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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