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Risk Management and Mitigation Strategies for Project Delays in EPCC Contracts

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ABSTRACT

Engineering, Procurement, Construction, and Commissioning (EPCC) is a contractual model in which the contractor is responsible for integrated project delivery from EPCC until handover. This study aims to analyze project delay risks and formulate mitigation strategies in oil and gas EPCC projects. A mixed-method approach (quantitative and qualitative) was employed, combining a questionnaire survey and in-depth interviews with eight senior experts from the contractor side—representing EPCC—each with more than 10 years of experience, to identify and formulate risk mitigation strategies for delays in EPCC projects. The results indicate that major delay risks are associated with changes in material specifications by the owner, delays in engineering document approvals, and poor cash flow from the parent company. Key mitigation strategies include formal documentation of scope changes through site instructions or technical queries, regular coordination meetings among engineering disciplines to accelerate document approvals, and robust project financial planning involving accurate cash flow projections, advance payment negotiations, and optimized payment terms. These findings provide practical guidance for contractors to improve delay risk management in oil and gas EPCC projects.

1. INTRODUCTION

In the project management life cycle of the construction industry, time is of the essence. Time delays can hinder the project's progress, eventually leading to failure [1]. Project delays frequently occur in construction projects, particularly in Engineering, Procurement, Construction, and Commissioning (EPCC) projects in Indonesia [2]. However, complex project scopes and challenging execution environments often lead to delays and inefficiencies [3]. To ensure that the project can continue to run well, the contractor must be able to offer innovative solutions with the latest integrated designs, appropriate construction quality, and methods by focusing on construction cost optimization to select the option through the construction technology system [4].

Various risks can negatively affect the achievement of construction project objectives, including quality, schedule, and cost performance. As EPCC contracts are increasingly adopted for large-scale construction projects, it becomes essential to identify prevalent risk categories and examine their underlying causes in order to develop effective strategies to mitigate or prevent future risks [5]. Project management capability refers to the ability to plan for not only the tasks that must be completed but also the potential issues that may emerge as one is working through tasks [6]. A construction project can be successful if it can be completed according to a predetermined time plan, achieving the required quality and obtaining benefits from the work [7].

Engineering is an idea that comes true with the totality of the system, namely by paying attention to the effectiveness of the whole system for operation and maintenance [8]. At the initial stage of EPCC projects, the design process involves various uncertainties; however, it also presents significant opportunities to improve project value through engineering optimization and effective managerial control [9]. In engineering projects, construction drawings serve as the primary reference for guiding construction activities. During the design phase, limitations in designers' practical experience or insufficient consideration of current technical capabilities may result in drawings that exceed the execution capacity of the construction team. Therefore, maintaining the quality of construction drawings is essential to ensuring overall construction quality [10].

An EPCC project, the procurement process takes much time and has many potential disputes, so it requires a third party as an intermediary [11]. The strategic procurement planning guide emphasizes that the extent of research and analysis conducted should be determined by the project's level of complexity, risk, and value to ensure that procurement strategies remain appropriate and aligned with project needs. A stronger emphasis on strategic procurement planning can enhance the achievement of project development objectives and contractual outcomes [12]. In EPCC projects, procurement commonly involves equipment and materials that are custom-designed and manufactured specifically for project needs. In certain cases, these items are delivered without undergoing adequate inspection and testing at the supplier's facilities to verify compliance with specified requirements. Timely delivery is therefore a critical factor in project success, as delays can adversely affect project costs, quality performance, and overall stakeholder outcomes [13].

Project management serves as the core framework of construction projects, which involve complex and well-coordinated activities aimed at delivering a completed facility or structure. For decades, project performance has commonly been evaluated using the Project Management Triangle (PMT), which emphasizes cost, schedule, and scope as the primary constraints influencing project success [14]. Risk management in the construction project includes identifying, analyzing, and responding to various risks to achieve the project objective. Hence, the risk is considered a negative term in construction projects [15]. Construction risk factors, such as construction delay, change in the work, availability of resources, delayed site access, damage to persons and property, late drawings and instructions, defective design, cost of tests and samples, and actual quantity of works [16]. The construction and design risk had the biggest influence, according to the findings. These included the lack of integrated design experience among the designers and the technical proficiency of the construction workers when performing the hoisting, stacking, and protection of on-site supplies. On the one hand, this study examined a project's entire life cycle, which compensates for the absence of risk analysis and the control being restricted to a particular engineering stage that has been reported in earlier studies [17].

Based on the author’s professional experience, several oil and gas EPCC projects in Indonesia have experienced substantial delays, including the Matindok Gas Development Project in Central Sulawesi, which exceeded its planned 26-month schedule by approximately 12 months. This condition highlights the need for a comprehensive study on delay risks throughout the EPCC life cycle, including the commissioning phase. Therefore, this study aims to analyze delay risks across EPCC phases and to formulate practical mitigation strategies to reduce their impact. The findings are expected to serve as a reference for improving delay risk management in similar EPCC projects.

2. METHOD

The quantitative phase aimed to identify dominant delay risks across the EPCC project phases. Data were obtained through a self-administered questionnaire delivered via Google Forms to employees working for EPCC contractors in oil and gas projects. Respondents were selected using purposive sampling with the following inclusion criteria:

Minimum educational background of high school level.

0-5 years of work experience;

Direct involvement in operational EPCC project activities.

The questionnaire consisted of three main sections:

Demographic information of respondents;

Perceptions and awareness of delay risks in EPCC projects;

Work experience related to EPCC project execution.

Responses were measured using a 5-point Likert scale, ranging from *“rare” to “almost certain”* for risk probability and *“insignificant” to “severe”* for risk impact. This scale was selected to ensure clarity, reduce ambiguity, and provide sufficient variability for statistical analysis. The collected data were analyzed using descriptive statistics, including mean values, frequencies, and percentages.

The qualitative phase was conducted through in-depth interviews to validate quantitative findings and formulate practical risk mitigation strategies. Interviews were carried out with eight senior experts from contractor organizations involved in EPCC projects.

The expert selection criteria (Table 1) were as follows:

Minimum 10 years of experience in EPCC projects;

Holding a strategic or decision-making position within the organization;

Minimum educational background of Diploma (D3) or Bachelor’s degree;

Possession of a recognized Work Competency Certificate.

Table 1. Expert identity description in a deep interview

Expert (Initial)	Position	Study	Work Experience
Expert 1	Supervisor	D3	13-year
Expert 2	Lead Project Control	S1	15-year
Expert 3	Lead Quality Control	S1	18-year
Expert 4	Engineering Manager	S1	16-year
Expert 5	Construction Manager	S1	17-year
Expert 6	Finance Manager	S2	10-year
Expert 7	Marketing Manager	S1	20-year
Expert 8	Division Manager	D3	32-year

The research methodology is illustrated in Figure 1.

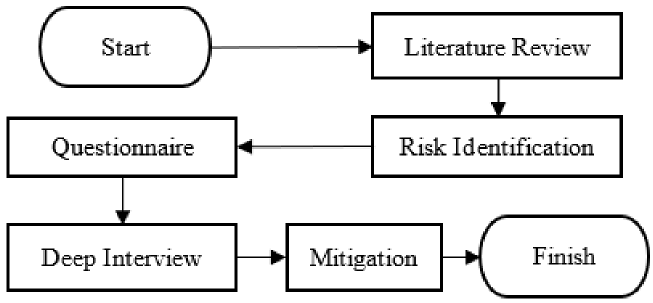

Figure 1. Flow chart of research

3. RESULTS AND DISCUSSION

Risk identification results were obtained through a literature review aligned with the project phases—namely, design, procurement, construction, and the final commissioning stage. These indicators formed the basis of a questionnaire distributed to respondents within the contractor company.

A total of 130 questionnaires were distributed via Google Forms to members of the engineering, procurement, construction, commissioning, and management teams. Of these, 123 responses were received; however, 16 were deemed invalid and excluded from the analysis, resulting in 107 valid questionnaires.

A combined risk rating, also known as the risk score (RS), has been found using a probability and impact matrix in relation to particular combinations of probability and impact values. The score was also used to prioritize the risks for subsequent risk management tasks. The relative severity of RSs is effectively communicated through a graphical probability and impact matrix. The lesson covers the specifics of assessing the risks and effects, as well as how to implement such measures. Additionally, a measure of the risk effect might be assessed by multiplying risk impact (I) by risk probability (P) to create an RS for each risk (Table 2).

$$RS = P \times I \quad (1)$$

Based on the ranking and scree plot methods, 17 high-level risk indicators were identified (Figure 2). These include 8 indicators from the engineering phase, 6 from the procurement phase, and 3 from the construction phase. The results are presented in the form of a risk matrix (Table 3).

Table 2. Indicators causing delays in EPCC projects

Element	Indicators	RS
X1	**Engineering**	
X1.1	The necessary data is incomplete and inaccurate, such as soil investigation data, DED, etc. [18]	11.21
X1.2	Changes requested by the owner, such as changes to material specifications or the addition of new items to accommodate plant operations [18]	13.21
X1.3	Slow productivity of the engineering team, such as the creation of RFQ (Request for Quotation) documents, IFA/IFC drawings, Material Takeoff, and Material Approval [18]	12.18
X1.4	Incompatibility between design (details) and field conditions (constructability), such as steel structures, piping, mechanical systems, etc. [19]	11.76
X1.5	Inaccurate and unsystematic image and document control processes [19]	8.38
X1.6	Lack of coordination and communication with relevant parties, such as owners, consultants/PMCs, or internal contractors (Eng-Proc-Con-Com) [18]	9.49
X1.7	Lack of competence and experience of the team to perform design, design review, and resolve issues in the field [18]	9.95
X1.8	Design changes from other disciplines, such as mechanical, piping, tanks, electrical, etc. [18]	12.34
X1.9	High workload (overload) requiring significant resources [19]	11.34
X1.10	Lack of a complete in-house team, resulting in design work being subcontracted to external parties [19]	9.54
X1.11	Delays in data feeding from other consortium members [20]	9.85
X1.12	Client and/or PMC (Project Management Consultant) is taking too long to approve [19]	13.20
X1.13	Interface issues with existing structures if the work site is located in an existing area [19]	10.81
X2	**Procurement**	
X2.1	Delays in RFQ (Request for Quotation) and MA (Material Approval) documents from Engineering [11]	10.64
X2.2	Lack of communication between external stakeholders (subcontractors, vendors, and suppliers) and the team in the field [19]	9.93
X2.3	Changes in the Scope of Work (SOW) of the work package from Engineering [20]	10.33
X2.4	Material specifications that are not common in the country require them to be imported from abroad [11]	9.87
X2.5	Subcontractor/vendor/supplier offers are not comparable, making it impossible to meet technical, commercial, quality control, and HSE requirements [11]	9.87
X2.6	The review and approval process for contract signatures by both parties (between the main contractor and subcontractor) takes a long time [19]	9.24
X2.7	The selection process for subcontractors, vendors, and suppliers is inadequate and does not follow procedures (conflict of interest) [11]	9.09
X2.8	The manufacturing process for materials in the workshop takes a long time [18]	11.34
X2.9	Packing and handling of materials is difficult due to their large dimensions [18]	7.98
X2.10	The parent company's cash flow is poor, resulting in delayed payments to subcontractors/vendors/suppliers [11]	13.20
X2.11	The customs clearance process at the port takes a long time, causing materials to arrive late at the site [20]	9.64
X2.12	Delays in the delivery of materials such as sand, gravel, rebar, and long lead items from overseas [20]	10.93
X2.13	The project's location and geographical conditions are in a remote area, making it difficult to deliver materials to the site [19]	11.55
X3	**Construction**	
X3.1	Failure to create a Workfront Project Execution Plan (PEP), such as labor requirements, materials, equipment, and site readiness [19]	9.79
X3.2	Lack of communication between relevant parties (Eng-Pro-Con-Com), both internally and externally [19]	9.75
X3.3	Lack of competence among recruited workers, resulting in low productivity in the field [20]	10.00
X3.4	Carelessness when reviewing documents, such as IFC (Issued for Construction) drawings [19]	9.94
X3.5	The impact of the sequence of work on-site, leading to crowded interfaces with other work, such as underground piping work [20]	11.23
X3.6	Damage and poor material quality due to handling processes and prolonged storage in the warehouse [18]	8.86
X3.7	Delays in the delivery of construction equipment such as cranes, pile drivers, excavators, etc. [20]	10.00
X3.8	Errors in the implementation of work methods [19]	9.09
X3.9	Insufficient supervision of work on-site [20]	8.89
X3.10	Construction drawings that are unrealistic and cannot be applied on-site [20]	8.18
X3.11	Insufficient QC oversight leading to rework (repairs) [19]	9.65
X3.12	Construction equipment unable to function properly (damaged), such as cranes, excavators, etc. [19]	8.85
X3.13	HSE issues such as workplace accidents and compliance with owner safety standards like MCU, training, and traffic management [19]	8.99
X3.14	Worker protests due to issues with local labor recruitment or other issues, such as wages [20]	9.46
X4	**Commissioning**	
X4.1	Delays in closing punch lists and safety diagnoses or PSSR (Pre-Startup Safety Review) [21]	9.89
X4.2	Limitations on the commissioning team's work area due to other activities that could interfere, such as X-rays on pipes [22]	8.15
X4.3	Delays in the handover of documents from QC to the precommissioning team [23]	8.25
X4.4	Outstanding remaining work from other disciplines, such as civil, mechanical, electrical, and piping work [22]	9.93

X4.5	Limitations in manpower and equipment for precommissioning activities such as hydrotests/leak tests, flushing/blowing, solo runs, N2 purging, terminations, and loop tests [24]	8.53
X4.6	Additional work is required due to non-compliance with safety/security standards during operations, e.g., additional handrails, stairs, platforms, etc. [25]	8.79
X4.7	Delays in the delivery of materials and equipment for the precommissioning process, such as compressors, blowers, nitrogen, generators, fuel, etc. [22]	8.96
X4.8	Availability of power supply for running mechanical static and rotating equipment during precommissioning activities [26]	8.56
X4.9	Availability of supporting facilities (utilities) for precommissioning activities, such as eyewash stations, firefighting equipment, retention ponds, shelters, etc. [27]	7.76
X4.10	Damage or leaks in installed equipment during performance testing [13]	8.67
X4.11	Operators hired by the owner are not yet proficient in system operation, such as in the control room [10]	8.07

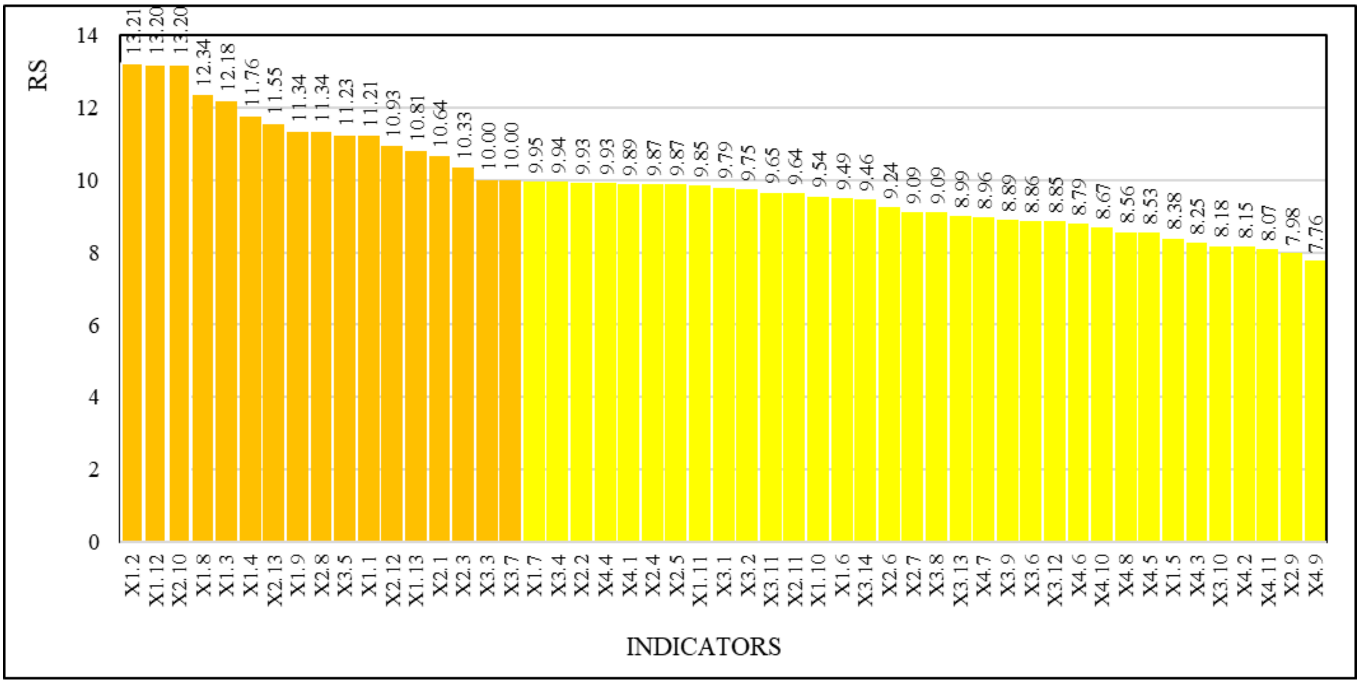

Figure 2. Risk ranking

Table 3. Risk matrix

Frequency	**Impact**				
	1. Insignificant	**2. Minor**	**3. Significant**	**4. Major**	**5. Severe**
5. Almost Certain **4. Likely**					
3. Moderate			X1.7; X3.4; X2.2; X4.4; X4.1; X2.4; X2.5; X1.11; X3.1; X3.2; X3.11; X2.11; X1.10; X1.6; X3.14; X2.6; X2.7; X3.8	X1.2; X1.12; X2.10	
2. Unlikely				X3.13; X4.7; X3.9; X3.6; X3.12; X4.6; X4.10; X4.8; X4.5; X1.5; X4.3; X3.10; X4.2; X4.11; X2.9; X4.9	X1.8; X1.3; X1.4; X2.13; X1.9; X2.8; X3.5; X1.1; X2.12; X1.13; X2.1; X2.3; X3.3; X3.7
1. Rare					

Table 4. Mitigation of high risk

Code	**Mitigation**
X1.2	Request the owner to include a clause in the contract regarding design changes that can be claimed in terms of cost and time, such as Site Instruction (SI) or Technical Query (TQ). Stated in the form of Q&A during the tender phase (Aanwijzing). Ensure that the engineering stage is in accordance with the requirements. Hire proper, competent, and experienced engineering.
X.12	Conduct co-nengineering with owners from various disciplines so that all engineering documents can be evaluated and their approval process monitored. • Ensure that the contract contains a time period for the recycle approval document process, for example, 2 or 3 recycles for 7 working days. Create a record in a system such as the Engineering Document Management System (EDMS) to monitor documents during the

	approval document submission process.
	Request the PMC to carry out the document approval process at the project site.
X2.10	Create a good cash flow plan so that it can be monitored properly.
	Form a consortium with other companies that have good cash flow.
	Look for subcontractors/vendors/suppliers who have good financial conditions.
	Payment method with SCF (supply chain financing) facilities with banks.
	Request for DP (down payment) to the owner so that there is initial business capital that can be managed.
	Ensure that the term of payment (TOP) is stated in the contract, such as monthly progress or milestones.
	Request the owner to include a clause in the contract regarding design changes that can be claimed in terms of cost and time, such as SI or TQ. Stated in the form of Q&A during the tender phase (Aanwijzing).
	Make payments to subcontractors according to their priority level; for example, ongoing projects are the first priority, and completed projects are the second priority.
	Request funds from a state-owned company in the form of state capital participation (SCP), then make payments for large amounts.
	Arrange mapping of payment patterns or systems to subcontractors, for example, terms of 3 months or 4 months.
	Issuance of LC (Letter of Credit) for overseas vendors, then TOP is arranged according to work progress.
	Restructuring MRAs (Master Restructuring Agreements), such as arranging cash-out payments to subcontractors/vendors.
X1.8	Design from previous experience with a contingency of several percent.
	Form an interface team & conduct IDC (Inter Discipline Check) on work in the field.
	Form an advisor team to carry out designs that are in accordance with requirements.
X1.3	Make a good manpower loading plan for the engineering team.
	Hire competent and experienced engineers.
	Monitor documents that have been submitted to the owner or PMC.
X1.4	Make modeling on BIM software such as Navis, Tekla, Revit, etc.
	Hire a project engineer (PE) to communicate with other disciplines.
	With good document control, documents distributed in the field are the latest documents (the latest drawing).
X2.13	Need good material management using software such as SAP (System Application and Product).
	Mapping & monitoring of goods delivery via land and sea, such as ship schedules.
	Create off-site storage for materials from outside the site.
	There is a PIC as an expediter who ensures the delivery of goods.
	Create a temporary jetty to facilitate the loading and unloading of materials.
X1.9	Adopt the Lean Construction method.
	Add personnel to increase productivity.
	Make plans for personnel needs (manpower loading), both direct and indirect, according to the load on each section.
X2.8	Provide down payments to subcontractors or fabrication vendors so that the fabrication process can be carried out immediately.
	Issuance of a purchase order (PO) to subcontractors is used as a milestone for billing to the owner so that it can be billed to the owner.
	Appoint a PIC Expediter to supervise and monitor the fabrication process in the workshop, including delivery to the site.
	Ensure that production capacity is sufficient according to project needs (schedule).
	Ensure that the drawings received by the fabricator are the final drawings and prioritize the priority scale of construction.
	Ensure that the subcontractor's cash flow is not disrupted.
X3.5	Coordination and communication with other disciplines at every safety morning talk or regular meeting (daily).
	Appoint a construction engineer to monitor the implementation of interdisciplinary work in the field.
X1.1	Create a TQ for the owner to collect new data from the field.
	Re-check the project data in the tender given by the owner.
X2.12	Look for local material sources from other places, quarry more than one location, and create a larger stockyard.
	Appoint third-party expediters such as TUV Rheinland, Sucofindo, BKI, etc., including supervision and inspection of materials abroad.
	Create a special team for long lead item materials from fabrication to delivery to the site.
	More intense communication with subcontractors/vendors.
	Monitor shipments, such as ship schedules, ship routes, travel times, and customs, to avoid demurrage.
X1.13	Request as-built drawings from the owner and conduct test pits in the existing area.
	Conduct SIMOPS (simultaneous operations) with the existing owner.
X2.1	Add engineering team personnel to increase engineering team productivity.
X2.3	Changes in the scope of work are stated in the contract so that claims can be made for both time and cost.
X3.3	Recruit workers who have competent qualifications with screening in the administration section and validation of field practices.
	Add workers if their productivity is low.
	Provide motivation by means of a persuasive approach to workers.
	Plan direct manpower well by considering low productivity.
	Form a JO Direct Management or Task Force team to catch up on the schedule.
X3.7	Looking for other equipment from local communities or those closest to the project location, according to construction needs.
	Monitoring shipments, such as ship schedules, ship routes, travel times, and loading-unloading processes at the port.

Based on expert validation of all identified factors, recommendations were provided to refine and specify the risk descriptions. In-depth interviews were conducted with subject matter experts to explore mitigation strategies for high-level risks, aiming to reduce their severity to moderate or even low levels (Table 4).

In summary, prioritized mitigation strategies for high-level risks are not only theoretically sound but also operationally and financially feasible within the local context. The most immediately actionable strategy can be implemented during the engineering phase. If any changes occur in the scope of work, a coordination meeting should be held to discuss these changes, and the outcomes must be documented in the meeting minutes.

4. CONCLUSIONS

This study investigated delay risks in oil and gas projects executed under EPCC contracts and formulated practical mitigation strategies based on expert judgment and empirical data. The findings indicate that the most critical delay risks originate from engineering changes initiated by the owner, slow approval of engineering documents, material procurement constraints, and contractor cash flow instability.

Effective mitigation measures include formalizing scope changes through contractual mechanisms such as SIs and TQs, strengthening interdisciplinary coordination during the engineering phase, and implementing robust document control systems. In addition, proactive financial management—such as accurate cash flow planning, optimized payment terms, advance payments, and collaboration with financially stable partners—plays a crucial role in reducing schedule delays.

The findings provide practical guidance for project owners, contractors, and project management consultants in improving delay risk management under EPCC contracts. Future research is recommended to develop quantitative risk modeling approaches, evaluate the effectiveness of the proposed mitigation strategies across different project scales, and integrate digital project management tools to enhance risk monitoring and decision-making in complex EPCC projects.

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REFERENCES

[1] Sarwani, Baihaqi, I., Utomo, C. (2024). Causes of delay in EPC projects: The case of Indonesia. International Journal on Advanced Science, Engineering and Information Technology, 14(2): 618-628. https://doi.org/10.18517/ijaseit.14.2.19744

[2] Ade, F.A., Santoso, S. (2023). Delay factor analysis and dynamic system modeling on the EPC project of liquid petreleum gas tank in Kupang. Journal Research of Social, Science, Economics, and Management, 2(6): 1187-1202. https://doi.org/10.36418/jrssem.v2i06.381

[3] Alkatiri, S.M., Riantini, S.L., Sentosa, O.B.B. (2025). Risk identification and analysis in engineering, procurement, and construction (EPC) projects at mining facilities by PT. XYZ. International Journal of Science, Technology & Management, 6(4): 675-678. https://doi.org/10.46729/ijstm.v6i4.1323

[4] Natasasmita, T.U., Herwindiati, D.E., Anondho, B. (2024). Current challenges of multidisciplinary industrial construction projects: A study of the EPC design model on cost performance in Indonesia. International Journal of Structural and Civil Engineering Research, 13(1): 14-23. https://doi.org/10.18178/ijscer.13.1.14-23

[5] Khairullah, N.H., Hilal, M.A., Mohammed, A. (2022). Identification of the main causes of risks in engineering procurement construction projects. Journal of the Mechanical Behavior of Materials, 31(1): 282-289. https://doi.org/10.1515/jmbm-2022-0029

[6] Tran, T.V., Nguyen, T.A., Hoang, T.M. (2024). A study on the enhancement of the large-scale construction project capability of project management boards. Engineering, Technology & Applied Science Research, 14(3): 13804-13814. https://doi.org/10.48084/etasr.6963

[7] Lubis, A.M., Widyarini, M., Sunardi, O. (2023). Risk mitigation in supply chain disruption during pandemic covid-19 in EPC project, study case Pt Xyz. Jurnal Ekonomi, 12(4): 1404-1416.

[8] Kahfi, A., Bintoro, B.P.K., Nugroho, R.E. (2024). Risk factor analysis of planning stage of lumpsum hydropower EPC project impacted to quality and time performance. International Journal of Science and Research, 9(12): 249-257. https://doi.org/10.21275/SR201126170057

[9] Li, Q., Guo, Y., Wang, B., Chen, Y., Xie, J., Wen, C. (2023). Research on risk evaluation of hydropower engineering EPC project based on improved fuzzy evidence reasoning model. Systems, 11(7): 327. https://doi.org/10.3390/systems11070327

[10] Zhao, Z.Z., Meng, Q., Pang, N. (2020). Research on quality risk assessment of EPC projects for transmission and distribution engineering based on design enterprises. IOP Conference Series: Earth and Environmental Science, 571(1): 012022. https://doi.org/10.1088/1755-1315/571/1/012022

[11] Andaru, G.R., Adi, W.T.J. (2024). Risk analysis of e-procurement process of EPC construction project based on risk management. Jurnal Indonesia Sosial Teknologi, 5(3): 1286-1295. https://doi.org/10.59141/jist.v5i3.985

[12] Mohammed, A. (2023). Evaluation of the procurement management system for residential complex projects in Erbil governorate. Journal of Engineering and Sustainable Development, 27(1): 54-67. https://doi.org/10.31272/jeasd.27.1.5

[13] Berawi, M.A., Soepardi, A., Sayuti, M.S. (2020). Risk analysis on the equipment and material procurement process of engineering, procurement, and construction (EPC) projects. International Journal of Real Estate Studies, 14(1): 78-90. https://doi.org/10.11113/intrest.v14n1.137

[14] Kabirifar, K., Mojtahedi, M. (2019). The impact of Engineering, Procurement and Construction (EPC) phases on project performance: A case of large-scale residential construction project. Buildings, 9(1): 15. https://doi.org/10.3390/buildings9010015

[15] Pawade, S., Patil, V., Kadam, P., Bhoir, P., Dhurve, S. (2022). Effective risk management in construction projects. International Journal of Civil Engineering, 9(5): 1-4. https://doi.org/10.14445/23488352/ijce-v9i5p101

[16] Niroula, T.R., Poudel, M.K., Kayastha, G.P. (2024). Risk assessment in selected hydropower projects of nepal under engineering, procurement and construction (EPC) contracts. In Proceedings of 15th IOE Graduate Conference, pp. 186-194.

[17] Cao, P., Lei, X. (2023). Evaluating risk in prefabricated building construction under EPC contracting using structural equation modeling: A case study of Shaanxi Province, China. Buildings, 13(6): 1465. https://doi.org/10.3390/buildings13061465

[18] Yapputro, P.A., Trisetya, A.A.A., Cheriesta, J. (2023). Sipadan and Ligitan Island sovereignty disputes: Foreign policy analysis of Indonesia and Malaysia in resolving

international conflicts. Journal Research of Social Science, Economics, and Management, 2(9): 2223-2233. https://doi.org/10.59141/jrssem.v2i10.446
[19] Firdausy, F., Isvara, W. (2023). Risk analysis and recommendations to improve the logistics cost performance of the EPC Project at remote area. Journal Research of Social Science, Economics, and Management, 2(10): 2428-2448. https://doi.org/10.59141/jrssem.v2i10.442
[20] Hatmoko, J.U.D., Khasani, R.R. (2019). Mapping delay risks of EPC projects: A case study of a platform and subsea pipeline of an oil and gas project. IOP Conference Series: Materials Science and Engineering, 598(1): 012095. https://doi.org/10.1088/1757-899x/598/1/012095
[21] Federica, D.V. (2020). Pre-startup safety review performance and close-out management for a new licensed petrochemical plant. Chemical Engineering Transactions, 82: 25-30. https://doi.org/10.3303/CET2082005
[22] Setiadi, D.F.P., Nurcahyo, R. (2021). Critical success factors during execution of EPCC national strategic project in Indonesia. In 11th Annual International Conference on Industrial Engineering and Operations Management, IEOM 2021, pp. 565-575. https://doi.org/10.46254/AN11.20210115
[23] Prochazkova, D., Prochazka, J. (2020). Risk management plan for process associated with technical facility designing, construction and commissioning. In Proceedings of the 30th European Safety and Reliability Conference and 15th Probabilistic Safety Assessment and Management Conference, pp. 564-571. https://doi.org/10.3850/978-981-14-8593-0_4053-cd
[24] Colmenarejo, S.J.I., Camprubí, M.F., González-Gaya, C., Sánchez-Lite, A. (2022). Power plant construction projects risk assessment: A proposed method for temporary systems of commissioning. Buildings, 12(8): 1260. https://doi.org/10.3390/buildings12081260
[25] Antonov, A.E., Buică, G., Beiu, C., Dobra, R. (2022). Management of occupational safety and health in the commissioning of defective work equipment in the manufacturing industry. MATEC Web of Conferences, 373: 00068. https://doi.org/10.1051/matecconf/202237300068
[26] Zadeh, M.R.M., Qayoumi, A. (2023). Investigation and ranking the causes of delay in EPC projects of nonindustrial buildings of 9, 10, 19, 20 and 21 phases of South Pars of Iran. Journal of Project Management, 8(1): 37-44. https://doi.org/10.5267/j.jpm.2022.8.003
[27] Lokeshwaran M, Aswin Bharath A. (2023). A literature review on developing causes and mitigation strategies of delay in construction projects: Gaps between owners and contractors in successful and unsuccessful projects. International Journal of Advanced Research in Science, Communication and Technology, 3(2): 822-830. https://doi.org/10.48175/ijarsct-8925