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Time and Cost Analysis on Building Construction Project using Crashing Method

Mohammad Fadli Dermawan[1*]
Universitas Swadaya Gunung Jati, Indonesia
Email: dermawanfadli85@gmail.com

Teguh Santosa[3]
Universitas Swadaya Gunung Jati, Indonesia
Email: teguhsantosaaaa@gmail.com

Ricky Sugiarto[2]
Universitas Swadaya Gunung Jati, Indonesia
Email: rickysugiarto34@gmail.com

Niko Rozi[4]
Universitas Swadaya Gunung Jati, Indonesia

ABSTRACT
Crashing method is an effort to shorten the duration of a project by accelerating the work, Building Construction in Bogor can be built with the Crashing Method to save time and minimize costs. The purpose of this study was to determine the use of the Crashing method in building construction activities, and to determine the effect of duration on the addition of heavy construction equipment on the completion of faster 1st floor, 2nd floor, and 3rd floor work. The method used is field observation, this type of research is included in the type of comparative research. Based on the results of this study, the costs incurred have decreased compared to the previous cost of Rp. 1,477,760,967.01. It is known that the Normal Cost is Rp. 26,819,720,000.00 after doing the calculation, the Crashing Cost is Rp. 25,179,405,907.94. In the calculation of the amount of Normal Cost labor of Rp. 841,309,890.35 and Crashing labor of Rp. 633,974,914.30 for total normal materials of Rp. 3,212,062,893.19. Crashing materials totaled Rp. 2,361,951,475.67. In the calculation of the duration with the addition of Concrate Pump equipment on the K-300 concrete work of the 1st floor, 2nd floor, and 3rd floor, the duration of 14 days is accelerated, the normal duration is known to be 210 days after crashing the results of the duration of 196 days.

Keywords: Crashing; Duration; Construction

INTRODUCTION

Construction project activities are temporary activities where before the project is implemented, the beginning and end of the work implementation is usually determined (Ananda, 2022). Project management is a process of planning, implementing, controlling, and coordinating project work starting from the creation of ideas to the completion of the project so as to ensure the project is completed on time, in accordance with the cost and quality of its quality. (Khotimah, Rodhi, & Tjandra, 2024).. Projects are efforts that are organized to achieve goals and objectives using existing costs and resources, projects must be completed within a predetermined time limit. According to Rakos (in Wahyu Santoso, 2017) the definition of a project in brief is an activity or activity that produces a product or service (Umiyati, 2021). Project success is evidenced by effective and efficient project planning, scheduling, and control to achieve predetermined goals or deadlines. Implementation is often not done effectively and efficiently, which causes time delays and additional costs (Yoppie Fanny Ryandre, 2023). Management is the stage

of planning, organizing, leading, and controlling the activities of members and other resources to achieve the goals set by the organization (company) (Armalisa et al., 2020).

The Crashing method is used to estimate variable costs in reducing the most appropriate cost duration of activities that can be reduced. The crashing process is focused on activities on the critical path. In the implementation of construction project activities there are various jobs, especially for building projects these types of activities can reach tens, hundreds and even thousands of activity items (Eastman, 2018; Mubarak, 2015).

Project scheduling is an activity to determine the duration of completion of each project work, as well as determine the raw materials, personnel, and time required for each job (Umiyati, 2021). In adding labor, it is important to pay attention to the available work space so as not to interfere with ongoing work activities. In addition, supervision must be balanced because a narrow workspace and lack of supervision can reduce worker productivity (Caldwell et al., 2019; Kadushin & Harkness, 2014; Waworuntu et al., 2022).

Network planning includes information systems in project implementation, but not all information can be included in network planning. Relevant information is only related to activities in the network diagram (Umiyati, 2021). Value Engineering is a creative and systematic approach to reducing or eliminating unnecessary costs. In assessing the weight for each type of work, Barchart can use the "S" Curve which functions as a representation of time and percentage of work weight. To calculate the percentage weight of each type of activity, it is necessary to know the cost of each activity and the total project cost. To control the deviation of the project is done by comparing the planned S curve and the actual S curve (Ningrum et al., 2017). The Draft Cost Budget (RAB) includes all construction costs and other project budgets, but excludes return on capital and special costs such as brokerage fees. Crashing project can be interpreted as project acceleration. Acceleration is the reduction of normal activity time obtained by providing more resources (measured in units of currency) for activities that will be reduced in time (Bakry et al., 2014; Ballesteros-Pérez et al., 2019; Orm & Jeunet, 2018; Svejvig et al., 2019).

The purpose of this study is to provide an overview of the Building Construction project using the Crashing method and how to manage the time, cost and implementation of work in the field of Building Construction. The purpose of this method is to analyze the Construction Management of Building Construction with the Crashing method to determine the effect of the duration of adding heavy construction equipment on the completion of the 1st floor work to the 3rd floor which is more effective.

RESEARCH METHODS

This building construction research is located in Bogor, the determination of the object of this research is based on survey observations at the project site. In this study using descriptive quantitative, existing data and analyzed using the crashing method to determine a more efficient duration. Quantitative methods are carried out to process the data that has been obtained and then analyzed with the help of Microsoft Excel. The data analysis carried out is to calculate the acceleration of cost and time to be more efficient in project work in the field.

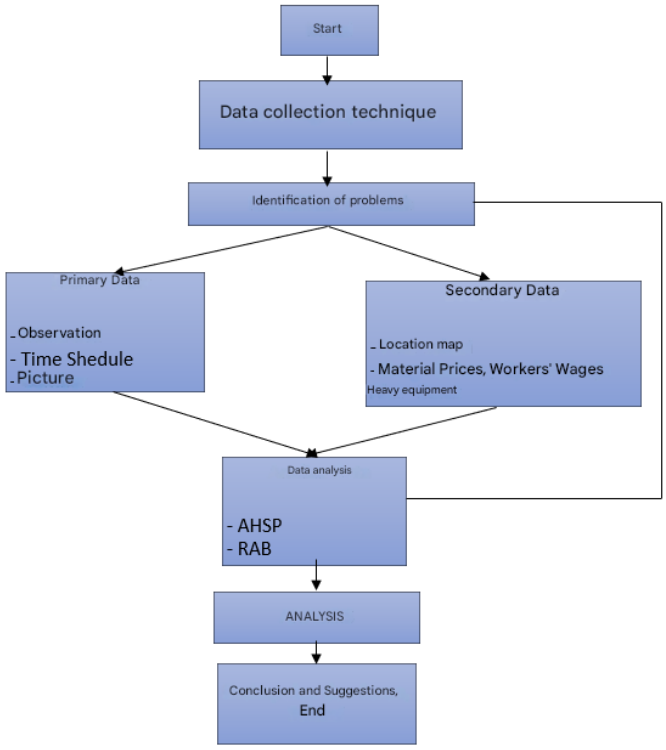

Figure 1 Research Flow Chart

Data Collection

In this study, data collection was carried out, namely field observations, the data obtained were:

a. Primary Data (interviews with stakeholders in the field)
b. Secondary Data
   In the form of data from observations (AHSP, HSP, S Curve, RAB)

Stages of Analysis

On the data that has been obtained, the researcher analyzes from the RAB data, S Curve, Barchat, The stages that will be carried out for the *crashing* method are:

a. Analyzing RAB data, S-curve, Barchat
b. Determine the work to be *crashed*
c. Calculate the cost to be minimized from the previous cost
d. Accelerate the duration

Determining the critical path

RESULTS AND DISCUSSION

1. Analysis of Labor Unit Price (AHSP):

AHSP = H.S Materials + H.S Wages + H.S Tools.....(1)

2. Unit Price of Materials:

Material = Material Price X Material Analysis Coefficient.....(2)

3. Unit Price of Wages:

Labor = Wage Price X Labor Coefficient.....(3)

4. Unit Price of Tools:

Tool rental price = Tool rental price X Tool coefficient.....(4)

5. Job Weight on the S Curve in the form of (%):

Percentage of work weight = (Volume x Unit price)/(Building Price) x 100%.....(5)

6. Cost (budget) is the sum of each volume of work.

RAB=∑(volume) X Labor Unit Price.....(6)

7. Normal cost:

Total Normal Price = Volume X Normal AHSP.....(7)

8. Calculating the *crashing* duration*:*

Crash duration = volume × worker coefficient .....(8)

9. Time costs are shortened:

Total Crashing Price = Volume X AHSP Crashing.....(9)

10. *Cost slope:*

(Crash Cost-Normal Cost) / (Normal Duration-Crash Duration).....(10)

Total Cost Slope = Cost Slope x (normal duration - crash duration) ....(11)

11. Calculation of *acceleration* time (*Crash Time*):

Total Acceleration Time = Normal Time - Acceleration Time.....(12)

12. *Acceleration* Fee:

Total Acceleration Cost = Acceleration Cost - Normal Cost.....(13)

1. Column Work Calculation

1st Floor Calculation

Volume = 62,98 m3

Unit price of workers = Rp .1,645,463.29 (obtained based on Permen PUPR No. 01 of 2022)

Total Price = Volume x HSP

= 62.98 x Rp. 1,645,463.29

= Rp. 103,642,696.28

Table 1 Pek. 1st Floor K1 Column (Normal)

No.	Description	code	Unit	Koef	Unit price	Total
A.	Labor					
	Workers	L01	OH	0.400	140,000.00	56,000.00
	Stonemason	L02	OH	0.100	150,000.00	15,000.00
	Head Builder	L03	OH	0.010	152,000.00	1,520.00
	foreman	L04	OH	0.040	153,000.00	6,126.92
	Total Labor Price 78,646.92					
B.	Material					
	Ready Mixed Concrete	M.09.x	M^2	1.02	1,389.440	1,417,228.80
C.	Equipment					
D.	Total Price of Labor, Materials, and Equipment (A+B+C) 1495,875.72					
E.	Overhead+Profit (10%)			10%	X D	149,587,57
F.	Unit Price of Work 1,645,463.29					

Volume = 62,98 m^3

Unit price of workers = Rp. 1,004,498.00 (obtained based on the results of research surveys in the field)

Total Price= Volume x HSP

= 62.98 x Rp. 1,004,498.00

= **Rp. 63,263,284.04**

Normal *Cost* = Rp. 103,624,696.28

Crash Cost = Rp. 63,263,284.04

= Normal *Cost* - *Crash Cost* =Rp.103,624,696.28-Rp.63,263,284.04

Total = **Rp. 40,361,412.19**

Table 2 Pek. 1st Floor K1 Column (*Crashing*)

No.	Description	code	Unit	Koef	Unit price	Total
A.	Labor					
	Workers	L01	OH	0.400	100,000.00	40,000.00
	Stonemason	L02	OH	0.100	120,000.00	12,000.00
	Head Builder	L03	OH	0.010	132,000.00	1,320.00
	foreman	L04	OH	0.040	140,000.00	5,600.00
	Total Labor Price 58,920.00					
B.	Material					
	Ready Mixed Concrete	M.09.x	M^2	1.02	813,000.00	829,260.00
C.	Equipment				250,000.00	25,000.00
	1. Concrete Pump		Hours	0.10		
D.	Total Price of Labor, Materials, and Equipment (A+B+C) 913,180.00					
E.	Overhead+Profit (10%)			10%	X D	91,318.00
F.	Unit Price of Work 1,004,498.00					

2nd Floor Calculation

Volume = 52,22 m3

Unit price of workers = Rp .1,645,463.29 (obtained based on the results of research surveys in the field)

Total Price = Volume x HSP

= 52.22 x Rp. 1,645,463.29

= Rp. 85,932,674.96

Table 3 Pek. Column K1 2nd Floor (Normal)

No.	Description	code	Unit	Koef	Unit price	Total
A.	Labor					
	Workers	L01	OH	0.400	140,000.00	56,000.00
	Stonemason	L02	OH	0.100	150,000.00	15,000.00
	Head Builder	L03	OH	0.010	152,000.00	1,520.00
	foreman	L04	OH	0.040	153,000.00	6,126.92
	Total Labor Price 78,646.92					

No.	Description	code	Unit	Koef	Unit price	Total
B.	Material					
	Ready Mixed Concrete	M.09.x	M^2	1.02	1,389.440	1,417,228.80
C.	Equipment					
D.	Total Price of Labor, Materials, and Equipment (A+B+C)					1495,875.72
E.	Overhead+Profit (10%)			10%	X D	149,587,57
F.	Unit Price of Work 1,645,463.29					

Volume = 52,22 m^3

Unit price of workers = Rp. 1,004,498.00 (obtained based on the results of research surveys in the field)

Total Price = Volume x HSP

= 52.22 x Rp. 1,004,498.00

= Rp. 52,454,885.56

Normal *Cost* = Rp. 85,932,674.96

Crash Cost = Rp. 52,454,885.56

= Normal *Cost* - *Crash Cost*

= Rp. 85,932,674.96 - Rp. 52,454,885.56

Total Crash= **Rp. 33,477,789.4**

Table 4 Pek. Column K1 2nd Floor *(Crashing)*

No.	Description	code	Unit	Koef	Unit price	Total
A.	Labor					
	Workers	L01	OH	0.400	100,000.00	40,000.00
	Stonemason	L02	OH	0.100	120,000.00	12,000.00
	Head Builder	L03	OH	0.010	132,000.00	1,320.00
	foreman	L04	OH	0.040	140,000.00	5,600.00
	Total Labor Price 58,920.00					
B.	Material					
	Ready Mixed Concrete	M.09.x	M^2	1.02	813,000.00	829,260.00
C.	Equipment				250,000.00	25,000.00
	2. Concrete Pump		Hours	0.10		
D.	Total Price of Labor, Materials, and Equipment (A+B+C) 913,180.00					
E.	Overhead+Profit (10%)			10%	X D	91,318.00
F.	Unit Price of Work 1,004,498.00					

Volume = 39.17 m^3

Unit price of workers = Rp. 1,645,463.29 (obtained based on the results of research surveys in the field)

Total Price= Volume x HSP

= 39.17 x Rp. 1,645,463.29

= Rp. 64,449,506.22

Table 5 Pek. 3rd Floor K3 Column (Normal)

No.	Description	code	Unit	Koef	Unit price	Total
A.	Labor					
	Workers	L01	OH	0.400	140,000.00	56,000.00
	Stonemason	L02	OH	0.100	150,000.00	15,000.00
	Head Builder	L03	OH	0.010	152,000.00	1,520.00
	foreman	L04	OH	0.040	153,000.00	6,126.92
	Total Labor Price 78,646.92					
B.	Material					
	Ready Mixed Concrete	M.09.x	M^2	1.02	1,389.440	1,417,228.80
C.	Equipment					
D.	Total Price of Labor, Materials, and Equipment (A+B+C) 1495,875.72					
E.	Overhead+Profit (10%)			10%	X D	149,587,57
F.	Unit Price of Work 1,645,463.29					

Volume = 39.17 m^3

Unit price of workers = Rp. 1,004,498.00 (obtained based on the results of research surveys in the field)

Total Price = Volume x HSP

= 39.17 x Rp. 1,004,498.00

= Rp. 39,346,186.66

Normal *Cost* = Rp. 64,449,506.22

Crash Cost = Rp. 39,346,186.66

= Normal *Cost* - *Crash Cost*

= Rp. 64,449,506.22 - Rp. 39,346,186.66

Total Crash= **Rp. 25,103,319.56**

Table 6 Pek. 3rd Floor K3 Column (*Crashing*)

No.	Description	code	Unit	Koef	Unit price	Total
A.	Labor					
	Workers	L01	OH	0.400	100,000.00	40,000.00
	Stonemason	L02	OH	0.100	120,000.00	12,000.00
	Head Builder	L03	OH	0.010	132,000.00	1,320.00
	foreman	L04	OH	0.040	140,000.00	5,600.00
	Total Labor Price 58,920.00					
B.	Material					
	Ready Mixed Concrete	M.09.x	M^2	1.02	813,000.00	829,260.00
C.	Equipment				250,000.00	25,000.00
	3. Concrete Pump		Hours	0.10		
D.	Total Price of Labor, Materials, and Equipment (A+B+C) 913,180.00					
E.	Overhead+Profit (10%)			10%	X D	91,318.00
F.	Unit Price of Work 1,004,498.00					

2. Calculation of Normal and *Crashing* Cost Budget Plan

Table 7 Normal Cost Budget Plan

No.	Job Description	Volume	Unit	Unit Price (Rp)	Total Price (Rp)
A	FLOOR 1				
1	Column K1				
	K-300 concrete	62,98	M^3	1.645.463,29	103.624.696,28
	Rebar	13.131,50	Kg	23.172,79	304.293.443,16
	Formwork	524,80	M^2	297.713,95	156.240.279,16
2	Inside Building Work				
	Urug soil Floor height t=45 cm + 5% compaction	395,55	M^3	363.543,61	143.799.676,14
	Urug sand on top of t=5 cm urug soil	92,48	M^3	344.092,90	31.820.851,44
	Cast Concrete Work Floor t=5cm	46,24	M^3	983.517,78	45.476.632,59
3	Cast concrete ground floor Fc' 25 Mpa t=13 cm (inside building)				
	K-300 concrete	123,32	M^3	1.645.463,29	202.915.242,24
	Rebar	3.261,18	Kg	23.172,79	75.570.520,38
	Iron Wiremesh M-8	1.189,63	M^2	18.041,00	21.462.142,14
B	FLOOR 2				
1	Column K1				
	K-300 concrete	52.22	M3	1,645,463.29	85,932,674.96
	Rebar	11,128.65	Kg	23,172.79	257,881,817.97
	Formwork	524.80	M2	297,713.95	156,240,279.16
2	Beam G1.1				
	K-300 concrete	24.31	M3	1,645,463.29	39,999,567.17
	Rebar	8,726.60	Kg	23,172.79	202,214,965.56
	Formwork	328.50	M2	303,323.95	99,641,916.45
3	Floor plate t = 130 mm				
	K-300 concrete	112.96	M3	1,645,463.29	185,877,292.59
	Rebar	21,767.72	Kg	23,172.79	505,519,080.58
	Formwork	868.95	M2	358,433.95	311,461,177.87
C	FLOOR 3				
1	K3 Column				

No.	Job Description	Volume	Unit	Unit Price (Rp)	Total Price (Rp)
	K-300 concrete	39.17	M3	1,645,463.29	64,449,506.22
	Rebar	8,905.01	Kg	23,172.79	206,803,923.43
	Formwork	391.68	M2	297,713.95	116,608,598.59
2	Beam G1.1				
	K-300 concrete	15.73	M3	1,645,463.29	25,874,910.27
	Rebar	5,694.07	Kg	23,172.79	131,947,435.39
	Formwork	212.50	M2	303,323.95	54,456,338.65
3	Floor plate t = 130 mm				
	K-300 concrete	112.96	M3	1,645,463.29	185,877,292.59
	Rebar	21,767.72	Kg	23,172.79	505,519,080,58
	Formwork	868.95	M2	358,433.95	311,461,177.87

Table 8 *Crash* Cost Budget Plan

No.	Job Description	Volume	Unit	Unit Price (Rp)	Total Price (Rp)
A	FLOOR 1				
1	Column K1				
	K-300 concrete	62,98	M^3	1,004,498.00	63,529,266.05
	Rebar	13.131,50	Kg	17,697.24	232,391,308.76
	Formwork	524,80	M^2	213,149.02	111,860,605.70
2	Inside Building Work				
	Urug soil Floor height t=45 cm + 5% compaction	395,55	M^3	328,318.87	129,866,529.03
	Urug sand on top of t=5 cm urug soil	92,48	M^3	298,540.00	27,608,232.85
	Cast Concrete Work Floor t=5cm	46,24	M^3	845,999.49	39,117,958.92
3	Cast concrete ground floor Fc' 25 Mpa t=13 cm (inside building)				
	K-300 concrete	123,32	M^3	1,004,498.00	123,872,684.36
	Rebar	3.261,18	Kg	17,697.24	57,713,803.99
	Iron Wiremesh M-8	1.189,63	M^2	15,281.00	18,178,759.16
B	FLOOR 2				
1	Column K1				
	K-300 concrete	52.22	M3	1,004,498.00	52,454,885.56

No.	Job Description	Volume	Unit	Unit Price (Rp)	Total Price (Rp)
	Rebar	11,128.65	Kg	17,697.24	196,946,383.60
	Formwork	524.80	M2	213,149.02	111,860,605.70
2	Beam G1.1				
	K-300 concrete	24.31	M3	1,004,498.00	24,419,346.38
	Rebar	8,726.60	Kg	17,697.24	154,433,168.23
	Formwork	328.50	M2	213,149.02	70,019,453.07
3	Floor plate t = 130 mm				
	K-300 concrete	112.96	M3	1,004,498.00	113,468,094.08
	Rebar	21,767.72	Kg	17,697.24	385,228,615.23
	Formwork	868.95	M2	213,149.02	185,215,840.93
C	FLOOR 3				
1	K3 Column				
	K-300 concrete	39.17	M3	1,004,498.00	39,346,186.66
	Rebar	8,905.01	Kg	17,697.24	157,594,029.80
	Formwork	391.68	M2	213,149.02	83,486,208.15
2	Beam G1.1				
	K-300 concrete	15.73	M3	1,004,498.00	15,800,753.54
	Rebar	5,694.07	Kg	17,697.24	100,769,299.79
	Formwork	212.50	M2	213,149.02	45,294,166.75
3	Floor plate t = 130 mm				
	K-300 concrete	112.96	M3	1,004,498.00	113,468,094.08
	Rebar	21,767.72	Kg	17,697.24	385,228,615.23
	Formwork	868.95	M2	263,015.68	228,547,475.14

3. Duration Calculation

Table 9 Duration Calculation

Type of Work	Vol	worker	Worker Coefficient	Duration	Tool Additions	Tool Coefficient	Crash Duration
1ST FLOOR WORK							
column K1	62,98	Workers	0,4	25	Concrete Pump	0,1	6
		Builder	0,1				
		Head Builder	0,01				

		Foreman	0,04				
Cast concrete ground floor fc' 25 Mpa	123,32	Workers	0,4	49	Concrete Pump	0,1	12
		Builder	0,1				
		Head Builder	0,01				
		Foreman	0,04				
2ND FLOOR WORK							
Column K1	52,22	Workers	0,4	21	Concrete Pump	0,1	5
		Builder	0,1				
		Head Builder	0,01				
		Foreman	0,04				
Beam G1.1	24,31	Workers	0,4	10	Concrete Pump	0,1	2
		Builder	0,1				
		Head Builder	0,01				
		Foreman	0,04				
Floor plate work t = 130 mm	112,96	Workers	0,4	45	Concrete Pump	0,1	11
		Builder	0,1				
		Head Builder	0,01				
		Foreman	0,04				
3RD FLOOR WORK							
K3 Column	39,17	Workers	0,4	16	Concrete Pump	0,1	4
		Builder	0,1				
		Head Builder	0,01				
		Foreman	0,04				
Beam G1.1	15,73	Workers	0,4	6	Concrete Pump	0,1	2
		Builder	0,1				
		Head Builder	0,01				
		Foreman	0,04				
Floor plate work t = 130 mm	112,96	Workers	0,4	45	Concrete Pump	0,1	11
		Builder	0,1				
		Head Builder	0,01				
		Foreman	0,04				

Table 10 Duration of Preceding Work

No.	Job Description	Code	Before Work	Duration (weeks)	ES	EF
1.	Lower Structure Work	C	A,B	10	14	77
2.	Pek. Column K1 1st Floor	D	C	1	56	56
3.	Work. Cast Concrete Base floor fc'25 Mpa	E	C	2	56	63
4.	Pek. Mechanical and Electrical std	F	C	21	56	196
5.	Pek. Mechanical and Electrical Non std	G	C	21	56	196
6.	Pek. Column K1 2nd Floor	H	D,E,F,G	1	63	63
7.	Beam G1.1 2nd Floor	I	H	1	70	70
8.	Floor Plate 2 t=130mm	J	H	2	70	77
9.	3rd Floor K3 Column	K	I,J	1	77	77
10.	Beam G1.1 3rd Floor	L	I,J	1	77	77
11.	Floor Plate 3 t=130mm	M	I,J	2	77	84
12.	Dak Floor	N	K,L,M	4	84	105
13.	Std Architecture 1st Floor	O	K,L,M	8	84	147
14.	Roof Floor	P	N,O	4	98	119
15.	Pek. Steel Roof Frame	Q	N,O	6	98	133
16.	Std Architecture 2nd Floor	R	N,O	8	98	147
17.	GWT Structure & Pump Room	S	N,O	12	98	175
18.	Pek.Sopi-Sopi	T	P,Q,R,S	4	112	133
19.	Architectural Std 3rd Floor	U	P,Q,R,S	8	112	161
20.	Exterior perimeter of the building	V	P,Q,R,S	8	112	168
21.	Drainage around the outside of the building	W	P,Q,R,S	8	112	168
22.	Pek.Ground Tank & R.Pompa Outside the building	X	P,Q,R,S	8	112	168
23.	Pek. Dak Floor and Roof	Y	T,U,V,W,X	8	126	175
24.	Pek. Others	Z	Y	10	133	196

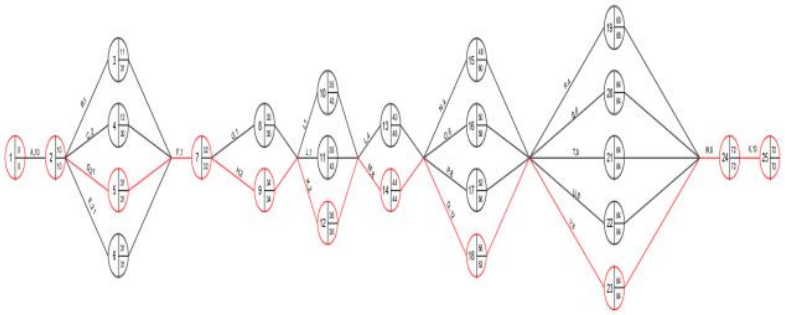

Figure 2 Critical Path

From the critical path above, it can be seen that the work that takes precedence is colored red, namely work (A) Preparation, (D) 1st floor K1 column work, (F) STD mechanical and electrical work, (H) 2nd floor K1 column work, (K) 3rd floor K3 column work, (M) 3rd floor plate work t = 130mm, (Q) steel roof truss work, (V) Work around the perimeter of the building, (W) Drainage work around the outside of the building, (X) Groun tank work and outside pump outside the building. To accelerate the duration of project completion from the initial agreed scheduling.

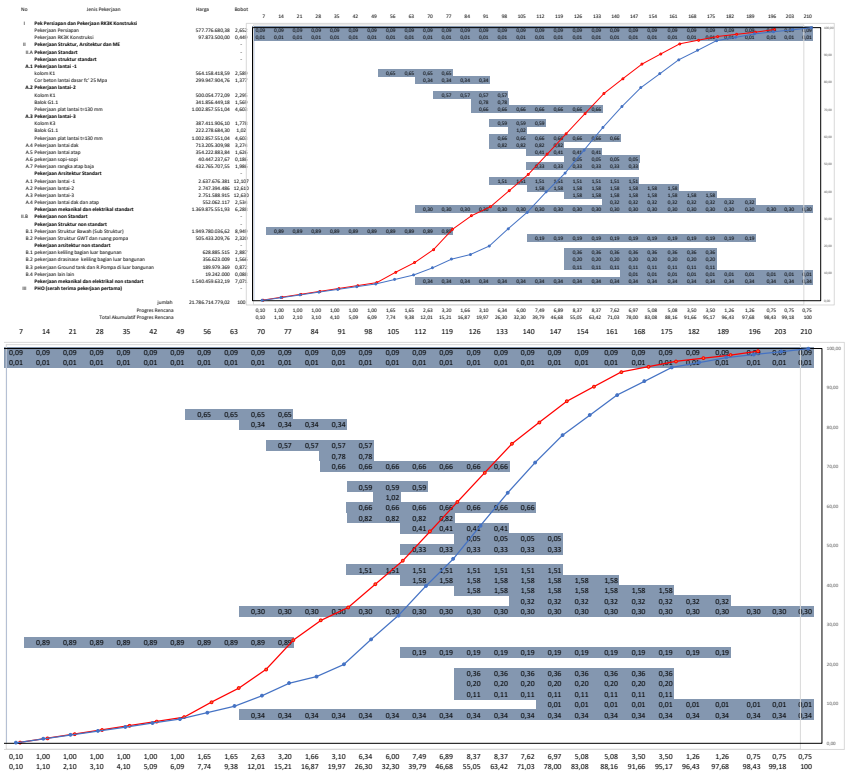

Figure 3 S-curve

It can be seen from the figure above that the initial graph is blue and the graph after *crashing* is red.

CONCLUSION

Based on the analysis of a 3-storey building construction project in Bogor, it can be concluded that the application of the crashing method has a positive impact on project completion. The construction project located on Jalan Narogong, Bogor Regency can be completed faster than the previously agreed schedule, as well as experiencing a decrease in cost. The total normal cost of this construction project is Rp 26,819,720,000.00, while after the application of crashing, the cost is Rp 25,179,405,907.94. In the calculation of normal labor costs of Rp 841,309,890.35, labor costs after crashing are reduced to Rp 633,974,914.30. For the total normal material cost of Rp 3,212,062,893.19, after crashing it becomes Rp 2,361,951,475.67. In addition, the calculation of crashing the duration of K-300 concrete structure work on floors 1, 2, and 3 with the addition of concrete pump also affects the acceleration of work duration. After crashing, the project duration has accelerated for 14 days, with a normal duration of work of 210 days, so that the duration of project completion after crashing becomes 196 days.

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