durasi Proyek....FTUI, 2001, n.d.; Timor, 2019). A more detailed examination reveals this evidence, with BPJS data indicating a rise in JKK (Work Accident Insurance) and JKM (Death Insurance) claims across all sectors from 2019 to 2023 (BPJS Ketenagakerjaan, 2024).

Table 1. JKK and JKM Claims 2019-2023

Year	JKK Claims (cases)	JKM Claims (cases)
2019	182.835	31.324
2020	221.740	32.094
2021	234.370	104.769
2022	297.725	103.349
2023	360.635	121.531

Source: (BPJS Ketenagakerjaan, 2024)

The construction sector accounted for approximately 32% of accident cases based on this data, as reported in Muntiyono et al. (2021); Sari & Latief (2021); and Wirahadikusumah & Adhiwira (2019). Factors contributing to construction accidents include poor planning and organization, unsafe working conditions, and human factors related to social issues, lack of training, psychological causes (Vasconcelos & Junior, 2015), and insufficient funding for implementing Construction Safety Management Systems (CSMS) (Machfudiyanto et al., 2021). Meanwhile, the impacts are financial losses (Sari & Latief, 2021), loss of productivity (Shirali et al., 2018; Yilmaz et al., 2015), cost and time overrun (Windapo, n.d.), and negative branding (Shirali et al., 2018). This research focuses on the financing of CSMS implementation as a factor contributing to construction accidents. According to Purwanti & Latief (2021), CSMS cost calculations must be based on work packages and activities derived from a proper Work Breakdown Structure (WBS) development, identification of hazards and risks based on related activities, risk control determination, objectives, programs, and construction safety cost components. This research will collect CSMS cost data from school infrastructure rehabilitation and renovation projects in NTT Province. This is based on data from edps-djck.id/, which shows that many CSMS cost calculations in NTT are inconsistent, and their components, sub-components, and quantities do not yet comply with Public Works and Public Housing Minister Regulation Number 10 of 2021, leading to suboptimal CSMS costs. Based on the above problems, this research is structured with the following objectives:

1. To identify, detail, and develop work packages and activities in the WBS for school infrastructure rehabilitation and renovation projects;
2. To identify, analyze, and develop potential hazards, risk levels, and construction safety risk controls in school infrastructure rehabilitation and renovation projects;
3. To identify, analyze, and develop objectives, programs, and cost components for CSMS implementation in school infrastructure rehabilitation and renovation projects;
4. To analyze and estimate the percentage of WBS-based CSMS implementation costs in school infrastructure rehabilitation and renovation projects.

2. LITERATURE REVIEW

2.1 Rehabilitation and Renovation of School Infrastructure

The technical guidelines for infrastructure rehabilitation and renovation projects are outlined in the Directorate General of Human Settlements Circular Letter No. 47 of 2020 (*SE DJCK No. 47 Tahun 2020 Tentang Petunjuk Teknis Standardisasi Desain Dan Penilaian Kerusakan Sekolah Dan Madrasah*, n.d.). In the circular letter, there are three (3) implementation construction design methods used: conventional, timber, and pre-cast. The design dimensions and material specifications are also regulated in the circular letter.

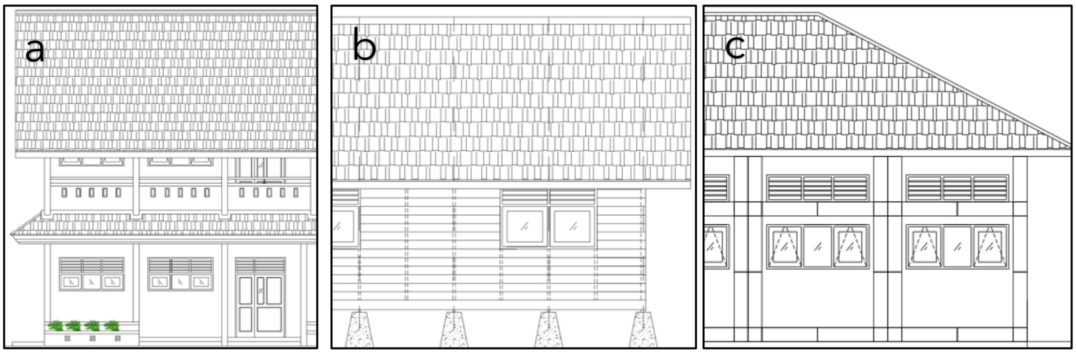

Figure 1. Construction design methods: a) conventional, b) timber, and c) pre-cast
Source: Directorate General of Human Settlements Circular Letter No. 47 of 2020

2.2 Work Breakdown Structure (WBS)

According to the Project Management Institute (2017) in the PMBOK 6th Edition, Work Breakdown Structure (WBS) is a hierarchical breakdown of the total work scope needed to achieve project goals and deliverables. The main purpose of it is to serve as a planning and design tool, a structural design tool, a tool for representing projects and instructions, and a project status reporting tool. Project performance measurement in safety planning is based on the results of WBS identification of deliverables and work packages (Saputra & Latief, 2020). According to Ferakhim & Latief (2019), a WBS is divided into the following levels: Level 1: Project Name, Level 2: Primary Construction Elements, Level 3: Type of Work, Level 4: Work Packages, and Level 5: Activities. The WBS for this project is tailored to the minimum scope of work specified in the relevant regulations Directorate General of Human Settlements Circular Letter No. 47 of 2020 such as classroom building, library building, science laboratory building, administrative building (principal's office), teacher's office building, worship building, school health unit, restrooms, storage room, connecting pathway, assembly ground, and fence and gate.

2.3 Potential Hazards and Risks

Potential hazards and risks of the lowest level scope (Activities) from WBS will be identified (Purwanti & Latief, 2021). According to Bernessa & Latief (2020), hazard identification is carried out to design a plan for implementing Construction Safety. According to the Ministry of Public Works Circular Letter No. 04 of 2021, risk is the potential for an event or occurrence that can hinder the achievement of objectives. Based on Public Works and Public Housing Minister Regulation No. 10 of 2021 (PermenPUPR No.10, 2021), risks are classified by their level through qualitative analysis or the multiplication of the frequency and severity of the hazard and risk itself. The risk level is then determined using a risk matrix (low, moderate, high risk). Hazards and risks can impact 5 (five) aspects, namely: workers, equipment, materials, and the public. Impact on the Environment Construction safety risk control is based on the regulation, consisting of elimination, substitution, engineering controls, and the use of PPE (Personal Protective Equipment) and Personal Safety Devices. The priority order is arranged based on the hierarchy of controls pyramid (*About Hierarchy of Controls | Hierarchy of Controls | CDC*, n.d.). Elimination control is prioritized, followed by substitution.

2.4 Specific Objectives and Specific Construction Safety Programs

Based on Public Works and Public Housing Minister Regulation No. 10 of 2021, specific objectives are detailed objectives for each risk management designed to achieve overall objectives from determined risk control. The specific objectives consist of descriptions and benchmarks. Specific programs include activity descriptions, resources, implementation schedules, monitoring forms, achievement indicators, and responsibility assignments.

2.5 Components of CSMS Implementation Costs

Based on Public Works and Public Housing Minister Regulation No. 10 of 2021, there are nine (9) components of CSMS implementation costs: Preparation of CSMS implementation documents, implementation of socialization, promotion, and training, procurement of personal safety devices and personal protective equipment, issuance of insurance and permits, procurement of construction safety personnel, procurement of various facilities, infrastructure, medical equipment procurement, signs and traffic equipment procurement, consultation with experts related to construction safety, and other activities and equipment related to construction safety risk control. All nine (9) components are based on identified resources from risk control's specific program.

2.6 Analysis of CSMS Implementation Costs Based on WBS

The stages for analyzing CSMS implementation costs based on WBS are developed from the theoretical review above. Identifying hazards and risks, controls, development of objectives, programs, and construction safety cost components become the independent variable (X). In this study, these stages will be formulated to achieve the research objective, which is the percentage of CSMS implementation costs as the dependent variable (Y) (Bernessa & Latief, 2021; Ferakhim & Latief, 2019; Nicodemus & Latief, 2021; Purwanti & Latief, 2021; Putra & Latief, 2020; Saputra & Latief, 2020; Utama & Latief, 2021). The detailed relationship between these variables can be seen in the diagram of the research conceptual framework.

3. METHODOLOGY

The research strategy employed a literature review and archival analysis, validation surveys, and a quantitative case study method.

In the first stage (RQ 1), a questionnaire instrument will be developed for validation by 5 experts regarding the work packages and activities (WBS).

Next, to address the second stage (RQ 2), a questionnaire instrument will be designed based on the validated WBS to validate the identification of hazards and risks. Following this, an assessment survey will be conducted using a Likert scale for frequency (1-5) and severity (1-5). This survey will involve 30 respondents with a minimum of 3 years of experience in school infrastructure rehabilitation and renovation projects, specifically as construction management or field supervisors. A qualitative risk analysis will be performed by multiplying the frequency mode and severity obtained from the survey results to determine the risk level.

In the third stage (RQ 3), a questionnaire instrument will be developed to validate the objectives, programs, and construction safety cost components. One of the outputs from this third stage, the construction safety cost components, will serve as input for the fourth stage, which involves calculating the CSMS implementation costs.

In the fourth stage (RQ 4), a questionnaire instrument will be developed for validation by 5 experts regarding the quantities and unit prices for each component and sub-component of CSMS implementation. The CSMS costs are then recalculated from the validated quantities and unit prices by comparing 5 similar projects. The results of these calculations will yield a percentage range for CSMS costs, which will serve as a reference for the minimum amount of CSMS implementation costs for school infrastructure rehabilitation and renovation projects.

4. RESULTS & DISCUSSION

4.1 Discussion of Stage 1 (RQ 1)

Stage one of this research aims to identify, detail, and develop work packages and activities within the Work Breakdown Structure (WBS) for school infrastructure rehabilitation and renovation projects. The literature review and archival analysis conducted during the development of the work package and activity validation questionnaire were used to collect data by distributing the questionnaire to 5 construction safety experts.

The results of the analysis indicated that the Activity: Well Point Planning under the Work Package: Dewatering was invalid. This was because, according to most experts, planning is not considered an Activity. Based on the validation results and expert feedback, the WBS for school infrastructure rehabilitation and renovation can be defined as follows:

1. WBS Level 1: Project Name (for 1 school)
2. WBS Level 2: Sub-Work (12 items)
3. WBS Level 3: Work Group (51 items)
4. WBS Level 4: Type of Work (137 items)
5. WBS Level 5: Work Package (360 Valid; 0 Invalid)
6. Alternative Design/Method
7. WBS Level 6: Activity (1603 Valid; 8 Invalid)

Ferakhim and Latief (2019) state that there are 5 WBS levels, whereas this study presents 6 WBS levels. This is due to the WBS for School Infrastructure Rehabilitation and Renovation being developed based on the Directorate General of Human Settlements Circular Letter No. 47 of 2020, which stipulates that a school must have a minimum of 12 buildings or infrastructure. This was adapted in this research to become Level 2 (Sub-Work). The WBS development process is crucial for optimizing CSMS (Construction Safety Management System) cost estimation (Bernessa & Latief, 2021). Furthermore, safety cost components based on the WBS are beneficial for improving the Construction Safety Management System (CSMS) and reducing accident rates (Hidayah et al., 2018; Lu et al., 2016).

The WBS diagram for school infrastructure rehabilitation and renovation projects conducted by the Ministry of Public Works is shown below.

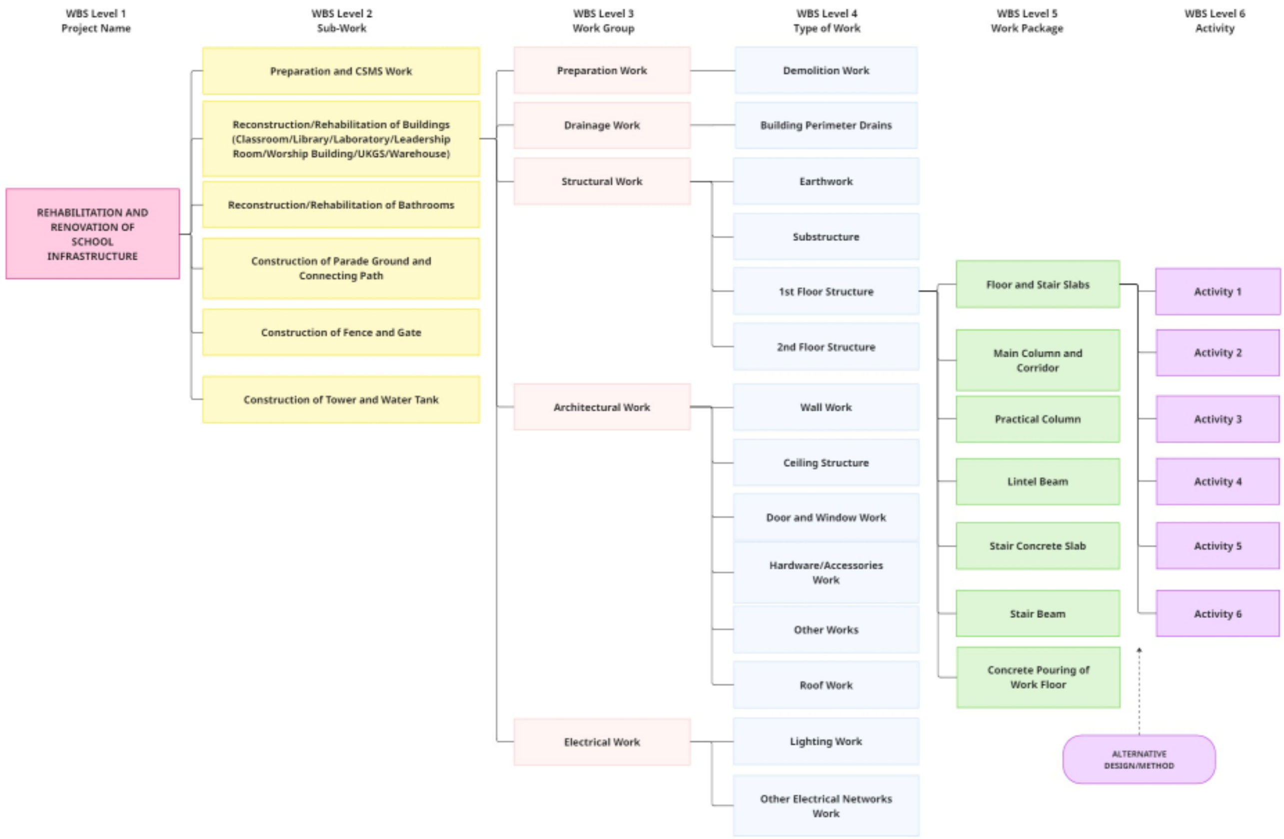

Figure 2. *WBS of Rehabilitation and Renovation of School Infrastructure*
Source: Primary data processed, 2025

4.2 Discussion of Stage 2 (RQ 2)

Stage 2 of this research aims to identify, analyze, and develop potential hazards and risks. The results of the literature review and archival analysis in the process of developing the hazard and risk validation questionnaire instrument were used to collect data by distributing the questionnaire to 5 construction safety experts, using the output from Stage one as input. Of the 1603 validated activities, 5066 hazards and risks (23 types) were validated and required control. The experts opined that the implementation of the Construction Safety Management System (CSMS) itself cannot have its construction safety hazards and risks identified. Hazards and risks are similar to those studied by Ferakhim & Latief (2019), namely: Falls from height, being struck by objects, contact with sharp objects, inhalation/absorption of hazardous substances into the body through respiration, slips, and excessive load on vertical transport equipment.

The next step in Stage 2 is the risk level assessment through a survey conducted by the respondents. Using the Harry King Nomogram (Sugiyono, 2013), 30 potential respondents were selected from a population of 76 technical directors across Indonesia. A pilot survey was conducted with 10 respondents to assess their understanding of the questionnaire items. The questionnaire was distributed to the 30 respondents to rate the frequency and severity of each risk on a Likert scale (1/2/3/4/5).

After obtaining the frequency and severity assessment data, the next step was statistical analysis, including: homogeneity test, validity test, and reliability test. 23 types of hazards were selected as input data variables into SPSS Version 27 software. The homogeneity test showed "no perception difference" or asymmetry. sig > level of sig (α) (0.05) among the 30 respondents for the 23 types of hazards assessed. This test was performed for each classification: position, education, work experience, and institution. The validity test, using a 95% confidence interval, resulted in a "Valid" conclusion by showing a product-moment correlation coefficient (r_table < r_analysis) for all 23 tested variables. The reliability test showed a "highly reliable level" result with a Cronbach's alpha value of 0.915 > 0.6.

After the statistical analysis was completed, a qualitative risk analysis was performed by calculating the previously surveyed frequency x severity. This yielded 3303 low risks (6 types), 1290 moderate risks (10 types), and 473 high risks (2 types). A ranking was performed based on the risk values, resulting in 12 rankings. Subsequently, the mode of their risk values was taken for repetitive risks. This resulted in 18 types of risks with 12 different rankings, as detailed in the table below.

Table 2. Risk Ranking for School Infrastructure Rehabilitation and Renovation

HAZARD IDENTIFICATION 1. Worker 2. Equipment 3. Material 4. Environment/Public		**RISK** 1. Worker 2. Equipment 3. Material 4. Environment/Public	**Risk Assessment**				
			F	S	Value	Level	Rank
Worker	Slip/fall/trip	Muscle/bone/head injury	4	4	16	High	1
Equipment	Incorrect work method	Short circuit leading to fire	3	5	15	High	2
Material	Material specifications not according to regulations	Damage to material/equipment	4	3	12	Moderate	3
Public	Incorrect work method	Landslide	2	5	10	Moderate	4
Worker	Exposed to sparks from grinder/welding tool	Burn	3	3	9	Moderate	5
Environment	Heavy equipment (excavator/bulldozer) and transport equipment (dump truck/truck mixer) colliding/tipping over/rolling over	Nearby facilities damaged	2	4	8	Moderate	6
Environment	Mobilization through busy traffic	Traffic congestion	4	2	8	Moderate	6
Environment	Material/Equipment lying around	Environmental pollution	3	2	6	Moderate	7
Equipment	Equipment specifications not according to regulations	Cannot be used anymore (damaged demolition equipment)	3	2	6	Moderate	7
Material	Material lost/stolen	Material loss	3	2	6	Moderate	7

HAZARD IDENTIFICATION 1. Worker 2. Equipment 3. Material 4. Environment/Public		RISK 1. Worker 2. Equipment 3. Material 4. Environment/Public	Risk Assessment				
			F	S	Value	Level	Rank
Equipment	Equipment specifications not according to regulations	Cannot be used anymore (broken sling)	3	2	6	Moderate	7
Environment	Occurrence of smoke and dust	Air pollution	5	1	5	Moderate	8
Worker	Exposed to ash/dust/material splashes	Impaired sight/skin/respiratory/hearing organs	4	1	4	Low	9
Environment	Affecting protected plants	Environmental damage	3	1	3	Low	10
Environment	Formwork and scaffolding collapse	Disturbing the project environment and surrounding community	3	1	3	Low	10
Equipment	Damaged work tools	Cannot be used anymore	2	1	2	Low	11
Material	Landslide/collapse	Damage to material/equipment (seepage well collapsed buried in soil)	2	1	2	Low	11
Equipment	Heavy equipment (excavator/bulldozer) and transport equipment (dump truck/truck mixer) colliding/tipping over/rolling over	Damage to heavy equipment	1	1	1	Low	12

Source: Primary data processed, 2025

The next stage in Stage 2 is to identify, analyze, and develop risk controls. From the results of the literature review and archival analysis in the process of developing the risk control validation questionnaire instrument, data were collected by distributing the questionnaire to 5 construction safety experts, with the risk assessment results that have moderate and high-risk levels as input (PermenPUPR No.10, 2021).

Controls are arranged according to priority order in to the hierarchy of the control pyramid. The experts opined that the risk control "Evacuating work accident victims" and subsequent related objectives and programs were considered "Invalid" because they are not preventive actions. The results of this validation are consistent with several studies that state the necessity of risk controls in the form of: installing "beware of falling" warning signs; ensuring scaffolding is in a strong condition; installing safety nets; adequate lighting; using PPE in the form of a full body harness; and holding toolbox meetings (Ferakhim & Latief, 2019).

4.3 Discussion of Stage 3 (RQ 3)

Stage 3 in this research aims to identify, analyze, and develop objectives, programs, and construction safety cost components. The results of the literature review and archival analysis in the process of developing the validation questionnaire instrument for objectives, programs, and construction safety cost components, data collection was conducted by distributing the questionnaire to 5 construction safety experts. The risk control results in Stage 2 served as a reference for its development. After expert validation, objectives and programs consistent with the risk controls for each activity were obtained, which are also aligned with previous research. For example, for electrical activities, Machfudiyanto et al. (2022) state that for the risk of exposure to electric current, some controls, objectives, and programs are:

1. Risk Control: Installing "electrical hazard" signs
    a. Objective: The description explains that all areas are equipped with signs, and the relevant sign standards are used as the benchmark.
    b. Program: Resources include warning signs, and implementation is scheduled before the start of work. The achievement indicator is 100% standardized signs. Program oversight is conducted using a checklist with the safety officer as the PIC (Person in Charge).
2. Risk Control: Avoid double connections.
    a. Objective: The description explains how to avoid double connections using the electric current as the benchmark.
    b. Program: Resources include work instruction documents with scheduled implementation during work. The achievement indicator is no excessive electrical load. Program oversight is conducted using inspections with the safety officer as the PIC.
3. Procurement of electrical PPE (Personal Protective Equipment) according to standards
    a. Objective: The description explains that all workers use PPE according to standards, with the benchmark being PPE compliant with applicable SNI (Indonesian National Standard).
    b. Program: Resources include electric gloves and safety shoes, with implementation scheduled before the start of work. The achievement indicator is 100% standard-compliant PPE. Program oversight is conducted using a checklist with the safety supervisor as the PIC.

4.4 Discussion of Stage 4 (RQ 4)

Stage 4 in this research aims to analyze and estimate the percentage of Construction Safety Management System implementation costs for school infrastructure rehabilitation and renovation projects. Five (5) similar projects were collected, with their respective CSMS cost percentages as follows:

1. Project 1 (2021): Owner's Estimate of Rp20,290,896,400.00. CSMS Value 2.57%
2. Project 2 (2021): Owner's Estimate of Rp16,908,614,600.00. CSMSValue 2.34%
3. Project 3 (2022): Owner's Estimate of Rp18,647,020,000.00 CSMS Value of 0.45%
4. Project 4 (2022): Owner's Estimate of Rp25,454,545,500.00. CSMS Value 1.01%
5. Project 5 (2023): Owner's Estimate of Rp20,290,896,400.00. CSMS Value 2.57%

A literature study and archival analysis were conducted to develop the questionnaire instrument for validating the quantities and unit prices of each Construction Safety Management System (CSMS) cost component. Validation and expert notes were used to refine the quantities and unit prices. After validation, the instrument was used to recalculate the 5 existing projects. The unit prices and Owner's Estimate (OE) values of the projects were calculated based on the Wholesale Price Index for 2025: 101.33 to account for inflation (*Indeks Harga Perdagangan Besar (IHPB) Bahan Bangunan/Konstruksi Indonesia - Tabel Statistik - Badan Pusat Statistik Indonesia*, 2025). Each project for each year was recalculated using the following formula:

$$\boldsymbol{OE\ Project\ year\ Y = OE\ Projct\ year\ X + \left(\frac{Index\ year\ Y}{Index\ year\ X}\right)}$$

The average index for Residential and Non-Residential Building Types was taken for 2021: 107.94 (Purwanto & Lolyta, 2022), 2022: 113.47 (Purwanto & Lolyta, 2023), 2023: 116.34 (Purwanto & Lolyta, 2024). Then, these indices were inserted into the above formula. After performing the calculations, the following percentages of Construction Safety Management System (CSMS) implementation costs for the 5 projects were obtained:

Table 3. Summary of CSMS Implementation Cost Percentage Comparison for Projects 1 to 5

No	CSMS Implementation Components	Project 1 (2021) (Rp)	Project 2 (2021) (Rp)	Project 3 (2022) (Rp)	Project 4 (2022) (Rp)	Project 5 (2023) (Rp)
1	Preparation of CSMS Implementation Documents	6,852,000.00	6,420,000.00	7,284,000.00	7,716,000.00	6,494,400.00
2	Implementation of Socialization, Promotion, and Training	97,595,300.00	90,292,100.00	104,348,500.00	114,001,700.00	97,920,100.00
3	Procurement Personal Safety Devices and Personal Protective Equipment	252,648,913.33	197,788,170.00	242,351,640.67	298,197,496.00	186,702,384.00
4	Insurance and Permitting	20,290,896.36	16,908,614.55	18,647,020.00	25,454,545.45	28,368,468.47
5	Procurement of Construction Safety Personnel	179,330,613.00	163,027,830.00	195,633,396.00	211,936,179.00	188,646,489.00
6	Procurement of Facilities, Infrastructure, and Medical Equipment	12,025,090.00	10,822,581.00	13,227,599.00	14,430,108.00	11,408,664.00
7	Procurement of Signs and Traffic Equipment	13,459,920.00	12,113,928.00	16,741,912.00	17,068,224.00	11,823,936.00
8	Consultation with Construction Safety Experts	0,00	0.00	0.00	0.00	0.00
9	Other Activities and Equipment Related to Construction Safety Risk Control	135,385,500.00	121,846,950.00	187,028,050.00	171,246,600.00	131,462,400.00
Total CSMS Cost		717,588,232.70	619,220,173.55	785,262,117.67	860,050,852.45	662,826,841.47
Total OE (Non-Inflation converted to year 2025)		19,276,332,969.84	16,121,535,355.23	17,361,959,383.48	23,360,584,490.50	25,187,463,938.85
Project Duration (Months)		7	7	7	7	9
Number of Schools		10	9	11	12	8
Found CSMS Percentage against OE Value		3.72%	3.84%	4.52%	3.68%	2.63%

No	CSMS Implementation Components	Project 1 (2021) (Rp)	Project 2 (2021) (Rp)	Project 3 (2022) (Rp)	Project 4 (2022) (Rp)	Project 5 (2023) (Rp)
CSMS Cost Range				**2.63% - 4.52%**		

Source: Primary data processed, 2025

From the table above, the CSMS cost range for school infrastructure rehabilitation and renovation is found to be 2.63% - 4.52%. The comparison of CSMS costs between the existing and recalculated results is as follows.

Table 4. Comparison of Total Existing CSMS Costs vs. Research Findings

Project	Existing CSMS Cost	Recalculated CSMS Cost
Project 1	2.57%	3.72%
Project 2	2.34%	3.84%
Project 3	0.45%	4.52%
Project 4	1.01%	3.68%
Project 5	0.74%	2.63%

Source: Primary data processed, 2025

The weighting of the 9 CSMS cost components for the 5 projects can be seen in the pie chart below.

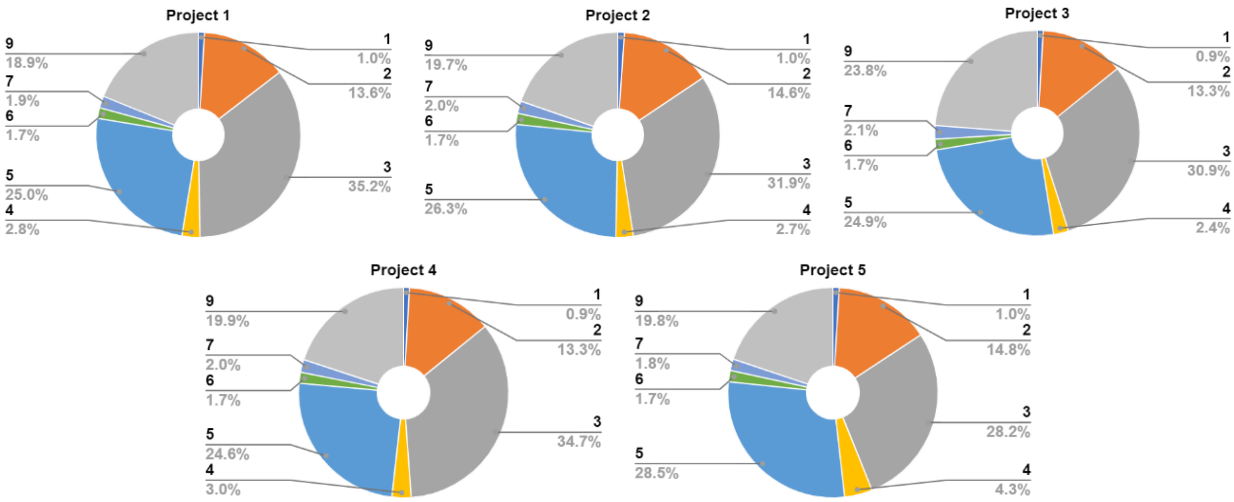

Figure 3. Comparison of Percentage for Each Component Across the 5 Projects
Source: Primary data processed, 2025

The analysis above shows that the highest component of CSMS (Construction Safety Management System) implementation costs for school infrastructure rehabilitation and renovation is Component No. 3, PPE (Personal Protective Equipment) and Personal Safety Devices, with a range of 28.2% - 35.2%. Conversely, the component with the lowest percentage is No. 8, Consultation with Construction Safety Experts, at 0.00%. This was validated by experts because, in addition to the low-risk nature of the project type, project management already includes the necessary K3 (Occupational Health and Safety) experts. Furthermore, the application of CSMS components is plotted into the project planning/time schedule to sharpen the understanding of the implementation of each CSMS component within the project.

5. CONCLUSION

5.1 Practical Implication

1. This percentage range can serve as a reference for project owners in calculating optimal budgeting, especially for CSMS, to prevent work accidents in related projects. This figure can also be used as a provisional sum, considering the lengthy upstream-to-downstream analysis process.

2. Based on experts' opinions, the calculated CSMS costs should form the basis for determining the provisional sums for CSMS component implementation costs for School Infrastructure Rehabilitation and Renovation projects carried out by the government through the Ministry of Public Works.

3. Based on the opinions of experts, the costs for K3 (Occupational Health and Safety) Personnel and Experts should not be charged to the CSMS implementation cost components but rather included in general overheads. This aims to maximize the CSMS implementation costs for activities, programs, training, and socialization of CSMS implementation, which are considered more crucial in preventing work accidents.

4. BPJS Ketenagakerjaan (Workers' Social Security Agency) costs are also recommended to be charged against the CSMS component.

5.2 Limitations and Future Research

1. The use of Directorate General of Human Settlements Circular Letter No. 47 of 2020 as the basis for developing the WBS (Work Breakdown Structure) for school infrastructure rehabilitation and renovation projects carried out by the Ministry of Public Works becomes a limitation for WBS development. For school infrastructure projects handled by parties other than the Ministry of Public Works, which may be more complex and have more than 2 floors, it is necessary to redevelop the WBS based on relevant provisions and regulations.

2. School Infrastructure Rehabilitation and Renovation projects are spread across disadvantaged, frontier, and outermost locations throughout Indonesia. This poses geographical challenges that can lead to construction accidents during the mobilization process and affect CSMS (Construction Safety Management System) costs. Therefore, further research is required to include geographical factors.

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