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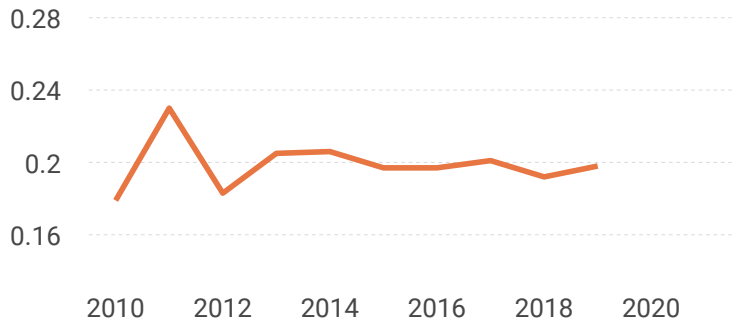

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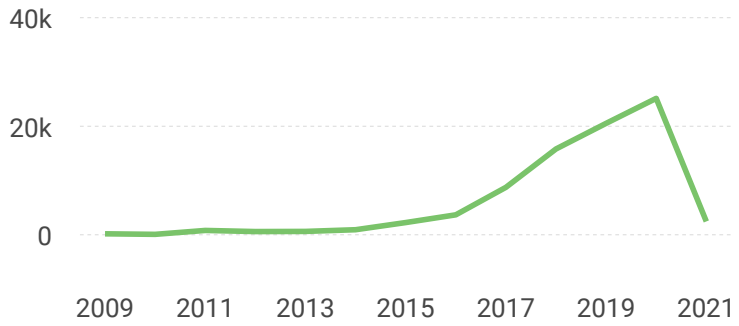

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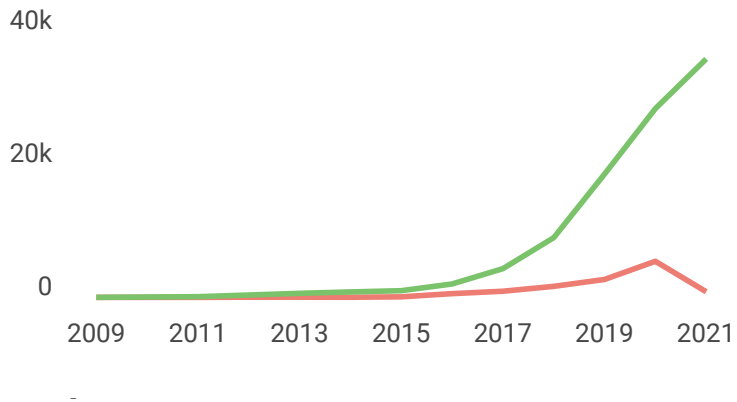

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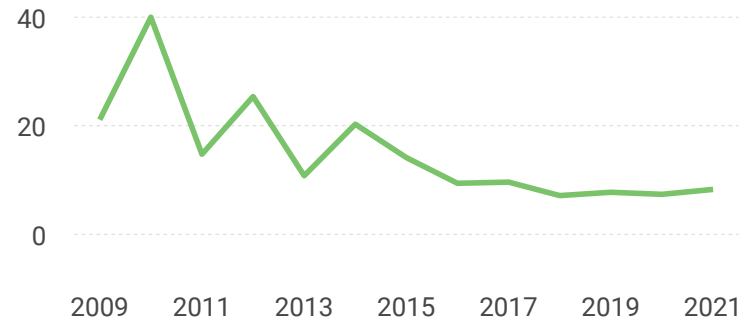

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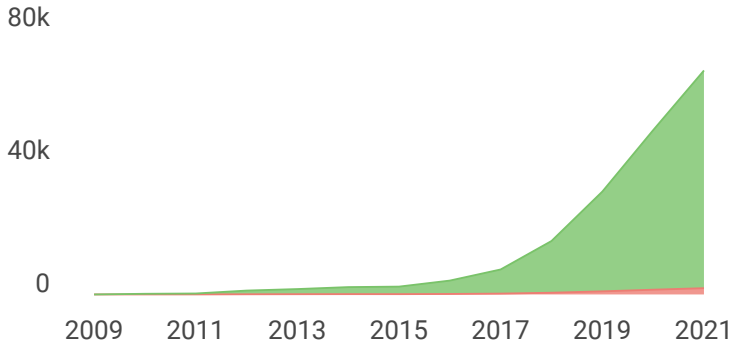

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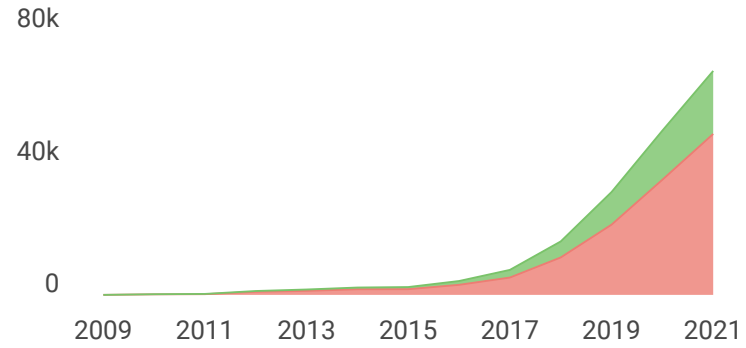

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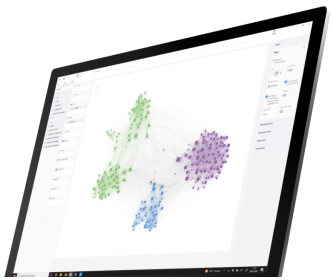

Simplified activities model for earned duration calculation

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Simplified activities model for earned duration calculation

Basuki Anondho[1]*, Yusuf Latief[2], Khrisna Mochtar[3], Joshua Aditya[1]

[1]Department of Civil Engineering, Universitas Tarumanagara, Jakarta, Indonesia
[2]Department of Civil Engineering, Universitas Indonesia, Depok, Indonesia
[3]Department of Civil Engineering, Institut Teknologi Indonesia, Serpong, Indonesia

*basukia@ft.untar.ac.id

Abstract. The research purpose to reduce complexity occur by lot of activity items on conducted Earned Duration method in forecasting project duration. The process of reducing activity items by grouping those items result should be on the same population with realization duration. There are two types of data which are S curves of ongoing project and realization duration from construction projects in Jakarta area. The S curve of ongoing project should be used to calculate project duration by simplified activity items model for each project to gain average forecasted duration compared to the realization duration. The result shows that simplified activity items model could be used in ED method to forecast project duration as reducing its complexity without compromising the ability of duration forecast. In this research, accuracy is not calculated and shows ED method using simplified activity items denote that the result of forecast calculation is a part of project duration population. Data were collected only from multistory building projects in Jakarta area. Substructure is not included in this research. This paper fulfils the validation of simplified activity items model to forecast project duration with ED method on a project that contains lot of activity items.

1. Introduction

Duration forecast is one of an important factor as the basis in adequate project management and as the success of the project. Planning cannot always be compared to actual implementation, due unexpected and uncertainty things that may occur. Therefore, an approximate technique is needed in order to overcome the uncertainty. By applying several forecasting techniques, uncertainties and uncontrollable aspects of the future could be controlled [1].

To avoid delays in the completion of construction projects, duration forecast is required. Forecasting is required as a control in construction projects, as well as benchmark in risk management that may occur [2]. Duration forecast could use some suggested methods, such as Earned Value (EV), Earned Schedule (ES) and Earned Duration (ED).

Earned value is a project management technique that uses work in progress to show what will happen to future work. In the 1960s, conventional EV method began to emerge as method that focused on the planned cost and actual cost. EV as a project management method achieves great success in cost management, but not at all in schedule management [3]. This is due to the use of cost indicators in schedule management. Meanwhile, Earned Schedule (ES) that developed by Lipke, 2003 [4], modifies the EV method by changing the way of schedule indicator calculation to eliminate the shortcomings of EV. In an academic study by Vanhoucke, it was shown that the ES method was better than the EV method based on time performance. Although the new indicators are better, the use of cost data on the

calculations causes the information obtained cannot always be trusted. Therefore, Khamooshi and Golafshani, 2013 [5] describe Earned Duration (ED) method as a new approach to the schedule performance management and measurement. This ED method eliminates the use of cost data in the context of schedule estimation. However, ED method is not easy to be understood. According to Batselier and Vanhoucke, 2015 [3], this new method is elusive and difficult to be implemented for practical used.

ED method requires the progress of each activities for the calculation. S curve of each project has a different presentation for activities item. Therefore, calculation will be difficult and complex. Simplification of activities item needed so that job description and calculation by ED method becomes easier to understand and more practice. This research will be focused on the application of simplified activity items in ED method to forecast duration for building projects in Jakarta and its surrounding areas.

2. Methodology

The S curve from ongoing projects were used as base calculation of Earned Duration (ED) method. S curve data contains planned and realization progress at a certain status date of the project.

Duration of finished projects should be used as comparing data to ensure that duration forecast by ED is a part of same population with realization duration. Multistory building project, at least 8 stories, is the limitation on this research. In order to obtain proportionate result, total floor area (m^2) from all projects are also required. Since substructure usually tend to generate uncertainty, the calculation on this research only concern of upper structure as another limitation.

Planned and realization S curve usually shows all activities of the project, which mean a complexity occur for a large-scale building project. Difficulties came along when lot of activities shown in S curve. A method to reduce this complexity is proposed in this research by grouping the similar activities to simplify number of activities. For example, activity items grouping can be seen in table 1.

Table 1. Similar Activity Grouping

Activity Items Grouping	Sub Activity Items
Preliminaries	Preliminaries, Setting Out, Location Cleaning, and others.
Sub Structure	Foundation, Pile Cap, Basement, and others
Structure	Upper structure: Beam, Column, Slab, and others.
Architecture	Wall, Floor Covering, Finishing, and others.
Mechanical & Electrical	Plumbing, Lift, AC, Genset, and others.
Miscellaneous works	Addendum, Signage, Gondola, Swimming Pool, and others.

A new grouped weight is total sum of each activity in the group. This grouping will be conducted in all planned and realization progress in the entire S curve. Removing substructures on the S curve causes the overall workload to be different, so calculations are needed to get the elaborated work weight among the S curve. Elaboration can be calculated as follows:

$$Bn = \frac{Ba}{Ba_{total}} \times 100\% \quad (1)$$

Bn = Elaborated work weight.
Ba = Activities weight without substructure.
Ba total = Total activities weight without substructure.

3. Calculation Algorithm

Here is a calculation algorithm, which describes the calculation of ED method and other processes in order to validate the duration forecast result of simplified activity items.

Calculation of Earned Duration for activity i (ED_i)

Earned Duration (ED_i) is the weight of work performed expressed as proportion of the approved duration assigned to that work for activity i. ED_i can be calculated as follows:

$$ED_i = \frac{BRi_i}{BRnt_i} \times BPD_i \quad (2)$$

BRi_i = Realization weight to status date for activity i (%)
$BRnt_i$ = Total planned weight for activity i (%)
BPD_i = Baseline planned duration for activity i (time units)

Calculation of Planned Duration for activity i (PD_i)

Planned Duration (PD_i) is the weight of work scheduled expressed proportion of the approved duration assigned to that work for activity i. PD_i can be calculated as follows:

$$PD_i = \frac{BRn_i}{BRnt_i} \times BPD_i \quad (3)$$

BRn_i = Planned weight to status date for activity i (%)
$BRnt_i$ = Total planned weight for activity i (%)
BPD_i = Baseline planned duration for activity i (time units)

Calculation of Total Earned Duration (TED)

Total Earned Duration (TED) at status dates is the sum of ED_i, which can be calculated as follows:

$$TED = \sum_{i=1}^{n} ED_i \quad (4)$$

Calculation of Total Planned Duration (TPD)

Total Planned Duration (TPD) at status dates is the sum of PD_i, which can be calculated as follows:

$$TPD = \sum_{i=1}^{n} PD_i \quad (5)$$

Calculation of Earned Duration (t) (ED(t))

Earned Duration (t) at status dates can be calculated as follows:

$$ED(t) = t + \frac{TED - TPD_t}{TPD_{t+1\,(calendar\ unit)} - TPD_t} \times 1\ (CU) \quad (6)$$

Calculation of Duration Performance Index (DPI)

Duration Performance Index (DPI) represents the overall schedule progress performance toward the completion of the project. DPI shows how well the project is doing in achieving the target completion date. DPI can be calculated as follows:

$$DPI = \frac{ED(t)}{AD} \quad (7)$$

Calculation Estimate Duration at Completion (EDAC)

Duration forecast can be obtained by calculating Estimate Duration at Completion (EDAC), which can

be calculated as follows:

$$EDAC=\frac{BP\ D}{DP\ I} \quad (8)$$

EDAC that obtained will be divided by the floor area (m^2), thereby can obtain comparable result.

Result validation

Hypothesis testing between forecast duration and realization duration can be calculated by statistical test as follows:

$$Z=\frac{(\overline{x_1}-\overline{x_2})-(\mu_1-\mu_2)}{\sigma_{x1-x2}} \text{ where } \sigma_{x1-x2}=\left(\frac{\sigma_1^2}{n_1}+\frac{\sigma_2^2}{n_2}\right)^{1/2} \quad (9)$$

4. Result and Discussion

Based on data collection, S curves were obtained from 39 ongoing projects, and realization duration data were obtained from 35 finished projects.

Activity items grouping is done in the entire data of S Curves, followed the calculation model that has described previously. S curve elaboration conducted by removing substructure weight work. Figure 2 shows the calculation example of elaboration.

No	Activity Items	Weight (%)		Oct-16			Nov-16				December - August 2017		
				31	32	33	34	35	36	37	38	73	74
1	Preliminaries	5.814	Planned	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062		
			Realization	0.069798	0.083067	0.084188	0.037181	0.044063	0.060956				
2	Structure	19.738	Planned	0.767	0.633	0.532	0.532	0.532	0.511	0.489	0.468		
			Realization	0.8635	0.8481	0.5508	0.319	0.3781	0.5024				
3	Architecture	25.167	Planned	0.161	0.246	0.33	0.389	0.448	0.5	0.821	0.879		
			Realization	0.1813	0.3296	0.3416	0.2333	0.3184	0.4936				
4	Mechanical & Electrical	22.944	Planned	0.298	0.298	0.351	0.351	0.351	0.351	0.351	0.351		
			Realization	0.3355	0.3993	0.3634	0.2105	0.2495	0.3451				
5	Miscellaneous work	15.868	Planned									0.628	0.056
			Realization										
	TOTAL	89.531											
	Elaborated Planned Progress (%)			1.288	1.239	1.275	1.334	1.393	1.424	1.723	1.76	0.628	0.056
	Cumulative Elaborated Planned Progress (%)			17.622	18.861	20.136	21.47	22.863	24.287	26.01	27.77	89.475	89.531
	Cumulative Elaborated Planned Progress 100% (%)			19.68257	21.06645	22.49053	23.98052	25.53641	27.12692	29.05139	31.01719	99.93745	100
	Elaborated Realization Progress (%)			1.45	1.66	1.32	0.8	0.99	1.4				
	Cumulative Elaborated Realization Progress (%)			16.8797	18.5397	19.8597	20.6597	21.6497	23.0497				
	Cumulative Elaborated Realization Progress 100% (%)			18.85347	20.70758	22.18193	23.07547	24.18123	25.74494				

Figure 2. S Curve Elaboration Calculation

According to example shown in figure 2, the cumulative planned progress at week 31 (Ba) is 17.6220% and the total cumulative planned progress (total Ba) is 89.5310%, so elaboration can be calculated as follows:

$$B_{31}=\frac{Ba}{Ba_{total}}\times 100\% = \frac{17.6220}{89.5310}\times 100\% = 19.6826\%$$

The elaborated weight (100%) is 19.6826%. same process is also occurred in the cumulative realization progress, for each time unit in the entire S curve.

Calculations using Earned Duration were performed in the entire ongoing 39 S curve. Data tabulation consist the average and standard deviation of duration forecast result ($EDAC/m^2$), and also 35 realization duration. The tabulation can be seen in table 2 as follows:

Tabel 2. Data Tabulation

Type of duration	Average	Standard Deviation
$EDAC/m^2$	0.00213	0.00148

Realization duration/m^2	0.00279	0.00194

Based on data tabulation, hypothesis testing between duration forecast and realization duration could be calculated as shown in table 3 as follows:

Table 3. Mean and standard deviation values

Type of calculation	Result
X1(EDAC Average)	0.00213
X2 (Realization Duration Average)	0.00279
σ1 (Standard Deviation 1)	0.00148
σ2 (Standard Deviation 2)	0.00194
n1(Number of samples 1)	39
n2(Number of samples 2)	35

$$\sigma_{x1\text{-}x2} = \left(\frac{\sigma_1^{\,2}}{n_1} + \frac{\sigma_2^{\,2}}{n_2}\right)^{1/2}$$
$$= \left(\frac{0.00148^2}{39} + \frac{0.00194^2}{35}\right)^{1/2}$$
$$= 0.000405$$

$$Z = \frac{(X1-X2)-(\mu1-\mu2)}{\sigma x1-x2}$$
$$= \frac{(0.00213-0.00279)-(0)}{0.000405}$$
$$= 1.6296$$

Z is within the area of hypothesis, -1.96 < 1.6296 < 1.96. In other word, duration forecast by simplifying activity items is on the same population with realization duration.

5. Conclusion

Analysis model for reducing complexity in ED method calculation by grouping similar activity items in this research was conducted to 39 ongoing multistory building projects in Jakarta and surrounding areas. To ensure an appropriate result of that model, a comparison between duration forecast and realization duration of finished projects was performed. Based on the result, there are several things that can be concluded, as follows:

- Simplified activity items can be implemented in forecasting project duration. By grouping similar activity, calculation can be conducted.
- The result in this research shows that Z = 1.43431, which is within the retaining hypothesis area testing (-1.96 < 1.43431 < 1.96). This suggests that duration forecast that gained by the simplification of activity items are the same population with realization duration.
- This research focused in multistory building projects, which contains lot of activity items. By simplifying activity items in ED method, complexity that caused by lot of activity items could be reduced.

Although grouping the similar activity items can simplify calculation in ED method, inaccuracy in the grouping process can lead to less accurate result.

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