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Cost Analysis of Construction Safety Management Systems: Compliance Assessment with Indonesian Safety Regulations

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ABSTRAK

The Indonesian construction sector plays a vital role in national economic development, yet it continues to face significant occupational safety challenges. This study assesses the implementation of Construction Safety Management Systems by national safety regulations, with a focus on compliance within the XYZ construction project. Using a mixed-methods approach, the research combines quantitative budget analysis with qualitative field observations and interviews with safety officers. Findings indicate that while safety measures were implemented, budget allocations remained insufficient to meet regulatory requirements. Critical components, such as safety training and preventive risk control measures, were notably underfunded, reflecting gaps between policy mandates and their practical execution. The study highlights systemic challenges in safety budget planning, including inconsistent incorporation of regulatory standards and disproportionate allocation across safety components. These findings contribute to broader discussions on construction safety governance in emerging economies, emphasizing the need for improved compliance mechanisms and accountability frameworks. Practical recommendations include the adoption of risk-based budgeting approaches and enhanced oversight to ensure adequate safety investments. The research provides valuable insights for policymakers and industry stakeholders seeking to strengthen safety management practices in public construction projects.

Keywords: *Construction Safety; Regulatory Compliance; Safety Management; Risk Prevention; Budget Allocation*

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INTRODUCTION

The Indonesian construction industry has experienced rapid growth, particularly in infrastructure development [1]. The success of construction projects is typically measured by four key indicators: compliance with technical specifications, timely completion, cost efficiency, and the implementation of a Construction Safety Management System (SMKK). However, in practice, many projects fail to meet these benchmarks. Project failures often stem from non-compliance with these critical aspects [2]. This highlights the critical importance of conducting a comprehensive assessment of construction safety risk management within the industry[3].

To identify the underlying causes of these failures and develop strategies that can enhance safety practices, ultimately leading to improved project outcomes and sustainability in the industry[4], [5]. to identify the underlying causes of these failures and develop strategies that can enhance safety practices, ultimately leading to improved project outcomes and sustainability in the industry[6].

Despite the critical importance of construction safety, its implementation in Indonesia remains suboptimal [7], [8], [9]. Data from the Ministry of Manpower (2024) recorded 278,564

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workplace accidents between January and August 2024, with 0.91% occurring in the construction sector. Emphasized that workplace accidents not only result in fatalities but also lead to material losses, production failures, and project delays. These findings reinforce the urgency of addressing construction safety management to mitigate multidimensional risks.

Implementing comprehensive safety training programs and fostering a culture of safety awareness among workers can significantly reduce the incidence of accidents, thereby enhancing overall productivity and efficiency in construction projects[10]. In addition to training programs, the adoption of advanced safety technologies, such as wearable devices and real-time monitoring systems, can further enhance risk management and ensure compliance with safety regulations on construction sites[11].

Construction Safety refers to all engineering activities that support construction work in fulfilling standards of security, safety, health, and sustainability[12]. These standards ensure the safety of construction engineering, workers' health and safety, public safety, and environmental protection (Ministry of Public Works and Housing Regulation No. 10 of 2021). Nevertheless, construction safety is often neglected due to discomfort or lack of awareness, even though construction projects involve complex risk factors such as site conditions, weather, natural disasters, work methods, and labor turnover[13]. These risks are dynamic and require a comprehensive management approach[14].

The significance of construction safety extends beyond worker protection to corporate sustainability[15]. Workplace accidents result in direct losses (medical costs and compensation) and indirect losses (project delays and reputational damage)[16]. Therefore, improving construction safety is not only a moral obligation but also a strategic investment to enhance worker welfare and company productivity[17], [18].

The Construction Safety Management System (SMKK) serves as a systematic solution to identify and control workplace accident risks[19]. SMKK ensures that safety, health, and sustainability standards are applied at all project stages through continuous monitoring[20]. Its implementation aligns with Government Regulation No. 14 of 2021 and Ministry of Public Works Regulation No. 10 of 2021, which mandate SMKK adoption and define construction accidents as consequences of negligence in meeting safety standards [21]. By adhering to these regulations, companies not only comply with legal requirements but also foster a culture of safety that can lead to long-term benefits such as reduced insurance costs and improved employee morale[22].

The novelty of this research lies in its analysis of the effectiveness of construction safety cost allocation in supporting SMKK. This study examines the gap between the ideal SMKK budget (1.5–2.5% of project value, as recommended by the Construction Safety Committee) and real-world implementation while proposing a risk-based allocation model. The findings are expected to provide policy recommendations for optimizing SMKK budgets based on project complexity.

METHOD

This study employs a quantitative approach with a descriptive method through a case study of the XYZ Building Construction Project in Padang City, West Sumatra, Indonesia. The case study was selected to comprehensively analyze the implementation of cost calculations for the Construction Safety Management System (SMKK) based on PUPR Ministerial Regulation No. 10 of 2021.

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The research procedure was conducted through five main stages. The first stage involved collecting primary data through structured interviews with the project manager and the occupational safety and health team, as well as field observations. Secondary data were obtained from project documents, including the Contractor's Bid Price (RAB), Owner Estimated Price (HPS), Contract Price, technical specifications, and literature studies related to safety construction standards. The second stage identified SMKK components based on PUPR Regulation No. 10/2021, which included personal protective equipment (PPE), construction safety signage, fire extinguishers, and training costs.

In the third stage, SMKK costs were calculated by comparing actual field prices with regulatory standards. The fourth stage conducted a comparative analysis between the calculation results and the safety construction budget in the project's RAB and HPS. The final stage calculated the percentage of SMKK costs relative to the total project value to evaluate budget allocation.

The research object was a four-story building construction project with one basement. The analysis focused on key project documents and the list of required construction safety equipment. Data processing was performed using Microsoft Excel to ensure calculation accuracy, supported by structured interview instruments and price references from the Ministry of PUPR.

Data validity was tested through triangulation by comparing interview results, project documents, and field observations. Calculation consistency was verified based on the articles of PUPR Regulation No. 10/2021. Primary data was obtained from interviews and field observations, while secondary data was sourced from regulations and material price reports.

This study references PUPR Regulation No. 10 of 2021 as the legal foundation, OSHA standards for construction safety component comparisons, and the literature on Construction Safety Management for risk analysis methodology. This approach is expected to yield valid and reliable findings regarding SMKK cost calculations in construction projects.

Table 1. Construction Safety Management System Components

Work Description	**Unit**	**Quantity**
Preparation of the Construction Safety Plan:		
Development of the Construction Safety Plan Document (RKK, RMPK, RMLLP)	Set	-
Development of Procedures and Work Instructions		
Development of the Construction Safety Management System Report		
Safety Socialization and Training		
Construction Safety Induction	Person	-
Safety Briefing	Person	-
Safety Meetings (Toolbox Meetings)		-
* Working at heights	Person	-
* Chemical handling (MSDS)	Person	-
Safety Construction Simulation	Person	-
Safety Banners	Sheet	-
Safety Posters	Sheet	-

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Safety Information Boards	Unit	-
Safety Equipment		
Collective Protection Equipment:		
Safety Net	Roll	-
Safety Lifelines	Ls	-
Guard Rails	Ls	-
Restricted Area Barriers	Roll	-
Personal Protective Equipment:		
Safety Helmet	Unit	-
Safety Goggles	Pair	-
Face Shields	Unit	-
Respiratory Masks	Pack	-
Safety Gloves	Pair	-
Safety Shoes	Pair	-
Full Body Harness	Unit	-
Safety Vest	Unit	-
Apron/ Coveralls	Unit	-
Fall Arrester	-	-
Insurance and Licensing:		
Insurance	Unit	-
Equipment certification testing for operational permits	-	-
Safety Personnel:		
Certified Construction Safety Officer	Person	-
Construction Safety Staff	Person	-
Flagmen	Person	-
Health Facilities and Equipment:		
First Aid Kits (Type C)	Set	-
Fogging Equipment	Set	-
Traffic Management Equipment:		
Directional Signs	Unit	-
Prohibition Signs	Unit	-
Warning Signs	Unit	-
Mandatory Signs	Unit	-
Information Signs	Unit	-
Safety Consultations:		
Foundation Engineering Consultant	-	-
Risk Control Equipment & Activities:		

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Portable Fire Extinguishers (APAR)	Unit	-
Safety Flags	Unit	-
External Safety Audits	Period	-
Environmental Inspections (Water Quality Testing)	-	-
Worker ID Card Preparation	Sheet	-

RESULT AND DISCUSSION

The data and computational results presented in Table 2 were derived from processed datasets. This comparison examines the cost allocation for construction safety components across four distinct perspectives: the Owner's Estimate, the Contractor's Bid Price, the Contract Price, and the standard stipulated in PUPR Regulation No. 10/2021.

Table 2. Comparison of Estimated Percentages of Construction Safety Costs

Work Description	Owner's Estimate (% of Cost)	Contractor's Bid Price (% of Cost)	Contract Price (% of Cost)	Cost Estimation Based on PUPR Regulation No. 10/2021 (% of Cost)
Preparation of Construction Safety Plan	0.00	0.00	0.00	0.75
Safety Socialization and Training	8.03	8.39	8.39	11.58
Safety Equipment	10.97	11.73	11.73	34.37
Insurance and Licensing	49.52	13.34	13.34	9.96
Construction Safety Personnel	29.71	46.08	46.08	34.91
Health Facilities and Equipment	1.06	18.81	18.81	0.92
Traffic Management Equipment	0.71	1.65	1.65	3.57
Construction Safety Consultant	0.00	0	0.00	0.56
Risk Control Equipment & Activities:	0.00	0	0.00	3.38

The data presented in the table compares cost estimates for various construction safety components from four different perspectives: the owner's estimate, the contractor's bid price, the contract price, and the cost estimation based on PUPR Regulation No. 10/2021. The results show significant variations in cost allocation for each component, which may reflect differences in priorities, standards, or interpretations of construction safety requirements.
Some notable preliminary findings include:

1) Non-compliance with Regulations: Certain components, such as Preparation of Construction Safety Plan and Risk Control Equipment & Activities, are allocated 0% in the owner's and contractor's estimates, whereas the PUPR regulation specifies certain allocations (0.75% and 3.38%, respectively). This suggests potential non-compliance or insufficient attention to these aspects.
2) Disproportionate Cost Allocation: The Insurance and Licensing component dominates the owner's estimate (49.52%) but is significantly lower in the contractor's and regulatory estimates (13.34% and 9.96%, respectively). Conversely, Health Facilities and Equipment

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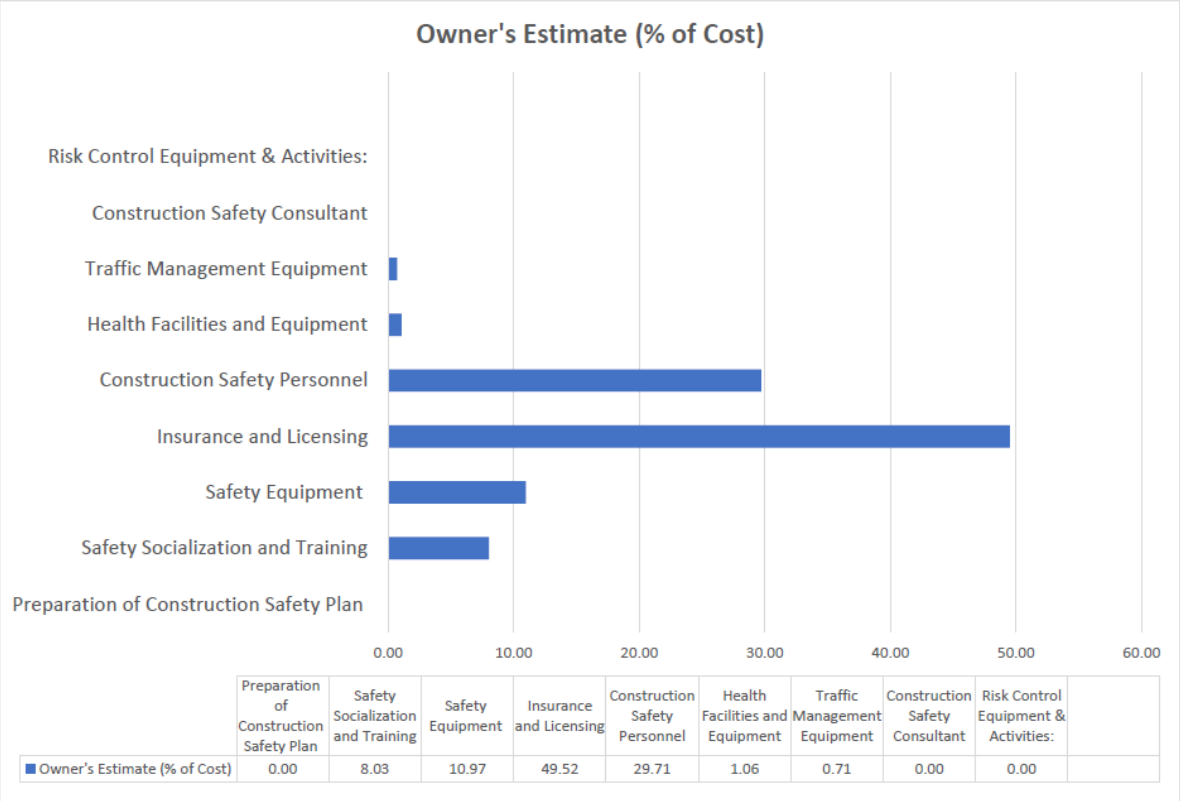
receives a large share from the contractor (18.81%) compared to the owner's estimate (1.06%) or the regulation (0.92%).

3) Consistency Between Contractor Bid and Contract Price: The contractor's bid price and the contract price are identical for all components, indicating no further negotiation after the bid submission.



	Preparation of Construction Safety Plan	Safety Socialization and Training	Safety Equipment	Insurance and Licensing	Construction Safety Personnel	Health Facilities and Equipment	Traffic Management Equipment	Construction Safety Consultant	Risk Control Equipment & Activities:
Owner's Estimate (% of Cost)	0.00	8.03	10.97	49.52	29.71	1.06	0.71	0.00	0.00

Figure 1. Distribution of Construction Safety Costs Based on Owner's Estimate

As shown in Figure 1, the data reveals the cost allocation pattern for various risk control components in a construction project. Insurance and Licensing receive the largest portion at 49.52% of the total budget, indicating a primary emphasis on legal and financial protection aspects. Construction Safety Personnel ranks second with a 29.71% allocation, reflecting the critical role of human resources in field operations. Safety Equipment is allocated 10.97% of the budget, while Safety Socialization and Training receive 8.03%.

Several components receive relatively small allocations, including Health Facilities and Equipment (1.06%) and Traffic Management Equipment (0.71%). Notably, some items show zero budget allocation: Preparation of Construction Safety Plan, Construction Safety Consultant, and Risk Control Equipment & Activities, each recorded at 0.00%.

This distribution illustrates the funding structure implemented by the project owner for managing safety and risk control aspects. The data shows significant variation in allocation proportions among components, with some elements receiving dominant shares while others are minimally funded or completely unallocated. The pattern demonstrates clear priorities in resource distribution for different risk management elements within the construction project framework.

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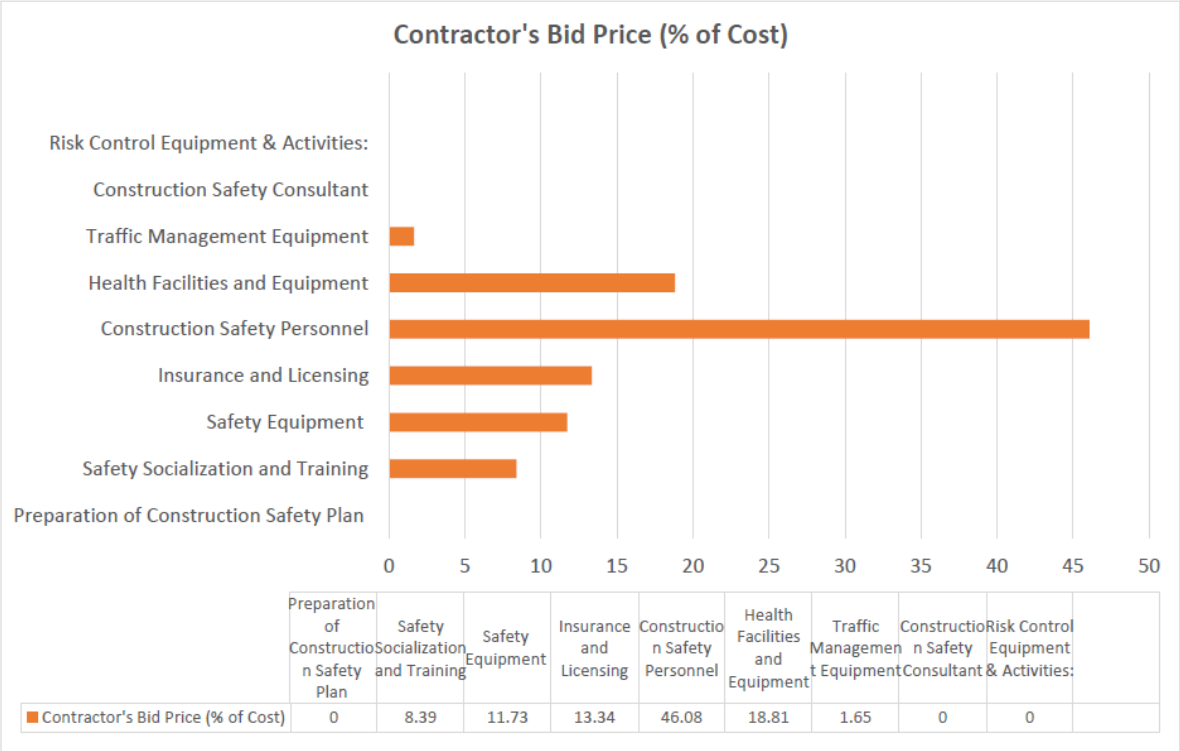

Figure 2. Distribution of Construction Safety Costs Based on Contractor's Bid Price

As shown in Figure 2, the contractor's bid price allocation for safety components reveals a distinct prioritization of resources in construction risk management. Nearly half of the budget (46.08%) is allocated to Construction Safety Personnel, indicating a strong emphasis on direct human supervision as the primary safety control measure. Health Facilities and Equipment receive the second-largest share at 18.81%, followed by Insurance and Licensing at 13.34%, demonstrating compliance with health regulations and financial risk management requirements. Safety Equipment accounts for 11.73% of the budget, while Safety Socialization and Training represent 8.39%, suggesting basic but not extensive investment in these areas.

Traffic Management Equipment receives only minimal funding (1.65%), potentially reflecting either subcontracting of these services or an underestimation of their importance. Notably, three critical components - Preparation of Construction Safety Plans, Safety Consultants, and Risk Control Equipment - show zero budget allocation, revealing potential gaps in strategic safety planning and expert oversight.

This distribution pattern suggests a predominantly reactive approach to safety management, focusing on immediate operational controls through personnel rather than preventive measures through planning, equipment, and expert consultation. The heavy reliance on safety personnel (46.08%) compared to the complete absence of a budget for safety planning (0%) creates an imbalance that may lead to vulnerabilities in addressing complex or unforeseen safety challenges throughout the project lifecycle. The allocation strategy appears to prioritize visible, day-to-day safety management over systematic risk prevention and long-term safety infrastructure development.

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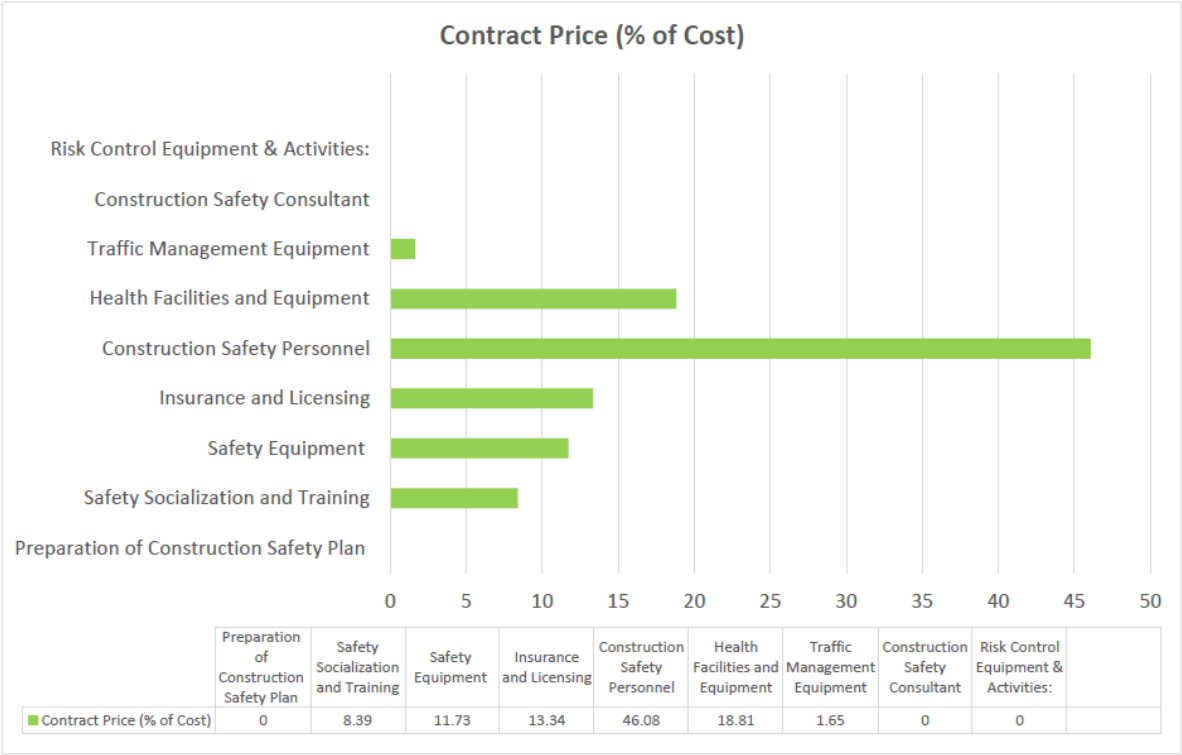

	Preparation of Construction Safety Plan	Safety Socialization and Training	Safety Equipment	Insurance and Licensing	Construction Safety Personnel	Health Facilities and Equipment	Traffic Management Equipment	Construction Safety Consultant	Risk Control Equipment & Activities:
Contract Price (% of Cost)	0	8.39	11.73	13.34	46.08	18.81	1.65	0	0

Figure 3. Distribution of Construction Safety Costs Based on Contract Price

As shown in Figure 3, the presented contract price data reveals a significantly uneven distribution of budget allocation across various construction safety components. Most notably, Construction Safety Personnel dominates with a substantial 46.08% share of the total budget, indicating a safety approach that heavily relies on direct human supervision in the field. This likely reflects either the labor-intensive nature of the project or the work complexity requiring strict oversight.

Health Facilities and Equipment ranks second with a considerable 18.81% allocation, demonstrating awareness of worker health aspects. This is followed by Insurance and Licensing at 13.34%, reflecting compliance with legal requirements and financial protection measures. Meanwhile, the 11.73% allocation for basic Safety Equipment and 8.39% for Safety Socialization and Training programs suggest minimal efforts in meeting fundamental safety standards.

Particularly concerning is the minimal 1.65% allocation for Traffic Management Equipment - a crucial component especially for public area projects. More alarmingly, three critical elements receive zero funding: Preparation of Construction Safety Plans (0%), Construction Safety Consultants (0%), and Risk Control Equipment & Activities (0%). These omissions indicate potential weaknesses in strategic planning and project risk anticipation.

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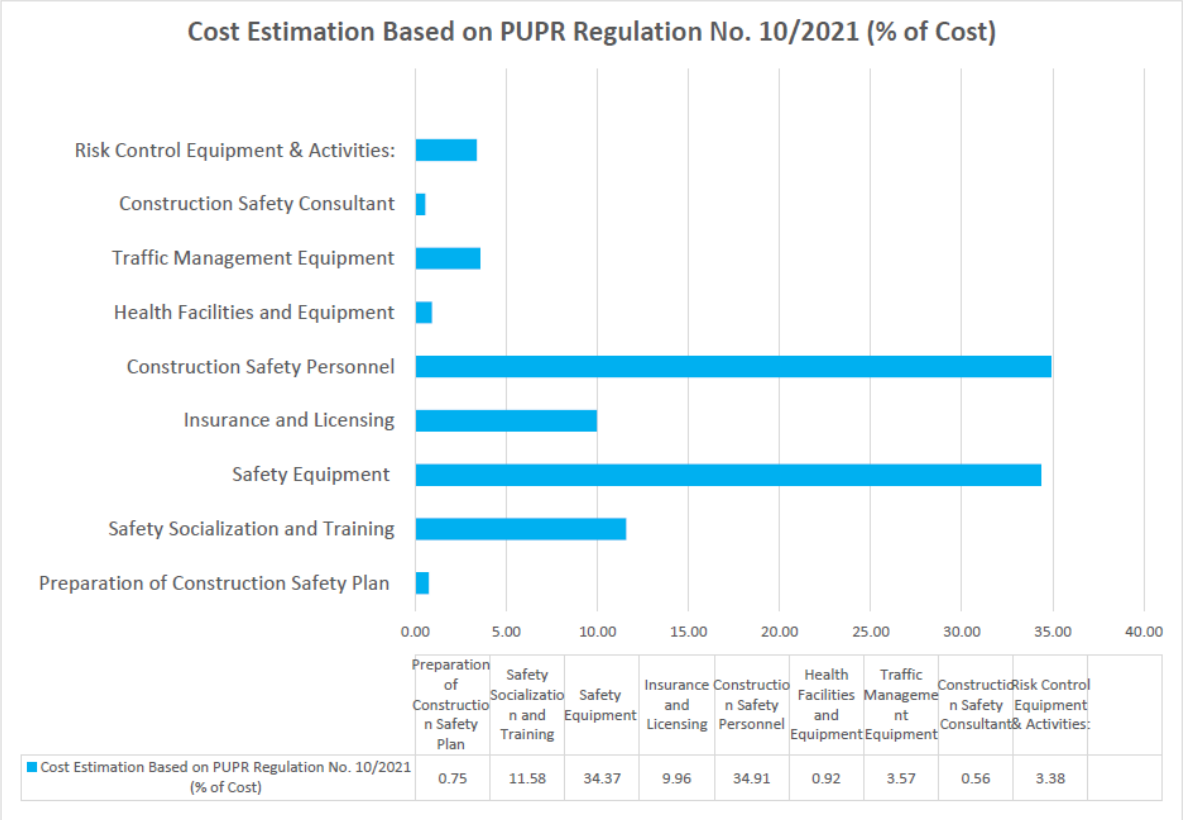

Figure 4. Distribution of Construction Safety Costs Based on PUPR Regulation

As shown in Figure 4, the distribution of construction safety costs under PUPR Regulation No. 10/2021 reveals a well-structured budgeting framework. Two primary components dominate the allocation: Construction Safety Personnel (34.91%) and Safety Equipment (34.37%). Together, these items account for nearly 70% of the total safety budget, demonstrating a balanced emphasis between human resources and safety support infrastructure at project sites. This nearly equal distribution between personnel and equipment reflects a comprehensive approach to ensuring worker safety.

Workforce capacity building through Safety Socialization and Training receives a significant allocation of 11.58%. This figure is substantially higher than typical contractor proposals, indicating that PUPR regulations place greater importance on worker competency development. Meanwhile, Insurance and Licensing are allocated 9.96%, a figure lower than the main components but still sufficient to ensure basic protection.

Supporting elements such as Traffic Management Equipment (3.57%) and Risk Control Equipment & Activities (3.38%) receive proportional allocations. However, several critical aspects appear underemphasized in this allocation structure. Health Facilities and Equipment receive only 0.92%, despite worker health being a crucial element of construction safety. Similarly, Construction Safety Consultants (0.56%) and Preparation of Construction Safety Plans (0.75%) receive less than 1% allocation - relatively small figures for such strategic components.

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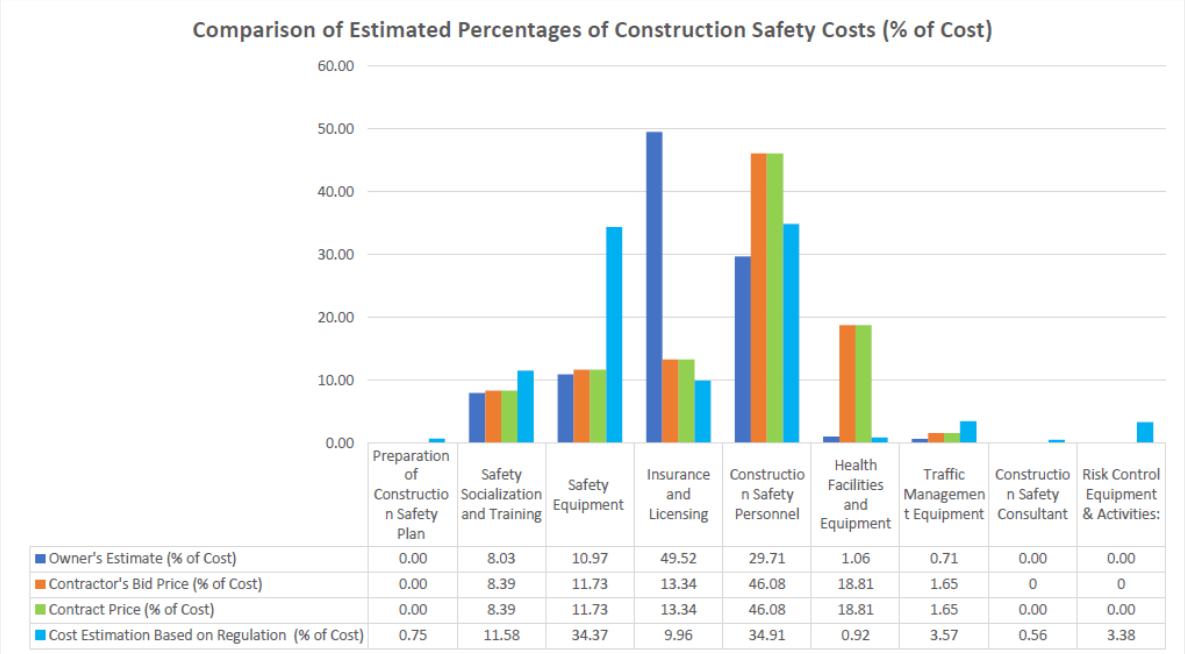

	Preparation of Construction Safety Plan	Safety Socialization and Training	Safety Equipment	Insurance and Licensing	Construction Safety Personnel	Health Facilities and Equipment	Traffic Management Equipment	Construction Safety Consultant	Risk Control Equipment & Activities:
Owner's Estimate (% of Cost)	0.00	8.03	10.97	49.52	29.71	1.06	0.71	0.00	0.00
Contractor's Bid Price (% of Cost)	0.00	8.39	11.73	13.34	46.08	18.81	1.65	0	0
Contract Price (% of Cost)	0.00	8.39	11.73	13.34	46.08	18.81	1.65	0.00	0.00
Cost Estimation Based on Regulation (% of Cost)	0.75	11.58	34.37	9.96	34.91	0.92	3.57	0.56	3.38

Figure 5: Comparison of Estimated Percentage of Construction Safety Cost

The comparative analysis of construction safety cost allocations, as shown in Figure 5, reveals significant disparities between regulatory benchmarks and industry practices. The data demonstrates that while PUPR regulations prescribe a balanced approach with substantial allocations to safety equipment (34.37%) and personnel (34.91%), coupled with meaningful investments in training (11.58%) and risk control (3.38%), actual industry practices show markedly different patterns. Field implementations consistently prioritize insurance coverage (45.32%) and safety personnel (46.08%) while largely neglecting critical components such as safety planning (0% across all industry samples) and consultant services (0%). This misalignment is particularly evident in the area of safety equipment, where practice allocations (10.97-11.73%) fall significantly below regulatory standards (34.37%), suggesting potential underinvestment in preventive safety measures.

The findings highlight several concerning gaps in current safety investment practices. Most notably, the complete absence of budget allocation for safety plan preparation in field implementations contrasts sharply with the regulatory requirement of 0.75%, indicating a systemic undervaluation of strategic safety planning. Similarly, training investments in practice (8.03-8.39%) consistently lag behind regulatory benchmarks (11.58%), potentially compromising workforce safety competency development. The data also reveals inconsistent attention to health facilities, with industry allocations ranging dramatically from 1.06% to 18.81% compared to the regulatory standard of 0.92%, suggesting a lack of standardized approaches to occupational health in construction projects.

These findings carry important implications for both policy and practice. From a regulatory perspective, the substantial gaps identified suggest the need for stronger enforcement mechanisms and clearer implementation guidelines. For industry practitioners, the results indicate opportunities to rebalance safety investments toward more preventive measures, particularly in equipment and training. The findings emphasize the significance of aligning practical safety investments with established regulatory frameworks to ensure comprehensive risk management in construction projects. Additionally, the study identifies potential gaps within existing regulations that may require refinement to more accurately reflect on-the-

ground operational conditions. Future research is recommended to investigate the impact of diverse allocation strategies on safety performance across different types of projects and regional contexts.

CONCLUSION

This study reveals critical gaps between regulatory standards and the practical implementation of construction safety management in Indonesia. The analysis demonstrates systematic underinvestment in preventive safety measures despite clear regulatory requirements, with disproportionate allocation toward reactive approaches like insurance coverage and personnel deployment. These findings highlight fundamental challenges in translating policy mandates into field practices, particularly regarding safety planning, equipment provision, and worker training. The consistent neglect of strategic safety components across all industry stakeholders suggests structural deficiencies in current compliance mechanisms. Importantly, the research identifies three key areas for improvement: strengthening regulatory enforcement, developing standardized risk assessment protocols, and implementing balanced budgeting frameworks that properly weigh both preventive and reactive safety measures. These insights contribute to ongoing global discussions about effective safety governance in emerging construction markets, providing evidence-based recommendations to align operational practices with regulatory expectations while accounting for practical implementation challenges. The study ultimately calls for a paradigm shift in construction safety management, from compliance-driven approaches to more holistic, risk-based investment strategies that genuinely enhance worksite safety outcomes.

REFERENCE

[1] N. F. Ali and M. A. Mansor, "Specify the Priorities of Indicators for Measuring the Performance Success of Construction Projects," *Tikrit Journal of Engineering Sciences*, vol. 29, no. 1, pp. 36–45, 2022, doi: 10.25130/tjes.29.1.4.

[2] M. Luo, B. G. Hwang, X. Deng, N. Zhang, and T. Chang, "Major Barriers and Best Solutions to the Adoption of Ethics and Compliance Program in Chinese International Construction Companies: A Sustainable Development Perspective," *Buildings*, vol. 12, no. 3, Mar. 2022, doi: 10.3390/buildings12030285.

[3] M. O. Sanni-Anibire, A. S. Mahmoud, M. A. Hassanain, and B. A. Salami, "A risk assessment approach for enhancing construction safety performance," *Saf Sci*, vol. 121, pp. 15–29, 2020, [Online]. Available: http://dx.doi.org/10.1016/j.ssci.2019.08.044

[4] A. Munang and I. Nurisusilawati, "Modeling Underlying Pattern Making Construction Safety Risk Mitigation Decisions Using Dynamic Systems," *Jurnal Ilmiah Teknik Industri*, vol. 21, no. 1, pp. 37–48, Jun. 2022, doi: 10.23917/jiti.v21i1.17429.

[5] A. Kadir *et al.*, "Safety Climate in the Indonesian Construction Industry: Strengths, Weaknesses and Influential Demographic Characteristics," *Buildings*, vol. 12, no. 5, May 2022, doi: 10.3390/buildings12050639.

[6] A. Othman I. and Azman, "Safety Misbehaviour and Its Effect Towards Safety Performance of Construction Projects," in *ICACE 2019*, M. R. Awang Mokhtar and Meor M Fared, Ed., Singapore: Springer Singapore, 2020, pp. 193–200.

[7] K. Manik, O. N. Putri, S. F. Azzahra, M. Anda, Juliastuti, and Y. Wijayanti, "Sustainability in Construction Work: A Perspective on Accidents and Building Failure Mitigation in Indonesia," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing Ltd, Aug. 2021. doi: 10.1088/1755-1315/794/1/012065.

[8] F. Lestari, R. Y. Sunindijo, M. Loosemore, Y. Kusminanti, and B. Widanarko, "A safety climate framework for improving health and safety in the Indonesian construction industry," *Int J Environ Res Public Health*, vol. 17, no. 20, pp. 1–20, Oct. 2020, doi: 10.3390/ijerph17207462.

[9] A. Syaiful, R. Arifin, A. Suraji, and D. B. Istijono, "Pengukuran Tingkat Penerapan Norma,

Standar, Prosedur Dan Kriteria Keselamatan Dan Kesehatan Kerja (Nspk K3) Pada Proyek Konstruksi," 2014.

[10] A. Tezel, E. Dobrucali, S. Demirkesen, and I. A. Kiral, "Critical success factors for safety training in the construction industry," *Buildings*, vol. 11, no. 4, Apr. 2021, doi: 10.3390/buildings11040139.

[11] H. Chen, Y. Mao, Y. Xu, and R. Wang, "The Impact of Wearable Devices on the Construction Safety of Building Workers: A Systematic Review," Jul. 01, 2023, *Multidisciplinary Digital Publishing Institute (MDPI)*. doi: 10.3390/su151411165.

[12] L. Albert and C. Routh, "Designing impactful construction safety training interventions," Jun. 01, 2021, *MDPI AG*. doi: 10.3390/safety7020042.

[13] O. Giri, "Factors Causing Health and Safety Hazards at Construction Sites," *Technical Journal*, vol. 2, pp. 68–74, Nov. 2020, doi: 10.3126/tj.v2i1.32841.

[14] A. Onazi, *Application of Dynamic Risk Approach to Mitigate Major Accidents*. 2021. doi: 10.2118/206273-MS.

[15] P.-É. Boileau, "Sustainability and prevention in occupational health and safety," *Ind Health*, vol. 54, pp. 293–295, Jul. 2016, doi: 10.2486/indhealth.54-293.

[16] O. Hadi, "Analyzing Explicit and Implicit accidents workplace costs: .," *International Journal of Scientific Research and Management*, vol. 10, pp. 3530–3539, May 2022, doi: 10.18535/ijsrm/v10i5.em08.

[17] T. Chen and Z. Cao, "Construction safety: an analysis of the cross-influence of economic, construction, and accident death factors," *Environmental Science and Pollution Research*, vol. 28, pp. 1–12, Dec. 2021, doi: 10.1007/s11356-021-15231-4.

[18] N. Ishak, M. Mansor, A. Ahmad, A. Jaafar, and N. Jaffar, "Hindrance in Safety Management Practices in The Construction of Infrastructure Projects," *International Journal of Academic Research in Business and Social Sciences*, vol. 12, Aug. 2022, doi: 10.6007/IJARBSS/v12-i8/14491.

[19] W. Darul and R. A. Saraswati2, "Analisis Implementasi Sistem Manajemen Keselamatan Konstruksi (SMKK) (Studi Kasus Pembangunan Gedung Kantor Pengadilan Negeri Sungguminasa Kelas 1a)," *Journal on Education*, vol. 05, no. 03, pp. 7528–7538, 2023.

[20] I. Sutapa, I. Suasira, P. Hermawati, and I. Dharma, "Analisis Tingkat Risiko Dan Penerapan Smk3 Pada Proyek Pembangunan Rumah Sakit Umum Daerah Mangusada Badung," *Jurnal Ilmiah Poli Rekayasa*, vol. 17, p. 25, Feb. 2022, doi: 10.30630/jipr.17.1.213.

[21] S. Jung and S. Kim, "A study on the scope of the safety and health management system at construction sites to respond to the Severe Disaster Punishment Act," *Forum of Public Safety and Culture*, vol. 16, pp. 173–187, May 2022, doi: 10.52902/kjsc.2022.16.173.

[22] F. Salguero-Caparrós, E. Sánchez-Teba, and G. Bermudez-Gonzalez, "Where is occupational health and safety management research in small and medium-sized enterprises headed? A thematic evolution and bibliometric analysis," *Cogent Business & Management*, vol. 12, Mar. 2025, doi: 10.1080/23311975.2025.2482021.