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Causes of Delay in EPC Projects: The Case of Indonesia

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***Abstract*—The construction industry is a significant part of the economy in developing countries. During Indonesia's 2010-2020 period, many large-scale EPC projects were launched to build new plants and infrastructure facilities. However, most of these projects experienced delays. This research aims to identify the causes of delays in EPC projects in Indonesia. It also investigates whether specific characteristics of EPC projects within the fertilizer industry in Indonesia, particularly those associated with state-owned companies, contribute to these delays. Data was collected through questionnaires with samples from company construction experts involved in EPC projects consisting of 41 owners, 14 contractors, and 12 consultants. The Relative Importance Index (RII) was subsequently computed, revealing the top ten delay causes for EPC projects in Indonesia based on the highest RII values consisting of delays in procuring equipment/materials, contractor difficulties in funding the project, ineffective project planning and scheduling, the winner of the tender is the lowest bidder, rework due to errors during construction, poor communication and coordination between parties involved in the project, delays in the work of design, disputes in understanding the EPC contract and project specification, unrealistic the duration of the project and delays in the owner's decision. Comparison of delay factors with other developing countries in Asia and Africa shows similarities. Notably, among these categories, contractor-related factors demonstrated the highest RII values. Spearman's rank correlation coefficient shows that all respondents highly agreed with the individual ranking of delay factors.**

***Keywords*—Delay factors; EPC project; design and build; construction sustainability; Indonesia.**

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I. 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. Project delays will cause several problems, such as increased project costs, loss of output, and contract cancellation [1]. The project's delayed completion has specific effects on the business. Customer complaints have a negative impact on the company's reputation and reduce customer satisfaction. Project delays raise project costs and cause budget overruns. Members of the project team have lower morale, and the delay has caused relationships to become more distrustful. The other effect is that there will be less trust for the next project from vendors, suppliers, consultants, and other third parties [2]. Delays in construction not only result in subpar work and a higher chance of accidents at work, but they also cause managers to face moral challenges in their careers [3]

The contractor is responsible for all EPC contract implementation of all engineering, procurement, and construction projects. Because the contract form is a lump sum turnkey and the determination of the winner during the tender uses the lowest price, the contractor is exposed to multiple risks. This can cause project delays if the contractor cannot anticipate risks that affect the bid price [4].

There are still a lot of claims and disagreements between customers and service providers, and it takes a lot of time, money, and effort to resolve them. Due to the frequent and recurrent nature of claims and conflicts, it is essential to have a solid understanding of how to prevent and limit these events and their effects. The auditor part of the study results from the auditor's conclusion that overpayments to service providers result in a loss for the state. Although the lumpsum payment mechanism adheres to the EPC contract, it is one of the factors generating claims [5].

A Lump Sum Turnkey (LSTK) contract is a construction agreement wherein the contractor agrees to provide the owner with a completed project at a specific cost and on a

predetermined schedule. Under an LSTK contract, the Contractor is solely responsible for the project's design, engineering, procurement, construction, and commissioning. [6] The construction business uses various procurement techniques, each with a different success rate. Because the Design and Build (D&B) method's unique qualities of combining design and construction have successfully addressed the issues with the traditional Design-Bid-Build (DBB) technique, its popularity has been rising globally. Projects with delivery like this are expected to experience many delays and exceed costs. However, if the factors causing delays can be identified and understood early, this can be prevented or at least reduced during the life cycle of a project [7]. Root causes of early contract termination (ECT) in projects implementing D&B contracts were deficiencies in the bidding evaluation process, which led to an inadequate selection of the general contractor, lack of experience of the owner, and regulatory limitations of the legal framework for public projects [8]

Sustainable building is crucial when it comes to reducing negative environmental effects and enhancing health and quality of life. Choosing the correct delivery method is vital, particularly for sustainable building projects with distinctive features that set them apart from conventional construction projects. The relative weights of these selection criteria were then evaluated by a survey sent to construction professionals, utilizing an analytical hierarchy process. In addition to scope-related factors, the results showed that the three most significant categories of selection criteria were level of integration, technology, and innovation [9].

In general, the type of project delivery in the fertilizer industry in Indonesia is D&B. In preparing the EPC project, they have planned well, referring to the success of previous projects. Best practices that contributed to the success of prior projects have been implemented, and lessons learned that contributed to project delays have also been mitigated. However, ninety percent of EPC projects in the 2010-2020 period experienced delays, and there were difficulties in resolving disputes with contractors.

This paper contributes to the existing body of knowledge regarding delay factors of EPC projects in Indonesia. The main objective is to identify critical delay factors commonly occurring in EPC projects in Indonesia where the delivery type is D&B and belongs to a state-owned company. There are two research questions: what are the critical delay factors that cause delays in EPC projects in Indonesia, and whether the characteristics of D&B delivery and its state-owned owners have an essential influence in contributing to these delays?

Previous investigations and studies have found several reasons contributing to delays, but most of them have ended without offering substantial or practical remedies. This study will deliver the measures/solutions accordingly. Then, persuade whether the identity of the D&B delivery project owned by the state company impacts project delays.

The rest of this paper is organized as follows: The structure complies with the logical processes of formulating the research questions, developing methodology, collecting and evaluating data, concluding with a discussion of the findings, and offering recommendations.

A. Basic Concept Theory of Delay

Delays in construction projects are common issues and global phenomena and are not beneficial for all stakeholders because they involve significant resources, require specialization, and have high complexity [3]; [10]. Every construction project worldwide has experienced delays, which is a common problem. In both industrialized and developing nations, delays in the construction sector are a frequent occurrence [10]. Every company involved in a project knows that delays are expensive, and they frequently lead to disputes, accusations, gross negligence, even more challenging viability, and a delay in the expansion of the construction sector [11].

A time delay occurs when the project's actual duration—the time needed to complete the task—exceeds the time estimates provided by the contractors and the project owner or when the completion date specified in the contract document is surpassed [1]. The project's delayed completion has specific effects on the business. Customer complaints have a negative impact on the company's reputation and reduce customer satisfaction. Project delays raise project costs and cause budget overruns. Members of the project team have lower morale, and the delay has caused relationships to become more distrustful. The other effect is that there will be less trust for the next project from vendors, suppliers, consultants, and other third parties [2].

B. Previous Related Studies

A study by [12] assessed the patterns and areas of interest in building delay research during the previous 20 years and pinpointed any knowledge gaps. Multiple data analysis methodologies are used in the construction delays literature research, utilizing qualitative and quantitative research approaches. Descriptive statistics are among the most used methods.

A previous study [13] used a fuzzy optimization technique and compound index to assess construction delays in the Hyderabad construction industry thoroughly. 67% of late cases are significantly affected by Owner/Client related factors, Consultant-related factors, and Scheduling. Product-related factors, as well as rules and regulations, have a low influence on delays.

A project by [14] examined the causes of construction delays in Bangladeshi public, mixed, and privately funded building projects. The overall RII ranking of the 37 delay factors showed “Construction mistakes and defective work,” “Contract modifications by the client,” and “Adverse weather conditions” as the top three factors causing the delay. For public-funded projects, “Construction mistakes and defective work” and “Slow decision-making by a consultant” are the top delay factors. For mixed projects, “Slow decision making of the client” and “Construction mistakes and defective work ranked top, and for private-funded projects, “Financial problems and payment delay of the client” and “Adverse weather condition” ranked top.

Another study by [15] identified, assessed, and prioritized the primary factors causing schedule delays in Saudi Arabian oil and gas pipeline projects. Initially, a comprehensive literature analysis yielded 47 distinct causes, refined through interviews with two regional authorities. These causes were ranked by distributing and analyzing questionnaires on the

topic. The top five major causes are Client-related materials, delays in materials and equipment delivery, permit approval, delays in subcontractor work, and delays in preparing and approving engineering drawings.

Factors contributing to construction project delays were identified, the most common reasons for delays were listed, and helpful suggestions for resolving the raised concerns in Cambodia's construction industry were offered [10]. The top ten substantial delay factors are poor planning and scheduling, late delivery of material, change of scope by owners during the construction phase, poor site management and supervision, insufficient finances of contractors or sub-contractors, lack of experience of the contractor's team, delay due to design error, low productivity of labor, delay in process payment by the owner, and delay in the decision making of the owners and consultants.

Previous research [11] revealed that many studies that remain delayed in construction projects are the subject of research; this is also the case with construction projects in India. Consequently, it is necessary to find the source of the delay more specifically. The views of 142 construction specialists from client, consultant, and contractor groups were obtained through a survey. Then, the data are ranked using a weighted relevance score considering frequency and severity. The top five are contractors' financial difficulties, inadequate planning and scheduling, late progress payment for completed work, incompetent site administration and oversight, and many changes requested.

The report analyzed the reasons behind delays in EPC contracts for nonindustrial buildings in Iran by reviewing relevant prior studies and conducting multiple interviews with subject matter experts. Next, 52 specialists involved in the South Pars project were given a questionnaire, and factor analysis and descriptive statistics were used to examine the responses. Descriptive analysis revealed that "Inflation and escalation of material prices and human resources salaries," "Unrealistic contract duration and requirements imposed," and "Political situation" were the most significant delay factors. Meanwhile, factor analysis indicates that "Improper construction methods," "Shortage of experienced and skilled labor," and "Long acceptance process (shop drawings, permits, tests, and samples)" were the most important causes of delay [17]

Because the delay factor identified in the previous study quantitatively showed little difference regardless of the time and area of the study, [3] conducted a qualitative study to discuss the delay factor more deeply by reviewing experts to find out the cause of the delay. This qualitative study showed the 'real' causes of construction delays, such as a short initial construction contract period, lack of site managers, rework, and design errors.

The study examined the leading causes of the Malaysian Ministry of Home Affairs (MOHA) when implementing physical projects. Contractors, consultants, end users, and customers comprised the respondents who participated in the survey on the causes and consequences of physical project delays. The data were analyzed using the relative importance index (RII) and Spearman's correlation to determine the most critical delay factors and their relationships to delay effects. There were 38 delay factors found in all, with contractor-related issues being the most important. Consultant-related, client-related, and other factors came in second and third. The effects were positively connected with these delay variables, which include abandonment, quality, litigation and arbitration, time and expense overruns, and litigation [18].

C. Research Opportunities

There are still many opportunities for future research on delay factors. Several recent studies recommend future research. A study by [15] revealed that future research should examine the reasons behind building delays for various projects and nations. Additional research should clarify the economic impact of delays in developing oil and gas projects. According to [19], in the future, researchers can quantify the effects of each of these aspects by conducting case studies and employing simulation studies. This can assist in formulating an appropriate plan of action. Lastly, it is suggested that future researchers investigate the effects of using cutting-edge technologies in the building sector in light of PDs.

Future studies will identify the causes of delays that significantly impact construction project expenses. Contractor companies working on construction projects are expected to use these delay factors as a guide to prevent losses [20]. Subsequent research is necessary to address the issues around evaluating BIM's significance and possible use in delays. The reviewed literature and articles do not indicate whether the Indian construction sector has used any instruments to apply the BIM process to reduce construction delays [12].

D. Characteristics of EPC Projects in Indonesia's

The fertilizer industry is incorporated in the Indonesian fertilizer holding company, a state-owned company that influences how subsidiaries conduct their EPC projects. In general, the project delivery type implemented in the fertilizer industry is EPC, where one party performs the design and construction of the project. Hence, the contractor's responsibilities are clear, from design and construction to performance guarantee.

The findings show that varied perspectives exist among the stakeholders in a project that employs the EPC contract paradigm. Particularly for EPC contracts funded by the Indonesian government, it gives rise to claims and conflicts amongst the parties, owner, Service Providers (Consultants and Contractors), and State Auditors. It is evident that construction service providers still attribute most claims and disputes to third parties [5].

State-owned enterprises (SOE) prefer to assign a third company as a contractor under an EPC/Turnkey contract for a lump sum. Because government regulations have not been obligatory, many claims and conflicts have arisen [5]. The researcher observes two characteristics that contribute to the delay in the EPC project, namely (1) the slowness of management decisions regarding change orders and resolving contract disputes and (2) the procurement method being the single stage with the lowest bid as the winner.

Another study by [21] compared the time and cost performance of DB projects using a one-stage low-bid, two-stage best value, and qualification-based procurement methods. They discovered that the two-stage best-value procurement method has the least cost and time growth, followed by a one-step, low-bid, qualification-based procurement method. Because the scope of work is typically

clearly specified and around 35% of the design is included in the proposal request, two-stage procurement at the best value has generally improved performance. In other words, there is a high likelihood of disagreements arising over the meaning of the clauses in the EPC contract and the project specifications in a one-step procurement.

II. Material and Method

This study used a quantitative survey methodology to investigate the factors contributing to delays in Indonesia's fertilizer industry's EPC project. The development of the questionnaire, data-gathering methods, and data analysis techniques are covered in this section.

A. Questionnaire Development and Identification of Delay Factors.

The questionnaire survey was created using the results of a Focus Group Discussion (FGD) that experienced managers who had worked on various EPC projects participated in. Managers were asked to identify delay issues during the focus group discussion (FGD) based on their knowledge and actual data collected from the close-out reports of prior projects. The delay variables found in earlier studies were then used to synthesize these data. There were 21 delay factors in total, and they were divided into seven main groups: Project-related, Owner-relative, Contractor-relative, Design-related, Material/ Equipment-Related, Labor-Related, and External-Related.

The questionnaire is divided into two sections, concentrating on the respondents' personal information and the causes of project delays. Based on their level of involvement in project delays, these factors were graded using a five-point Likert scale: “5” (very influential); “4” (influential); “3" (quite influential); "2" (less influential) and “1 " (least influential).

B. Data Collection

The following information was gathered through an internet poll that was directed at experienced managers who were involved in Indonesian fertilizer sector EPC projects that were finished during the last ten years:

- The owners are Pupuk Indonesia personnel and its subsidiaries
- The contractors are the EPC contractor personnel and its subcontractor
- Consultants are parties who carry out design work from basic engineering to detailed engineering, including licensors.

Of the 100 surveys, 67 respondents (or 67%) returned complete questionnaires. Most respondents (76.4 percent) have more than ten years of experience in the construction sector; the majority (47 percent) are project managers. Most respondents (61%) had postgraduate degrees, and 56.9% were older than 50.

C. Data analysis Approach

Relative Importance Index (RII), using a five-point Likert scale, is applied to determine the relative importance of the various delay causes. For overall analysis, the RII of each reason was computed by all respondents. The most significant variables or causes of delays in EPC projects in Indonesia were to be determined from the rating given to each source of delay. Equation (1) uses the relative important index (RII) as its input:

$$RII = \frac{\sum W}{A*N} \quad (1)$$

where A is the most significant weight (in this case, 5), N is the total number of respondents, W is the respondents' weighting (ranging from 1 to 5), and A is the highest. The range of the RII value was 0 to 1 (0 is not inclusive). The more significant the source or consequence of delays, the higher the value of RII.

The non-parametric test Spearman's rank correlation coefficient. It is used to gauge the level of agreement amongst the three respondents' rank-based categories. The connection between owners, contractors, and engineers about their understanding of the issues contributing to delays at the EPC project in Indonesia was tested. A perfect positive relationship (agreement) is implied by a correlation coefficient of +1, while a perfect negative relationship (disagreement) is indicated by a correlation coefficient -1. The conclusion is that values near 0 suggest little or no correlation, while sample estimates of correlation close to unity in a magnitude imply excellent correlation. Using Equation (2), Spearman's Rank Correlation is calculated:

$$Rs = 1 - [(6 \sum d^2)/(n^3 - n)] \quad (2)$$

where d is the difference between the ranks given to the variables for each reason, n is the number of rank-by-rank pairs, and Rs is Spearman's rank correlation coefficient between two parties.

III. Results and Discussion

Two additional secondary research questions are added to obtain a more thorough analysis that considers the actual reason for the delay in the Indonesian Fertilizer EPC project and how different respondents perceived it.

A. Numerical Results

The information gathered from the respondents was evaluated from the owner, consultant, contractor, and overall perspectives after being calculated for their RII. Table 1 displays the RII value and ranking of each source of delay. Based on the comments from each respondent (owners, consultants, and contractors), Table 2 ranks the causes. The RII and rating categories of delay, as observed by each responder, are summarized in Table 3. Table 1 shows the ten most essential causes of EPC project delays as perceived by all respondents.

TABLE I
RANKING CAUSES OF DELAYS (BASED ON OVERALL PARTICIPANTS)

Cause of Delays	RII	Rank
Project Related		
Disputes in understanding the clauses in the EPC contracts and PS	0.830	8
The project winner is the lowest bidder even though it is far below the OE	0.857	4
Owner Related		
Unrealistic determination of the duration of the contract	0.827	9
Delay in reviewing and approving engineering documents	0.785	13
Delays in the owner's decision to approve a change proposal from the contractor or resolve contract disputes	0.815	10
Owner intervention	0.699	20
Contractor Related		
Contractor difficulties in funding the project	0.896	2
Rework due to errors during construction	0.848	5
Ineffective project planning and scheduling by contractors	0.884	3
Poor communication and coordination by the owner and other parties	0.836	6
Poor site management and supervision (Inadequate competency of contractor staff)	0.815	10
Conflicts between contractors and their sub-contractors during the preparation of project implementation schedules	0.788	12
Differences in technical standards and specific deliverable documents for foreign contractors (e.g., EPC from China)	0.740	15
Design Related		
Delays in the work of design sub-contractors	0.833	7
Material/Equipment Related		
Damage to equipment/materials during delivery or storage in the field is not good	0.728	17
Delays in procurement of equipment/materials	0.910	1
Labor Related		
Low supply and productivity of local labor	0.779	14
External Related		
Obstacles in obtaining permits from the government	0.794	11
Effect of high rainfall on construction activities	0.737	16
The influence of social disturbance and local culture	0.704	19
Sub-surface conditions (unforeseen) at the site	0.722	18

TABLE II
COMPARISON OF THE TOP TEN OF RII BASED ON EACH RESPONDENT

No	Owner	RII	Consult.	RII	Contract.	RII
1	Obstacles to obtaining permits from local and central government	0.922	Ineffective project planning and scheduling by contractors	0.883	Unrealistic determination of the duration of the project by the owner	0.929
2	Rework (rework) due to errors during construction	0.912	Delays in procuring equipment/materials needed by the project	0.883	The winner of the tender is the lowest bidder even though it is far below the OE	0.914
3	Conflicts between contractors and their sub-contractors during the preparation of project implementation schedules	0.883	Contractor difficulties in funding the project	0.867	Delays in procuring equipment/materials needed by the project	0.900
4	Ineffective project planning and scheduling by contractors	0.859	Obstacles to obtaining permits from local and central government	0.867	Inadequate project planning and scheduling by contractors	0.886
5	Delay in reviewing and approving engineering documents by the owner	0.844	Delay in reviewing and approving engineering documents by the owner	0.850	Delays in the work of design sub-contractors	0.886
6	The winner of the tender is the lowest bidder even though it is far below the OE	0.834	Delays in the owner's decision to approve a change proposal from the contractor or resolve contract disputes	0.850	Contractor difficulties in funding the project	0.871
7	Owner intervention	0.834	The winner of the tender is the lowest bidder even though it is far below the OE	0.833	Delay in reviewing and approving engineering documents by the owner	0.857
8	Sub-surface conditions (unforeseen) at the site	0.829	Rework (rework) due to errors during construction	0.833	Delays in the owner's decision to approve a change proposal from the contractor or resolve contract disputes	0.857
9	Low supply and productivity of local labor	0.829	Poor communication and coordination between parties involved in the project	0.833	Poor communication and coordination between parties involved in the project	0.857
10	Delays in the work of design sub-contractors	0.829	Unrealistic determination of the duration of the project by the owner	0.817	Disputes in understanding the EPC contract articles and project specifications	0.843

TABLE III
RANKS CATEGORIES OF CAUSES OF DELAY BASED ON RESPONDENTS' GROUPS

Cause of Delays	Owner.	Rank	Consultant	Rank	Contractor	Rank	Overall	Rank
Project Related	0.824	5	0.817	2	0.918	1	0.843	1
Owner Related	0.785	6	0.825	1	0.850	3	0.782	5
Contractor Rela-ted	0.955	1	0.810	5	0.822	6	0.829	3
Design Related	0.829	4	0.783	4	0.886	2	0.833	2
Mat'l/Eqp Related	0.771	7	0.817	3	0.829	4	0.819	4
Labor Related	0.829	3	0.750	7	0.829	5	0.779	6
Extern Related	0.832	2	0.775	6	0.750	7	0.740	7

1) Delays in procuring equipment/materials needed by the project: Essential components, equipment, and materials for construction projects account for roughly 70% of the project's cost. Long lead or critical equipment is usually part of the essential path for the master schedule, so its delay will cause a total project delay. Some problems arise, such as changing the proposal of the Approved Manufacturer List (AML) by the contractor, which needs a long time to get approval from the owner—fabrication problem at the vendor shop, which caused the completion time to be delayed. The custom clearance process enters the red line, which takes a long time to issue.

2) Contractor difficulties in funding the project: Payments are held because the target of monthly progress is not achieved; if the contractor does not have sufficient contingency funds internally and externally, a cash flow problem will happen, causing the progress recovery target not to be achieved. This is due to subcontractors' or fabricators' payments that decrease progress. In general, the primary source of finance is from financial/banking institutions. So, EPC can get credit from banks for at least 70% of the project's value.

3) Ineffective project planning and scheduling by contractors: Contractor schedules with insufficient preparation and planning lead to less detailed and unworkable timetables. The main contributors are poor site management and a lack of competent or experienced planners. For subcontracted package work, the subcontractor often prepares detailed schedules; if not adequately reviewed and monitored closely by the contractor, it will affect the overall schedule.

4) The winner of the tender is the lowest bidder, even though it is far below the OE: The general rule in state-owned companies in Indonesia is that the tender's winner must be the lowest price. The problem is when the lowest price is 80% below the Owner's Estimate. Experience shows that projects with these conditions experience delays and cause many disputes. The condition causes the contractor to have difficulty managing the project, slowing progress. In addition, contractors will tend to look for additional work to cover their losses.

5) Rework due to errors during construction: Rework is a non-conformance found by the contractor. The rework costs for the case study projects were 3.15%. The cause of rework during construction is the lack of prevention (build quality product) measures, such as a lack of skills and competence, and inspection (assess the quality), such as inadequate inspection activities.

6) Poor communication and coordination between parties involved in the project: Planning, managing, and monitoring communication activities have never been done systematically. The forms and communication channels are only based on what the team previously remembered and did; even in some cases, it was done after complaints or requests from other parties (reactive). Appropriate communication channels between diverse parties were not developed during the planning stage. Communication issues can result in significant misunderstandings, which slow the completion of projects.

7) Delays in the work of design subcontractors: In EPC projects, many subcontractors are working under the main contractor. The project may be delayed if the subcontractor performs poorly due to inadequate experience or ability. The high subcontracting rate in Indonesia increases the risk of delays in EPC projects. When the subcontractor's scope is to carry out design activities on the critical path, then if there is a delay, it will cause delays in subsequent processes.

8) Disputes in understanding the EPC contract articles and project specifications: The fertilizer industry EPC project scheme in Indonesia is Design and Build (DB) or Lumpsum Fixed Turnkey (LSTK), where the project specifications are still general and determined at the beginning of the project. Schemes like this have a significant risk of deficiencies and errors and will be discovered when the project runs. The reason is that the human resources appointed to work in a matrix and lessons learned from previous projects are not fully conveyed, so the same error occurs.

9) Unrealistic determination of the project duration by the owner: In determining the project duration, the project team uses analogous data based on previous similar projects by considering the location factor. However, the final decision is made by top management, which sometimes is shortened in duration. Even if it is unrealistic, the Contractor must comply because it is a condition of the contract. At the time of implementation, it was proven that this duration was challenging.

10) Delays in the owner's decision to approve a change proposal from the contractor or resolve contract disputes: Preparing contract documents and project specifications inaccurately can cause problems when the project is running. The project team's comments on contractor designs are often not guided by contracts and project specifications but are based on wishes. When a change order claim arises from a contractor, the owner uses a third party with competency and authority to provide recommendations that take a long time to avoid a conflict of interest.

The findings in Table 2 demonstrate that the top ten features of the EPC project in the Indonesian fertilizer industry are the slowness of management decisions about modification orders and the procurement technique being the single stage with the lowest bid. The characteristics of the EPC project in the Fertilizer Industry in Indonesia position are the owner is at number 6, the consultant is at number 6 and 7, the contractor is at number 2 and 8, and overall is at number 4 and 10 (the bold ones). This indicates that the characteristics of the EPC project in the Indonesian fertilizer industry are significant delay causes and must be mitigated.

Table 3 shows the delay factors, categorized into seven groups and ranked based on the respondents' groups. Each respondent group gave a different ranking result. From the owner's point of view, the contractor-related category is the highest (0,955), while from the consultant's side, the owner-related category is the highest (0,825), while from the contractor and overall project-related category is the highest (0,918 and 0,843).

Table 4's Spearman's rank correlation coefficient demonstrates a generally good agreement among the groups regarding the importance of the delay variables. The sequence values of Rs that indicate the degree of agreement between respondents from the highest, medium, and lowest are 99.3% (owner and contractor), 98.3% (owner and consultant), and 97.4% (consultant and contractor), respectively. Therefore, it can be concluded that there is substantial agreement among the respondents regarding the delay factor of the EPC project in the Indonesian fertilizer industry. The respondents, including owners, contractors, and consultants, responded with a high correlation individually and collectively.

TABLE IV
SPEARMAN'S RANK CORRELATION COEFFICIENT

		Correlations		
		Owners	**Consultants**	**Contractors**
Owners	Correlation Coef.	1	.983**	.993**
	Sig (2-tailed)		.000	.000
	N	21	21	21
Consultants	Correlation Coef.	.983**	1	.974**
	Sig (2-tailed)	.000		.000
	N	21	21	21
Contractors	Correlation Coef.	.993**	.974**	1
	Sig (2-tailed)	.000	.000	
	N	21	21	21

** Correlation is significant at the 0.01 level (2-tailed)

B. Comparison in Developing Countries

By conducting a literature review, this research makes comparisons with other developing countries in addition to validation purposes. The developing nations are categorized into three geographical areas: Africa, the Middle East, and South and Southeast Asia. There are 53 possible reasons for the delay in total among eight primary groupings in these regions. These factors have been ranked and their frequency determined. Critical reasons for delays in developing countries include incorrect planning and scheduling, cash flow issues for contractors, modification orders from the owner during construction, and delays in progress payments by the owner [22].

A comparison of causes of time and cost overruns was done with various selected construction industries in Asia and Africa. A factor analysis technique was applied to categorize the causes, which yielded seven factors: slowness and Lack of constraint, incompetence, design, market and Estimate, financial capability, government, and Worker. These findings might encourage practitioners to focus on delay and cost overrun problems that might have existed in their present or future projects [23].

The findings, compared with similar studies in the developing regions of Vietnam and Iran, revealed that the consultants' lack of experience and designers' ability act as impediments during the project planning and execution phases of such projects. This results in repeated drawing revisions and conflicts among the execution team, the client, and the consultant [24].

C. Proposed Recommendation

The recommendation concerns several prior studies and is then synthesized with researchers' experiences. Some suggestions are provided, as in Table 5, regarding the most appropriate way to control the factors that cause delays in the fertilizer industry EPC project in Indonesia.

TABLE V
RECOMMENDATIONS

Cause of Delay	Recommendation/Mitigation	References
Delays in procuring equipment/materials needed by the project	• Strict controls from the stage of construction planning and measures • The degree of accuracy of the designer in describing the materials/equipment specifications required • Maintaining a balance and establishing inter-organizational linkages through ownership, formal strategic alliances, and joint ventures. • The project management team should ensure that the proper resources are available before the project being awarded • Extensive planning is required to account for transportation times for materials and other available resources	[25]; [15]; [10]

Cause of Delay	Recommendation/Mitigation	References
	• Before purchasing materials or equipment, the contractor must ensure that they can be delivered to the location on time	
Contractor difficulties in funding the project	• The owners should pay for the contractors on time or after no longer than 15 days • Emphasize banking guarantees and documents to ensure the contractor's ability to complete the work • The contractor must have an adequate budget and not only depend on progress payments from the owner	[26]; [27]; [10]
Ineffective project planning and scheduling by contractors	• Experts should be engaged in the scheduling • To increase contractors' managerial skills and adequately practice project management principles, using the appropriate tools and techniques in managing a construction project • A preliminary study should be conducted to better understand the resources required to complete the work, such as materials, labor, equipment, etc. • The company should have its in-house database or create its schedule estimation standard depending on the project size because the requirements for each project size are different • The estimators should consider other events when estimating the project duration, such as weather conditions, labor productivity, equipment productivity, and lead time	[28]; [26]; [19]; [10]
The winner of the tender is the lowest bidder even though it is far below the OE.	• It is necessary to increase transparency from the stage of selection of contractors • Proposes Dual Feed Competition (DFC) or Design Build competition (DBC) tender strategy concept to complete the fast-tracking strategy • Apply an appropriate project delivery method (PDM), considering sustainable construction, which can mitigate environmental impacts and promote better health and quality of life.	[25]; [6]; [9]
Rework due to errors during construction	• Weekly project review meetings should be organized to avoid any concern resulting in suspension of work • Unnecessary rework should be prevented in advance through training and supervision of work quality • It is recommended that companies should offer training classes to their employees to foster improvement. This will help to minimize job errors and increase productivity as employees expand their abilities.	[28]; [3]; [10]
Poor communication and coordination between parties involved in the project	• Easy and advanced channels of communication like WhatsApp, Texting, and Emails should be declared official • Construction management demands strong connections between owners, consultants, contractors, and site workers, in addition to outstanding communication and coordination.	[28]; [26]; [18]
Delays in the work of design sub-contractors	• Selecting the right contractor is very important, and replacing the subcontractor immediately • Consider potential errors from designers unfamiliar with the environment or local conditions • Owner to approve the consultant group's CV to ensure sufficient experience • Before the start of construction, an intensive final review by the design manager of design documents is required	[15]; [27]; [3]
Disputes in understanding the EPC contract articles and project specifications	• Need attention and accuracy in making contract documents by paying attention to the risk of claims and disputes behind • Clearly define the scope of work • delineate contracts among project stakeholders, ensuring thorough review by contract management to articulate the rights and responsibilities of each party and avert potential legal disputes or claims in construction	[5]; [27]
Unrealistic determination of the duration of the project by the owner	• A realistic contract period calculation for the construction project should be a prerequisite • Owner to approve the consultant group's CV to ensure sufficient experience	[27]; [3]
Delays in the owner's decision to approve a change proposal from the contractor or resolve contract disputes	• Address delays in the owner's decision-making process by selecting highly experienced advisors to expedite and facilitate efficient decision-making. • The owners should clearly define a project's scope before commencing the construction phase	[27]; [10]

D. Discussion

The opinion of contractors, consultants, and owners was surveyed to determine the causes of delays in Indonesia's fertilizer industry's EPC projects. The survey itself is based on factors causing delays from selected previous studies in other countries synthesized with empirical facts that occurred in previous EPC projects in Indonesia. According to the survey, all three parties usually concur that respondents' levels of agreement and the ranking of specific delay reasons are very high.

The results show the top ten factors causing delays are delays in procuring equipment/materials needed by the project, contractor difficulties in funding the project, ineffective project planning and scheduling by contractors, the winner of the tender is the lowest bidder even though it is far below the OE, rework due to errors during construction, poor communication, and coordination between parties involved in the project, delays in the work of design sub-contractors, disputes in understanding the EPC contract articles and project specifications, unrealistic determination of the duration of the project by the owner, delays in the owner's decision in approving a change proposal from the contractor or resolving contract disputes. There are three causes of delay agreed between all respondents, which are "Ineffective project planning and scheduling by contractors," "The winner of the tender is the lowest bidder even though it is far below the OE," and "Delay in reviewing and approving engineering documents. Many causes are common between two parties, such as "Unrealistic determination of the duration of the contract," "Delays in procuring equipment/ materials needed by the project," "Contractor difficulties in funding the project," "Poor communication and coordination between parties involved in the project," "Rework due to errors during construction," "Obstacles in obtaining permits from the government" and "Delays in the work of design sub-contractors."

Compared with previous research, the top ten causes of delays in the fertilizer industry EPC project in Indonesia are mostly related to internal factors from owners, contractors, and consultants, none of which are related to external factors. This is proven based on Table 4.3, which shows that external-related factors have the lowest RII value (0.740). This finding is consistent with earlier studies' findings by [22], [23], [24], which are mostly related to the internal factors of the owner, contractor, and consultant. In general, the causes of delays in developing countries are much more basic, serious, and complex. These problems are difficulties and challenges related to the implementation of project management practices that are not yet good, a chronic shortage of resources, relatively unskilled labor forces, low levels of productivity, overruns, excessive wastes, poor infrastructure, fraudulent practices, the inability to adopt best practice and financing characteristics typical in developing countries.

The owner, contractor, and overall consider that the highest factor causing delays is related to the client and contractor; the consultant has a different opinion where the highest factor is owner related. This matches and is similar to previous studies' conclusions, where the typical delay causes occur in developing countries. The results of this research apply to other EPC projects in Indonesia outside the fertilizer industry, especially those belonging to state-owned companies that implemented D&B in delivering their project.

To solve problem delays in the EPC project in Indonesia, mitigation must be carried out by all parties involved in the project. In general, the mitigation done by contractors starts with carrying out proper planning and scheduling, availability of funds at the start of the project, improving personal competence, conducting effective communication, purchasing materials/equipment on time, etc. Then, the owner mitigates by determining realistic project duration, making fast decisions, making timely progress payments, and preparing good contract documents. The most minor mitigation carried out by the consultant is to ensure the competence of engineers and allocate sufficient time and funds.

Regarding recommendations, there are several things to be highlighted. The owner then decides which PDM best fits the strategic objectives of the sustainable project. Empirically, several things have been done when creating a project specification that regulates the contractor's obligations to be concerned with safety, health, and environment (SHE) issues, empowering local workers, obeying the rules, using the most efficient and environmentally friendly technology, corporate social responsibility (CSR), etc. Then, in determining the selection of prospective contractors, the company should not only consider the lowest price but also consider factors related to sustainability.

The tender system can be more flexible by implementing a Dual Feed Competition (DFC) or Design Build Competition (DBC). Both methods are essentially the same as D&B, but the additional advantage is that bidders compete during the tender to deliver the best design and innovation to increase project efficiency, quality, cost-effectiveness, and timeliness.

A study by [29] supports the technological developments and trends that aim to solve major reasons for the delay. EPC projects have the potential to address highly complex situations through the introduction of an integrated thought process during design, procurement, construction, and commissioning. Participants in EPC projects must measure the business impact of associated digital technology expenditures, as is the case with most projects operating in a global business environment [30].

To complete the recommendations above to avoid delays in the EPC project, all EPC projects could implement Building Information Modelling (BIM). BIM is an application that helps to improve design quality and communication among stakeholders. The EPC industry should employ it to reduce errors and increase speed up operations [10], [31]. A study by [32] showed that BIM's primary result is reduced delays in construction projects by 14.55%. Furthermore, this study discovered that BIM has a minimum impact of 11.76% on a contractor's lack of expertise and managerial abilities and a maximum impact of 17.65% on subpar site management and contractor supervision.

IV. Conclusion

This study strengthens previous findings regarding the causes of delays in EPC projects in developing countries, especially Indonesia. By synthesizing data from prior research and local empirical experience, this study confirms that internal factors such as ineffective project planning and selection of tender winners based on the lowest bid are the leading causes of delays. This study adds weight to the research and provides consistency in understanding the causes of delays. This study identifies the causes of delays and offers comprehensive mitigation recommendations involving all parties in the EPC project. Thus, this study not only describes the problem but also offers practical solutions that stakeholders can implement to reduce delays in the future.

The main limitation of this study is the relatively small number of respondents. This study may affect the results' representation and limit the findings' generalizability.

Collecting data from more respondents can increase the validity and reliability of research. Another limitation is the imbalance in the number of respondents returning questionnaires, with the owner group dominating. This study can lead to bias in the results due to the unbalanced perspectives of the various parties involved in the project.

This study is limited to the fertilizer industry, which may have unique characteristics that are not directly applicable to EPC projects in other industries. This limitation limits the generalization of this study's findings to different sectors in Indonesia or abroad. This study should be seen as the first effort to develop a solution to reduce the delay factor in Indonesia's fertilizer industry's EPC project. To improve the accuracy of the result, further research in a qualitative way and focus on the top ten factors of a delay from this research are necessary. To obtain better recommendations, it is essential first to carry out a root cause analysis on each critical delay factor so that the resulting recommendations can be more precise in solving the problem.

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