Reinventing Formulas for Construction Project Delay Index Due to Management and Production

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Abstract

The objective of this study is to construct a precise formula for the management and production delay indicators that are integrated into Ms. Project's dashboard. Two simulation techniques, such as the manual formula computation and calculation integrated into the Ms. Project dashboard, were employed. Due to management and the production team's tardiness, the data were obtained through trial-and-error methods. Excel was used to analyze the data, and Ms. Project was used to enter the calculations. The research showed that the Ms. Project dashboard formula gave more detailed information about the construction project, including: (1) contract value; (2) actual progress value during monitoring; (3) value of plan progress during monitoring; (4) progress deviation; (5) cause of delay; and (6) management delay index and production delay index. The novelty of this study is that project delays have traditionally been held against the production party (contractor), whereas implementation delays have never been taken against the management party (consultant). However, using this method makes it evident who is responsible for a project delay, whether it comes from management (a consultant) or the manufacturing side (a contractor).

Keywords: Formula; Index of Delay; Management; Production.

1. Introduction

Due to the additional funds required for rescheduling, a construction project completion delay invariably results in a loss for the construction service provider. Due to the construction project's delay, the contractor's, consultant's, and owner's activities would be hampered, which would further result in a loss [1, 2]. The contractor team suffers a loss due to the requirement to pay a lateness fine, which results in cost overruns [3–5]. The consultant misses the chance to take on other projects in the interim, and the owner is unable to utilize the construction site on schedule. Many large-scale projects regularly encounter delays as a result of various causes, including the design documentation, payment to contractors, and change of working premises [6–8]. Failure to adhere to the payment term that the owner and contractor previously agreed upon constitutes lateness in contractor payments [8, 9]. The failure of the contractor to provide complete shop drawings, bills of quantities, invoices, tax returns, and progress reports is the reason for the payment delay [10–12].

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The aforementioned research points out that the project owner is the main reason for tardiness. Furthermore, earlier research by de Araujo et al. (2017), Martens and Vanchoucke (2018), and Lee & Won (2021) [13–15] found additional variables contributing to construction project delays, such as inadequate planning, poor consultant performance, ineffective management, owner-related problems, bureaucracy, and subpar contracts. According to several studies by Korhonen (2020), Liu et al. (2022), and Chou et al. (2023) [16–18], the owner's actions have three main implications for the duration of a construction project: delaying payments to subcontractors, interfering with the contractor's cash flow, and having trouble obtaining the necessary materials. In the meantime, a complicated payment system, missing paperwork, and subpar labor are the main reasons why owners fail to pay their contractors. Numerous studies by Zahid et al. (2019), Wang et al. (2020), Arditi et al. (2017), and Chen et al. (2014) [19–22] also noted that owner late payment has a significant impact on other project lateness characteristics. As a result, a project's delay can be due to a variety of factors, but in actuality, the contractor should be held accountable for the construction project's lateness. This occurs as a result of the contract's lack of legally binding provisions governing sanctions for other stakeholders [23–25].

According to Indonesian Presidential Degree No. 16, issued in 2018, regarding government procurement of goods or services, Article 56 states that (1) the commitment-making officer (CMO) will give the service provider the chance to finish the job if they are unable to do so until the contract expires but the CMO believes they are capable of doing so; (2) the opportunity given to the service provider to finish the job depends on how quickly the contract is completed. The presidential decree makes it quite clear that only the service provider (the production team) is subject to the fine. According to the rule, even though multiple studies have shown that the owner and consultant might occasionally contribute to project delays, the penalties should only be placed on the contractor. Therefore, the weight of the delay penalty index serves as the foundation for calculating the amount of delay penalty that must be borne by each party (Management and Production) for the delay in the implementation of a building project. The cutting-edge aspect of this research is its ability to estimate the amount of late penalty costs that must be carried by management or production based on the weight of the delay index determined using a formula integrated with Ms. Project. As a result, the goal of this study is to develop a method to calculate the index of delay fines for each stakeholder participating in the construction project.

2. Material and Methods

Ex-post facto techniques and interviews were implemented in this study in order to find an accurate formula for calculating the index of a construction project delay from management and production. Therefore, we conducted an ex-post facto survey of 20 construction project scheduling experts and conducted interviews with scheduling experts who worked as construction project supervising consultants. The results of a questionnaire and interviews with two construction project scheduling experts were analyzed to identify the causes and warning signs of project delays. The simulation technique is then continued when a formula for the indicators is constructed based on the findings. During the experiment, we employed two simulation techniques: manual simulation and simulation utilizing a formula included in Ms. Project's dashboard. The management and production teams' perspectives on project lateness were used to obtain the data through a process of trial and error. The data was then manually evaluated with Ms. Excel and manually analyzed using the method built within the Ms. Project dashboard. The formula underwent a feasibility test using the TELOS approach based on the benchmark criteria and an operating feasibility assessment using the PIECES framework before the data analysis. [26–28]. The following sub-sections go into further detail about the feature that was assessed using the TELOS approach and the PIECES framework.

2.1. Technical Aspect

If it received a high enough score, the technical component of the formula included in Ms. Project was deemed to be practical. Table 1 lists the technical feasibility requirements on a scale of 1 to 10.

<table>
<thead>
<tr>
<th>No.</th>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sufficient</td>
</tr>
<tr>
<td>1</td>
<td>Utilizing simple technologies</td>
<td>8 – 10</td>
</tr>
<tr>
<td>2</td>
<td>Extremely flexible software</td>
<td>8 – 10</td>
</tr>
<tr>
<td>3</td>
<td>Robust technology</td>
<td>8 – 10</td>
</tr>
</tbody>
</table>

2.2. Economic Aspect

According to a scale of 1 to 10, the economic element was evaluated based on funding availability, as indicated in Table 2. This is because the study's sole objective is to create a mathematical model that will be used by the software to calculate the project lateness index using the management and production components. The ultimate mathematical model was added to the Ms. Project. Therefore, the analysis of the payback period, Return on Investment (ROI), Net Present Value (NPV), and Internal Rate of Return (IRR) was not necessary.
2.3. Legal Aspect

The feasibility of the legal element was evaluated using the criteria presented in Table 3, with a 1-10 range score.

Table 3. Feasibility Criteria for Legal Aspect

<table>
<thead>
<tr>
<th>No.</th>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Legality from the Director General of Vocational of the Ministry of Education and Culture</td>
<td>8 – 10</td>
</tr>
<tr>
<td>2</td>
<td>Legality from the Institution of research and Community Service of Universitas Negeri Medan</td>
<td>8 – 10</td>
</tr>
<tr>
<td>3</td>
<td>Legality from PT. Bentareka Cipta Consulting Group Jakarta</td>
<td>8 – 10</td>
</tr>
</tbody>
</table>

2.4. Operation Aspect

The feasibility test on the operation element was carried out using the PIECES framework, as is shown in Table 4.

Table 4. Feasibility Criteria for Operation Aspect

<table>
<thead>
<tr>
<th>No.</th>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Performance (P)</td>
<td>Speed of software performance</td>
</tr>
<tr>
<td>2</td>
<td>Information (I)</td>
<td>Accurate and dynamic information</td>
</tr>
<tr>
<td>3</td>
<td>Economy (E)</td>
<td>Efficiency of operational cost</td>
</tr>
<tr>
<td>4</td>
<td>Control (C)</td>
<td>Security level of software</td>
</tr>
<tr>
<td>5</td>
<td>Efficiency (E)</td>
<td>Software optimum suitability with the company goals</td>
</tr>
<tr>
<td>6</td>
<td>Service (S)</td>
<td>Provision of easy-to-understand service for user</td>
</tr>
</tbody>
</table>

2.5. Schedule Aspect

In the schedule aspect, we evaluated the formula integration into the software using the criteria of schedule presented in Table 5.

Table 5. Feasibility Criteria for Schedule Aspect

<table>
<thead>
<tr>
<th>No.</th>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Utilizing ethical time management</td>
<td>8 – 10</td>
</tr>
<tr>
<td>2</td>
<td>Time management that is appropriate for the planning</td>
<td>8 – 10</td>
</tr>
<tr>
<td>3</td>
<td>Synchronization of the time with the schedule</td>
<td>8 – 10</td>
</tr>
</tbody>
</table>

The TELOS method’s average score was derived by adding together the scores for each factor and dividing the total by the number of feasibility factors, as shown in Equation 1.

\[
\text{TELOS Score} = \frac{TS + ES + LS + OS + SS}{5}
\]

Where: \(TS\) = Technical Score; \(ES\) = Economic Score; \(LS\) = Legal Score; \(OS\) = Operational Score; \(SS\) = Schedule Score.

The software formula integration was ultimately found to be possible if the final average score was greater than 6. However, the created method built into the program was considered to be unworkable if the score obtained is less than 6 points.
3. Results and Discussion

3.1. Formula for Estimating the Delay of Construction Project

In this study, the formula was built using indications that accurately reflected the actual field scenario. These metrics were discovered during a construction management field interview. The job's starting time, the actual start date, the planned start date, the actual completion time, the interlude after the work has begun, the inclusion of the actual field condition in the work schedule, the presence of free float, and the critical path deviation from the planned schedule make up the final set of indicators. Additionally, a mathematical model was created using the indicators to determine the index of delay brought on by the management and production teams. The formulas for delay induced by management time consist of formulas for: (1) delay from management factors; (2) delay time; and (3) index of delay from the management aspect, as presented in Equations 2 to 4.

3.1.1. Delays from Management Factors

\[
DMF = (S_1 - S_2) + \text{free float} - \text{pending}
\]  
(2)

Where:

- \(DMF\) = Delay from management factors;
- \(S_1\) = Work starting time;
- \(S_2\) = Actual starting date.

Note:

1. If \(DMF < 0\), then the delay of the construction project is caused by the management;
2. If \(DMF > 0\), then there is no delay in construction induced by the management.

**Delay Time**

\[
DT = DMF + DPF
\]  
(3)

Where:

- \(DT\) = delay time;
- \(DMF\) = Delay from the management factors;
- \(DPF\) = Delay from the production factors.

**Index of Management Delay (MDI)**

\[
MDI = \frac{DT}{DMF}
\]  
(4)

Where:

- \(DT\) = delay time;
- \(DMF\) = delay from the management factors.

In addition, the formulas for delay caused by production factors consist of formulas for (1) delay from production factors, (2) delay time, and (3) index of a delay from the production team, as shown in Equations 5 to 8.

3.1.2. Delay Due to the Production Factor (DPF)

\[
DPF = (D_1 - D_2) + MD \ (\text{if} \ MD > 0)
\]  
(5)

\[
DPF = (D_2 - D_1) + MD \ (\text{if} \ MD < 0)
\]  
(6)

Where:

- \(DPF\) = Delay from production factor;
- \(D_1\) = Planned project completion time;
- \(D_2\) = Actual time for completing the project;
- \(DM\) = Management delay.
Notes:
(1) If $DPF < 0$, then the delay of the construction project is caused by the production factor;
(2) If $DPF > 0$, then there is no delay in the construction project caused by the production factors.

**Delay Time**

$$DT = DMF + DPF$$  \hspace{1cm} (7)$$

Where:
\begin{itemize}
  \item $DT$= Delay time;
  \item $DMF$= Delay from the management factors;
  \item $DPF$ = Delay from the production factors.
\end{itemize}

**Index of Production Delay (PDI)**

$$PDI = \frac{DT}{DPF}$$  \hspace{1cm} (8)$$

Where:
\begin{itemize}
  \item $DT$= Delay time;
  \item $DPF$= Delay caused by the production factors.
\end{itemize}

The results of estimation using the above formulas are interpreted using criteria presented in Table 6.

<table>
<thead>
<tr>
<th>PKM</th>
<th>PKP</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ zero</td>
<td>≥ zero</td>
<td>There is no delay in the project caused by management and production factors</td>
</tr>
<tr>
<td>Negative</td>
<td>≥ zero</td>
<td>The project delay is caused by the management factors</td>
</tr>
<tr>
<td>≥ zero</td>
<td>Negative</td>
<td>The project delay is not caused by the production factor</td>
</tr>
<tr>
<td>≥ zero</td>
<td>Negative</td>
<td>The project delay corresponds to the score of lateness from the management factor</td>
</tr>
<tr>
<td>Negative</td>
<td>Negative</td>
<td>The production factor also contributes to the delay</td>
</tr>
<tr>
<td>Negative</td>
<td>Negative</td>
<td>The project delay is caused by both management and production factors</td>
</tr>
</tbody>
</table>

3.2. Feasibility Test for Formula Integrated into Ms. Project Dashboard

The results of the feasibility test using the TELOS method for the formula integrated into Ms. Project are summarized in Tables 7–11. Table 7 presents the average obtained score of 8.50 > 6.00, indicating that the developed formula integrated into the Ms. Project has fulfilled the technical criteria.

<table>
<thead>
<tr>
<th>No.</th>
<th>Criteria</th>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Easy-to-use technology</td>
<td>8.33</td>
<td>Sufficient</td>
</tr>
<tr>
<td>2</td>
<td>Highly developable software</td>
<td>8.67</td>
<td>Sufficient</td>
</tr>
<tr>
<td>3</td>
<td>Stable technology</td>
<td>8.33</td>
<td>Sufficient</td>
</tr>
<tr>
<td>4</td>
<td>Applicable software for construction project</td>
<td>8.67</td>
<td>Sufficient</td>
</tr>
<tr>
<td></td>
<td>Average score</td>
<td>8.50</td>
<td>Sufficient</td>
</tr>
</tbody>
</table>

In this study, the economic criteria were only investigated based on the availability of funding sources from the company for internet quota financing since the computer and internet network have been provided by the company. Thus, the estimation of the Return of Investment (ROI) and Payback Period are not included.
Table 8. Results for economic criteria

<table>
<thead>
<tr>
<th>No.</th>
<th>Criteria</th>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Availability of source of funding</td>
<td>7.33</td>
<td>Sufficient</td>
</tr>
<tr>
<td></td>
<td><strong>Average Score</strong></td>
<td><strong>7.33</strong></td>
<td><strong>Sufficient</strong></td>
</tr>
</tbody>
</table>

According to Table 8, the obtained average result is 7.33 > 6.00, indicating that the economic criteria have been fulfilled.

Table 9. Results for legal criteria

<table>
<thead>
<tr>
<th>No.</th>
<th>Criteria</th>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Legality from Director General Vocation of the Ministry of Education and Culture</td>
<td>8.67</td>
<td>Sufficient</td>
</tr>
<tr>
<td>2</td>
<td>Legality from the Institution of research and Community Service of Universitas Negeri Medan</td>
<td>8.33</td>
<td>Sufficient</td>
</tr>
<tr>
<td>3</td>
<td>Legality from PT. Bentareka Cipta Consulting Group Jakarta</td>
<td>9.00</td>
<td>Sufficient</td>
</tr>
<tr>
<td></td>
<td><strong>Average Score</strong></td>
<td><strong>8.67</strong></td>
<td><strong>Sufficient</strong></td>
</tr>
</tbody>
</table>

As is shown in Table 9, the obtained score in the legal criteria is 8.67 > 6.00, signifying that the formula integrated into Ms. Project has fulfilled the legal criteria.

Table 10. Results in operation criteria

<table>
<thead>
<tr>
<th>No.</th>
<th>Indicators</th>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Speed of software performance</td>
<td>7.67</td>
<td>Sufficient</td>
</tr>
<tr>
<td>2</td>
<td>Accurate and dynamic information</td>
<td>8.33</td>
<td>Sufficient</td>
</tr>
<tr>
<td>3</td>
<td>Efficiency of operational cost</td>
<td>8.67</td>
<td>Sufficient</td>
</tr>
<tr>
<td>4</td>
<td>Security level of software</td>
<td>8.33</td>
<td>Sufficient</td>
</tr>
<tr>
<td>5</td>
<td>Software optimum suitability with the company goals</td>
<td>8.33</td>
<td>Sufficient</td>
</tr>
<tr>
<td>6</td>
<td>Provision of easy-to-understand service for user</td>
<td>8.00</td>
<td>Sufficient</td>
</tr>
<tr>
<td>7</td>
<td>Speed of software performance</td>
<td>8.33</td>
<td>Sufficient</td>
</tr>
<tr>
<td>8</td>
<td>The need for the design of a formula to detect the delay index</td>
<td>8.67</td>
<td>Sufficient</td>
</tr>
<tr>
<td></td>
<td><strong>Average</strong></td>
<td><strong>8.29</strong></td>
<td><strong>Sufficient</strong></td>
</tr>
</tbody>
</table>

The data in Table 10 shows that we obtained an 8.29 > 6.00 score for the operation criteria. Thus, the formula integrated into Ms. Project has fulfilled the operation criteria.

Table 11. Results for schedule criteria

<table>
<thead>
<tr>
<th>No.</th>
<th>Criteria</th>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Using fair time management</td>
<td>8.33</td>
<td>Sufficient</td>
</tr>
<tr>
<td>2</td>
<td>Using time management suitable with the planning</td>
<td>8.33</td>
<td>Sufficient</td>
</tr>
<tr>
<td>3</td>
<td>Conformity between the time and scheduling</td>
<td>8.33</td>
<td>Sufficient</td>
</tr>
<tr>
<td>4</td>
<td>Obtain information rapidly</td>
<td>9.00</td>
<td>Sufficient</td>
</tr>
<tr>
<td></td>
<td><strong>Average Score</strong></td>
<td><strong>8.50</strong></td>
<td><strong>Sufficient</strong></td>
</tr>
</tbody>
</table>

Table 11 shows that the obtained 8.50 > 6.00 score, signifying that the formula integrated into the Ms. Project has fulfilled the schedule criteria. Further, we also calculated the average scores for all criteria, resulting in an 8.26 score. Therefore, the formulated formula for estimating the index of a delay from management and production aspects is highly feasible and accurate.

3.3. The First Simulation: Manual Formula Calculation using Ms. Excel

The formula was applied to several instances of building project lateness caused by management and production issues in the first simulation. According to management, delays occur when work starts but is still within the free float, when it starts but is outside the free float, when it starts but stops in the middle of the work, when it starts but stops outside the free float, when it starts but stops during the work but is still within the free float, and when it starts but stops in the middle of the work and (7) The work starts following the free float and is terminated in the middle of it. The simulation was carried out for those seven examples using the accepted formula, and the simulation results are displayed in Table 12.
The simulation employing these related formulas for construction project delays were incorporated into Ms. Project. In light of this, we also ran simulations in four different scenarios. First off, labor doesn't begin with any production; rather, it builds over a few days, lengthening the period while continuing to occur inside the free float. Second, productivity increases after a few days, extending the time beyond the free float. Third, low productivity results in longer workdays while keeping free float. Fourth, low duration improves working duration after free float. Table 13 shows the outcomes of applying the algorithm to estimate those four situations.

<table>
<thead>
<tr>
<th>Cases</th>
<th>Plan</th>
<th>Actual Data</th>
<th>KM</th>
<th>KP</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S1=1</td>
<td>D1-4</td>
<td>FF=3, S2=3</td>
<td>P=0</td>
<td>D2=6</td>
</tr>
<tr>
<td>2</td>
<td>S1=1</td>
<td>D1-4</td>
<td>FF=3, S2=3</td>
<td>P=0</td>
<td>D2=6</td>
</tr>
<tr>
<td>3</td>
<td>S1=1</td>
<td>D1-4</td>
<td>FF=3, S2=3</td>
<td>P=0</td>
<td>D2=6</td>
</tr>
<tr>
<td>4</td>
<td>S1=1</td>
<td>D1-4</td>
<td>FF=3, S2=3</td>
<td>P=0</td>
<td>D2=6</td>
</tr>
</tbody>
</table>

Both the management and the production teams might be responsible for lateness during the construction project. In light of this, we also ran a simulation of how the management and production teams contributed to construction project delays. In the first scenario, the management team begins the task after its scheduled start time but while it is still in the free float, and the output is higher than expected. Second, the management team begins the job after it should have, exceeding the free float and producing little in the process, lengthening the project's duration and causing it to finish late. Third, the management team starts the project later than expected but is still in free float, and there are breaks throughout the project, thus productivity exceeds expectations. The algorithm was used to simulate those four scenarios, and the outcomes are shown in Table 14.

<table>
<thead>
<tr>
<th>Case</th>
<th>Plan</th>
<th>Actual Data</th>
<th>KM</th>
<th>KP</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S1=1</td>
<td>D1-4</td>
<td>FF=3, S2=3</td>
<td>P=0</td>
<td>D2=5</td>
</tr>
<tr>
<td>2</td>
<td>S1=1</td>
<td>D1-4</td>
<td>FF=3, S2=3</td>
<td>P=0</td>
<td>D2=5</td>
</tr>
<tr>
<td>3</td>
<td>S1=1</td>
<td>D1-4</td>
<td>FF=3, S2=3</td>
<td>P=0</td>
<td>D2=5</td>
</tr>
<tr>
<td>4</td>
<td>S1=1</td>
<td>D1-4</td>
<td>FF=3, S2=3</td>
<td>P=0</td>
<td>D2=5</td>
</tr>
</tbody>
</table>

3.4. The Second Simulation: Calculation Using Formula Integrated with Ms. Project Dashboard

The management and production-related formulas for construction project delays were incorporated into Ms. Project. The simulation employing these integrated formulas also made use of indications from the management and production aspects, as well as indicators from both of these aspects. Figure 1 displays the outcomes that were acquired from the dashboard display.
Figure 1 shows the more thorough outcomes of the computation utilizing the formulas included in Ms. Project's dashboard. The outcomes comprise the contract value, actual progress during the monitoring, deviation of progress, causes of project lateness, as well as the indices of project lateness resulting from management and production factors. Based on the aforementioned research findings, it is clear that the formula used in this study can determine the amount of fines that management (consultants) and production parties (contractors) are required to pay based on the weight of the project delay index obtained from using a formula that is integrated with Ms. Project. The novelty of our research is that the production party (contractor) has always been held accountable for project delays, while the management party (consultant) has never been penalized for implementation delays. However, with this formula, the party accountable for a project delay is clearly identified, regardless of whether it originates from management (a consultant) or the production party (contractor). Additionally, this formula gives the total amount of fines that will be paid depending on the weight determined by calculations made using the formula discovered through this study.

4. Discussion

Based on the results of the formula simulation carried out and the resulting prototype on the dashboard design, which provides information, namely: (1) contract value; (2) actual progress value when reviewed; (3) assess the progress of the plan when it is reviewed; (4) progress value deviation; (5) causes of delays; and (6) MDI and PDI. The value of the contract functions against the value of MDI and PDI to determine the value of late fines as stipulated in Presidential Regulation Number 16 of 2018 concerning Procurement of Government Goods/Services Article 79, Paragraph 4, stipulated by the Commitment Making Officer (CMO) set forth in the contract of 1 0/00 (one per mil) of the contract value or the value of the portion of the contract for each day of delay. The dashboard's plan progress value and actual progress value are used to calculate the difference between the planned work and the actual work [29–31]. The deviation value is accurate. When it's negative, it means the work is behind schedule; when it's zero, it's on schedule; and when it's positive, it means the work has accelerated [32–35].

The variation for the delay, which impacts whether the delay is the result of MDI or PDI, is -9.27 on the dashboard. When work is encountering difficulties, the dashboard also provides information on the causes of those delays. Thus, in a sequence of dependence relationships, the task will be an issue that needs to be addressed right away; if it is on a critical route, it must be finished before; if it is on free float, it will be obvious how much time is left to complete the project [25, 36, 37]. In order for the dashboard to automatically produce an index value for each delay that occurred and how long the delay occurred, the cause of the delay will be tied to the MDI and PDI values, where work activities will reveal what or who is the source of the delay. The dashboard displays a 3-day delay, despite the fact that it was supposed to be finished on August 21, 2022.

The work could only be finished on August 24, 2022, as a result of delays; hence, the score of the MDI was 0.4 and the PDI was 0.6. If the MDI and MDI scores are still 0.4 and 0.6 at the conclusion of the work, the management was responsible for paying a fine of (1 0/00 × IDR. 732,500,000) × 0.4, which is equivalent to IDR 293,500, while the
production party is responsible for paying a fine of \((1 \times 0.00 \times \text{IDR} 732,500,000) \times 0.6\), which is equal to IDR 439,500. It gives details on the amount that each team will have to pay based on a dashboard that was created using a formula for each index. The advantage is that, whereas production-related fines have historically been calculated, management-related fines have never been computed [38–40]. One of the advantages of the Ms. Project display is that details that were previously only partially published have now been disclosed by the project in full, even though production is not solely to blame for the delay.

5. Conclusion
The formula found in this study produces accurate and useful findings that can be used to compute IKM and IKP in a construction project, as can be inferred from the results and discussion. The Ms. Dashboard formula is superior to the manual approach in this case. Project offers more thorough information about how construction project work is being carried out, including: (1) Contract value; (2) Actual progress value when reviewed; (3) Assess the progress of the plan when it is reviewed; (4) Progress Value Deviation; (5) Delay Causes; and (6) Management Delay Index and Production Delay Index. The party accountable for project delays will have a clearer understanding of the fines that will be paid by the management (consultant) or production party (contractor), depending on the index weight generated from the formula found in this study. The findings of this study also directly assist the Commitment Making Officer (CMO) of a government agency in making more equitable judgments on fines for tardy project completion as well as in the advancement of project/construction management knowledge.

6. Declarations
6.1. Author Contributions
Conceptualization, P.L. and N.S.; methodology, P.L., N.S., and S.S.; software, P.L.; validation, P.L., N.S., and S.S.; formal analysis, P.L.; investigation, N.S.; resources, P.L.; data curation, N.S.; writing—original draft preparation, P.L.; writing—review and editing, N.S.; visualization, P.L.; supervision, S.S.; project administration, P.L.; funding acquisition, P.L and N.S. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement
The data presented in this study are available on request from the corresponding author.

6.3. Funding
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6.5. Institutional Review Board Statement
Not applicable.

6.6. Informed Consent Statement
Not applicable.

6.7. Declaration of Competing Interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

7. References


