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Original Article

Analysis of Construction Project Duration Acceleration Through Workforce Addition Using the Crashing Method at SD Negeri 2 Murtajih Building

Anggatha Misykat Alamsyah[1*], Budi Witjaksana[2], Jaka Purnama[3]

[1-3]Master's Degree Program in Civil Engineering, Faculty of Engineering, Universitas 17 Agustus 1945 Surabaya, Indonesia
Email: [1)] anggatha.alamsyah23@gmail.com, [2)] budiwitjaksana@untag-sby.ac.id, [3)] jakapurnama@untag-sby.ac.id

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Abstract

Delays in the completion of construction projects remain a major problem, particularly in the construction and rehabilitation of educational buildings, which require precision in terms of time, cost and quality. One effort to address this problem is accelerating the project duration through the crashing method. Therefore, this study aims to analyze the acceleration of construction project duration through the addition of workforce using the crashing method in the rehabilitation project of SD Negeri 2 Murtajih, Pamekasan Regency. The research method used is a quantitative descriptive method with a case study approach, using secondary data in the form of a time schedule, budget plan (RAB), S curve, and project progress reports. The analysis was conducted by determining normal workforce productivity, crashing productivity, normal duration, crash duration, and the percentage of time acceleration due to the addition of workforce. The results showed that adding workers significantly accelerated the implementation duration. For instance, in the brick wall and tile floor installation, which had a normal duration of 10 days, adding 15 workers resulted in a crash duration of 7 days with an acceleration of 33%, while adding 17 workers resulted in a crash duration of 6 days with an acceleration of 41%. In conclusion, the crashing method proved effective in accelerating the project duration, despite impacting increased workforce costs. Thus, optimal acceleration planning is required to achieve a balance between time savings and additional costs for more efficient and economical project implementation.

Keywords: Construction Projects, Crashing Method, Project Acceleration, Time Management, Workforce.

1. Introduction

Infrastructure development is one of the Indonesian government's top priorities, especially in the education sector, because the quality of education services is greatly influenced by the availability of adequate school facilities. Good facilities and infrastructure create a conducive learning environment and support the effectiveness of the learning process (Saputro, 2025). Therefore, the construction and rehabilitation of school buildings are strategic steps to improve the quality of education at the primary level.

However, the implementation of school building construction projects often faces various obstacles, such as delays in completion, cost increases, and a decline in the quality of work. These delays are usually caused by poor planning, ineffective project supervision, design changes, weather constraints, workforce shortages, and delays in material supply (Saifuddin, 2019; Putri & Muhtar, 2021; Sutrisno et al., 2024). These conditions indicate that project time management is a crucial aspect in achieving cost efficiency and work quality.

One approach that can be applied to accelerate the duration of construction projects is the crashing method, which is the acceleration of projects through the addition of workforce, working hours, or the use of more efficient equipment without reducing the quality of work (Faturrohman, 2023). Several previous studies have demonstrated the effectiveness of this method in reducing project duration with additional costs that remain under control. For example, Koten and Tjendani (2023) in the Naibonat-Nunkurus road improvement project, and Firdaus et al. (2023) in the construction of SDN Kutisari 2 Surabaya, showed that adding workforce was able to accelerate project completion with a relatively small increase in costs. Furthermore, Jayantari et al. (2022) in the Wolowaru Community Health Centre project in Ende Regency emphasized that the use of shift work or overtime can significantly accelerate project duration with minimal additional costs.

The construction project of the Murtajih 2 State Elementary School building in Pamekasan Regency, which included the rehabilitation of four classrooms with a budget of IDR 495,000,000.00 and a duration of 120 calendar days, faced delays due to a lack of workforce for several items of work, suboptimal field coordination, delays in material supply, and workforce productivity that did not meet the plan. This situation makes this project relevant as a case study to analyze project duration acceleration through workforce addition using the crashing method.

This study aims to evaluate the extent to which the application of the crashing method can accelerate project duration while still controlling costs and maintaining work quality. Using primary and secondary data, this study aims to provide actionable recommendations for schools, planners, and project supervisors in optimising the implementation of educational construction projects, especially in areas with limited resources and time constraints.

2. Literature Review

2.1. Construction Projects

A project is a set of activities with objectives and goals that are limited by time, cost and resources, which are carried out on a non-recurring basis and completed with performance requirements and skill specifications from various professions and organizations as required by the service user in order to achieve measurable results. According to Mirza and Yanuarta (2024), a project is a temporary endeavor to produce a unique product or service. In general, projects involve several people whose activities are interrelated, and the main sponsors of the project are usually interested in the effective use of resources to complete the project efficiently and on time.

2.2. Project Management

Construction Project Management is the science and concept used to execute and complete construction projects by ensuring that the work is completed on time, within budget, and meets quality standards. Its implementation covers various elements such as costs, human resources, time management, quality, effective and efficient work methods, and project productivity. In general, the implementation of construction projects often experiences delays in the completion of work. Control over workforce, tools, and materials is very important for contractors, because in the implementation process, the use of workforce, tools, and materials can deviate from the initial plan (Utomo & Saputro, 2025)

Project management based on the Project Management Body of Knowledge (PMBOK) is the application of knowledge, skills, tools, and techniques used to design activities to suit the needs of the project objectives. It is understood that project management is also referred to as a collection of people and materials, information, or resources that utilize modern management methods in accordance with predetermined objectives (Alwaly & Alawi, 2020).

2.3. Time Management

Project time management involves the planning, organizing, and controlling of time allocation to ensure that all project activities are completed according to the established schedule. In the context of construction projects, time management is a crucial aspect because it is directly related to the successful execution of work, coordination of resources, and the achievement of project completion targets. Effective time management helps reduce the potential for delays and minimizes the risk of cost overruns due to activity delays.

In general, time management includes activities such as preparing work schedules, identifying dependencies between tasks, determining activity durations, and developing critical paths using methods such as the Critical Path Method (CPM). With this planning in place, project managers can determine the most efficient work sequence, allocate resources appropriately, and identify activities that have the potential for acceleration or delay. The schedule evaluation process is carried out periodically to adjust field conditions to the initial plan so that time control can be optimized.

In addition, time management also plays a role in ensuring effective coordination between project parties. The implementation of good time management allows each party to understand their tasks, deadlines, and roles in the workflow. In the event of design changes, field constraints, or other technical obstacles, a good time management system can provide alternative solutions, such as rescheduling, adding manpower, or using acceleration methods (crashing). Thus, time management does not only focus on schedule preparation, but also on the ability to adapt to project dynamics to ensure that time targets are still achieved.

3. Methods

3.1. Research Instruments

This research involves several stages. The research began with data collection, which included the project implementation schedule, budget plan, S-curve, unit price of work, and cumulative project progress. These data served as the foundation for analyzing normal productivity and duration before acceleration. Following data collection, the crashing method was applied. At this stage, crash cost and crash duration calculations were performed using the acceleration method, namely the method of adding man-hours. This approach was chosen over other crashing techniques, such as overtime or equipment substitution, because workforce addition is more practical and immediately implementable in school rehabilitation projects in Pamekasan Regency. Given the project's location in a residential area and its relatively small scale, adding workers avoids noise disturbances associated with night overtime, does not require additional heavy equipment, and can be mobilized quickly from the local workforce. This method directly addresses the identified problem of workforce shortages while maintaining work quality and safety standards. From this analysis, the time and cost after acceleration were obtained and then compared with the normal time and cost to assess the effectiveness of the method.

3.2. Data Collection Procedure

The data collection procedure utilizes secondary data in the form of project planning documents and time control documents. Project planning documents include the RAB (Budget Plan), which is used to determine the total project cost, unit prices for work, as well as workforce and material costs. The Work Plan and Specifications (RKS) provide technical specifications that affect work methods and duration. Shop drawings/detail drawings are used to determine the volume of work for each item, while the Bill of Quantity (BOQ) details the volume of work required for calculating duration and costs. Time control documents include a time schedule used to determine the critical path, a planned S-curve to determine the baseline schedule (initial project schedule), the weight of work per activity to calculate time deviations between the plan and actualization, and weekly and monthly progress reports to see the physical progress of the project and potential delays.

3.3. Data Analysis Techniques

The crashing method is used in this project to accelerate the duration of the work. The application of the crashing method includes:

1) Determining the number of workers per day

a. Determine the volume of work from the plan drawings or RAB (e.g. m^2, m^3, units).

b. Take the workforce coefficient (foreman) from AHSP/SNI.

c. Determine the normal duration (Dn) from the project schedule.

$$volume \times workforce\ coefficient$$

The result is divided by the normal duration

2) Calculating Normal Productivity per Day

a. Use the total work volume

b. Use the normal duration (Dn)

$$volume \div normal\ duration$$

3) Calculating Normal Productivity per Workforces per Day

a. Use the normal productivity per day result

b. Use the normal number of workforces. Calculation steps:

$$Productivity\ per\ day \div number\ of\ workers$$

4) Calculating Normal Productivity per Hour

a. Use productivity per worker per day

b. Determine the normal working hours per day (e.g., 8 hours)

$$Productivity\ per\ worker\ per\ day \div working\ hours$$

The result shows workforce productivity per hour.

5) Calculating the Percentage of Acceleration

a. Use the normal duration (Dn)

b. Use the crash duration (Dc)

$$(Dn - Dc) \div Dn \times 100\%$$

6) Calculating Crashing Productivity

a. Use normal productivity (Pn)

b. Determine the total normal and crash workforce

$$Pn \times (total\ crash\ workforce \div total\ normal\ workforce)$$

7) Calculating Total Additional Wages

a. Determine the number of additional workforces.

b. Determine the wage per person per day

c. Use the crash duration (Dc).

$$Additional\ workforces \times wage \times Dc$$

4. Results and Discussion

4.1. Research Results

The duration of the work is calculated based on the estimated time required to complete each type of work.

Table 1. Normal Duration of Work

No	Job Description	Volume	Unit	Duration	Unit
I	SURVEYING AND DEMOLITION WORK				
1	Dismantle 1 m² of roof truss/battens/wooden structure	343	m²	6	Day
2	Dismantle 1 m² of ceiling including wooden/hollow frame	296.4	m²	7	Day
3	Dismantle 1 m³ of trusses/girders/wooden beams	1.61	m³	5	Day
4	Dismantle 1 m³ of brickwork manually	21.02	m³	3	Day
5	Dismantle 1 m³ of low-grade concrete f'c < 20 MPa with a jackhammer	25.04	m³	2	Day
II	LAND WORK				
1	Excavation of soil	4.12	m³	2	Day
2	Backfilling of excavated soil	3.96	m³	2	Day
3	Compaction of compacted soil	50.12	m³	4	Day
IV	CONCRETE WORK				
1	Installation of formwork for sloof	19.14	m²	5	Day
2	Installation of formwork for columns	44.86	m²	5	Day
3	Installation of formwork for beams	38.45	m²	7	Day
4	Reinforcement with plain steel or threaded steel	3567.92	Kg	7	Day
5	Making 1 m³of concrete with a strength of f'c = 21.7 MPa (K 250)	14.36	m³	4	Day
V	WALL PANELLING WORK				
1	Installation of 1m2 of stone wall 1/2 mixed stone 1SP: 5PP	298.02	m²	10	Day
VI	PLASTERING AND RENDERING WORK				
1	Installation of plaster 1SP: 4PP, 15 mm thick.	298.02	m²	10	Day
2	Installation of plaster.	298.02	m²	8	Day
VII	FLOOR FINISHING WORK				
1	Installation of 40cm x 40cm colored tile flooring	286.51	m²	10	Day
VIII	DOOR AND WINDOW WORK				
1	Manufacture and installation of door frames and window frames, Kempas wood	0.8	m³	7	Day
2	Manufacture and installation of panel doors, Kempas wood	13.44	m²	7	Day
3	Manufacture and installation of glass windows, Kempas wood	5.88	m²	4	Day
4	Installation of 5 mm thick glass	12.76	m²	2	Day
5	Installation of door hinges	24	Bh	2	Day
6	Installation of 1 wind catcher	12	Bh	2	Day
7	Installation of butterfly window hinges	24	Bh	2	Day
8	Installation of window spring clips/latches	12	Bh	2	Day
9	Installation of door handles	4	Bh	2	Day
IX	ROOF FRAMEWORK & ROOF COVERING WORK				
1	Installation of 1 m² of small palentong roof tiles.	418.76	m²	10	Day
2	Installation of roof ridge tiles.	31.7	m	8	Day
3	Installation of 1 m of (2 x 25) cm lisplank, Kempas boards.	161.64	m	7	Day

No	Job Description	Volume	Unit	Duration	Unit
4	Installation of conventional truss construction, Gelam wood.	2.52	m^3	7	Day
5	Installation of 1 m^3 of gordeng construction, Gelam wood	1.83	m^3	6	Day
6	Installation of tile roof frame, Gelam wood	418.44	m^2	10	Day
X	**CEILING WORK**				
1	Installation of 1 m^2 ceiling frame (60 x 60) cm, Gelam wood	340	m^2	13	Day
2	Installation of 5 mm Kalsiboard ceiling, size 120 x 240 cm	340	m^2	13	Day
XI	**PAINTING AND VARNISHING WORK**				
1	Painting new wooden surfaces (1 coat of filler, 1 coat of primer, 3 coats of topcoat)	111.41	m^2	5	Day
2	Painting new walls (1 coat of filler, 1 coat of primer, 2 coats of topcoat)	265.21	m^2	5	Day
3	Painting new ceilings (1 coat of filler, 1 coat of primer, 2 coats of topcoat)	340	m^2	7	Day

Based on the acceleration calculation with additional workforce for bricklaying, the effectiveness coefficient is calculated as follows:
Work volume = 298.02 m^2
Number of workers = 13 people
Normal duration = 10 days
Normal productivity per day (Pn) = 298.02/(10 days) = 29.80 m^2/man-hour
Normal productivity per person per day = 29.80/(10 days) = 2,980 m^2/person-hour
Normal productivity per hour = 2.98/(10 days) = 0.298 m^2/hour/person

Based on acceleration calculations by adding workforce to bricklaying work, the effectiveness coefficient is calculated as follows:
Work volume = 286.51 m^2
Number of workers = 13 people
Normal duration = 10 days
Normal productivity per day (Pn) = 286.51/(10 days) = 28.65 m^2/man-hour
Normal productivity per person per day = 298.65/(10 days) = 2.87 m^2/person-hour
Normal productivity per hour = (2.87)/(10 days) = 0.287 m^2/hour/person

The following table 2 shows normal productivity per day, normal productivity per man-day, and normal productivity per hour for the entire job.

Table 2. Normal Productivity

No	Job Description	Vol.	Duration	2.4	2.5	2.6
			Day	m^2/OH	m^2/OH	m^2/ Time.People
I	**SURVEYING AND DEMOLITION WORK**					
1	Dismantle 1 m^2 of roof truss/battens/wooden structure	343	6	57.17	9.53	1.588
2	Dismantle 1 m^2 of ceiling including wooden/hollow frames	296.4	7	42.34	6.05	0.864
3	Dismantle 1 m^3 of trusses/girders/wooden beams	1.61	5	0.32	0.06	0.013

No	Job Description	Vol.	Duration Day	2.4 m²/OH	2.5 m²/OH	2.6 m²/ Time.People
4	Dismantle 1 m³ of brickwork manually	21.02	3	7.01	2.34	0.779
5	Dismantle 1 m³ of low-grade concrete f'c < 20 MPa with a jackhammer	25.04	2	12.52	6.26	3.130
II	**LAND WORK**					
1	Excavation of soil	4.12	2	2.06	1.03	0.515
2	Backfilling of excavated soil	3.96	2	1.98	0.99	0.495
3	Compaction of compacted soil	50.12	4	12.53	3.13	0.783
IV	**CONCRETE WORK**					
1	Installation of formwork for sloof	19.14	5	3.83	0.77	0.153
2	Installation of formwork for columns	44.86	5	8.97	1.79	0.359
3	Installation of formwork for beams	38.45	7	5.49	0.78	0.112
4	Reinforcement with plain steel or threaded steel	3567.92	7	509.70	72.81	10.402
5	Making 1 m3 of concrete with a strength of f'c = 21.7 Mpa (K 250)	14.36	4	3.59	0.90	0.224
V	**WALL PANELLING WORK**					
1	Installation of 1m2 of stone wall 1/2 mixed stone 1SP: 5PP	298.02	10	29.80	2.98	0.298
VI	**PLASTERING AND RENDERING WORK**					
1	Installation of plaster 1SP: 4PP, 15 mm thick.	298.02	10	29.80	2.98	0.298
2	Installation of plaster.	298.02	8	4.66	0.582	
VII	**FLOOR FINISHING WORK**					
1	Installation of 40cm x 40cm coloured floor tiles	286.51	10	28.65	2.87	0.287
VIII	**DOOR AND WINDOW WORK**					
1	Manufacture and installation of door frames and window frames, Kempas wood	0.8	7	0.11	0.02	0.002
2	Manufacture and installation of panel doors, Kempas wood	13.44	7	1.92	0.27	0.039
3	Manufacture and installation of glass windows, Kempas wood	5.88	4	1.47	0.37	0.092
4	Installation of 5 mm thick glass	12.76	2	6.38	3.19	1.595
5	Installation of door hinges	24	2	12.00	6.00	3.000
6	Installation of 1 wind catcher	12	2	6.00	3.00	1.500
7	Installation of butterfly window hinges	24	2	12.00	6.00	3.000
8	Installation of window spring clips/latches	12	2	6.00	3.00	1.500
9	Installation of door handles	4	2	2.00	1.00	0.500

No	Job Description	Vol.	Duration	2.4	2.5	2.6
			Day	m²/OH	m²/OH	m²/ Time.People
IX	ROOF FRAMEWORK & ROOF COVERING WORK					
1	Installation of 1 m² of small palentong roof tiles.	418.76	10	41.88	4.19	0.419
2	Installation of roof ridge tiles.	31.7	8	3.96	0.50	0.062
3	Installation of 1 m of 2 x 25 cm lisplank, Kempas boards.	161.64	7	23.09	3.30	0.471
4	Installation of conventional truss construction, Gelam wood.	2.52	7	0.36	0.05	0.007
5	Installation of 1 m³ of gordeng construction, Gelam wood	1.83	6	0.31	0.05	0.008
6	Installation of tile roof frame, Gelam wood	418.44	10	41.84	4.18	0.418
X	CEILING WORK					
1	Installation of 1 m² ceiling frame (60 x 60) cm, Gelam wood	340	13	26.15	2.01	0.155
2	Installation of 5 mm Kalsiboard ceiling, size 120 x 240 cm	340	13	26.15	2.01	0.155
XI	PAINTING AND VARNISHING WORK					
1	Painting new wooden surfaces	111.41	5	22.28	4.46	0.891
2	Painting new walls	265.21	5	53.04	10.61	2.122
3	Painting new ceilings	340	7	48.57	6.94	0.991

Source: Personal Compilation, 2025

4.1.1. Crash Duration (Dc) Bricklaying Work

1) Crash Duration (Dc) 15 workers

In calculating acceleration by adding workers, use the following crash duration formula:
Dc= Volume/(Productivity per worker x number of workers) = (298.02)/2.98x15 = 7 days
Acceleration Percentage = (Normal Duration (Dn) - Crash Duration (Dc)) / (100%) = (10 - 7) / 10 x 100% = 33%

2) Crash Duration (Dc) 17 workers

In calculating acceleration by adding workers using the crash duration formula as follows:
Dc = Volume/(Productivity per worker x number of workers) = (298.02)/2.98x17 = 6 days
Acceleration Percentage = (Normal Duration (Dn) - Crash Duration (Dc)) / (100%)
= (10-6)/10 x 100% = 41%

4.1.2. Crash Duration (Dc) for Floor Tile Installation Work

1) Crash Duration (Dc) 15 workforces

In calculating acceleration by adding workforces using the crash duration formula as follows:
Dc = Volume/(Productivity per workforce x number of workforces) = 286.51/2.87 x 15 = 7 days
Acceleration Percentage = (Normal Duration (Dn) - Crash Duration (Dc)) / (100%) (10 - 7) / 10 x 100% = 33%

2) Crash Duration (Dc) 17 workers

In calculating acceleration by adding workers, the crash duration formula is as follows: Dc = Volume/(Productivity per workforce x number of workforces) = 286.51/2.87x17 = 6 days Percentage of Acceleration = (Normal Duration (Dn) - Crash Duration (Dc))/(100%) = (10-6)/10 x 100% = 41%

Based on the results of the analysis above, using the example of bricklaying and floor tile installation, it is known that the addition of 2 and 4 workers to the classroom renovation project had an effect on reducing the duration of the work. This change is demonstrated by a shorter crash duration compared to the normal duration, as well as a percentage of time acceleration that illustrates the level of time efficiency resulting from the addition of workforce. Tables 3 and 4 below show the calculation of crash duration and percentage acceleration for the entire classroom rehabilitation work.

Table 3. Crash Duration and Acceleration Percentage (1)

No.	Job Description	Number of Staff	Pn	DC+4 Power	DC
		Addition	m^2/OH	Day	Acceleration (%)
I	**MEASUREMENT AND DEMOLITION WORK**				
1	Demolish 1 m^2 of roof truss/battens/wooden structure	11	9.53	3	45%
2	Demolish 1 m^2 of ceiling including wooden/hollow frames	10	6.05	5	30%
3	Demolish 1 m^3 of trusses/girders/wooden beams	8	0.06	3	38%
4	Demolish 1 m^3 of brickwork manually	5	2.32	2	40 %
5	Demolish 1 m^3 of low-strength concrete f'c < 20 MPa with a jackhammer.	5	6.26	1	60%
II	**EARTHWORKS**				
1	Earth excavation.	4	1.03	1	50%
2	Backfilling of excavated earth.	3	0.99	1	33%
3	Compacted gravel backfilling.	6	3.13	3	33%
IV	**CONCRETE WORKS**				
1	Formwork installation for footings.	6	0.77	4	17%
2	Formwork installation for columns.	12	1.79	2	58%
3	Installation of formwork for beams	9	0.78	5	22%
4	Reinforcement with plain or threaded steel bars	11	72.81	4	36%
5	Making 1 m^3 of concrete with f'c = 21.7 MPa (K 250)	10	0.90	2	60%
V	**WALL BRICKWORK WORK**				
1	Installation of 1 m^2 of half-brick wall with a mixture of 1SP : 5PP	15	2.98	7	33%
VI	**PLASTERING AND RENDERING WORK**				
1	Installation of plaster 1SP: 4PP, thickness 15 mm	17	2.98	6	41%
2	Installation of rendering.	15	4.66	4	47%
VII	**FLOOR COVERING WORK**				
1	Installation of 40cm x 40cm coloured tiles	15	2.87	7	33%
VIII	**DOOR AND WINDOW WORK**				

No.	Job Description	Number of Staff	Pn	DC+4 Power	DC
		Addition	m²/OH	Day	Acceleration (%)
1	Manufacture and installation of door frames and window frames, Kempas wood	7	0.02	7	0%
2	Manufacture and installation of panel doors, Kempas wood	11	0.27	4	36%
3	Manufacture and installation of glass windows, Kempas wood	9	0.37	2	56%
4	Installation of 5 mm thick glass	5	3.19	1	50%
5	Installation of door hinges	6	6.00	1	50%
6	Installation of 1 wind hook	5	3.00	1	50%
7	Installation of butterfly window hinges	6	6.00	1	50%
8	Installation of window spring clips/latches	5	3.00	1	50%
9	Installation of door handles	5	1.00	1	50%
IX	ROOF FRAME & ROOF COVERING WORK				
1	Installation of 1 m² of small *palentong* roof tiles	14	4.19	7	29%
2	Installation of tile ridge	11	0.50	6	27%
3	Installation of 1 metre of 2 x 25 cm lisplank, Kempas wood	11	3.30	4	36%
4	Installation of conventional truss construction, Gelam wood	10	0.05	5	30%
5	Installation of 1 cubic metre of curtain construction, Gelam wood	7	0.05	5	14%
6	Installation of tile roof frame, Gelam wood	13	4.18	8	23%
X	CEILING WORK (PLAFON)				
1	Installation of 1 m² ceiling frame (60 x 60) cm, *gelam* wood	17	2.01	10	24%
2	Installation of 5 mm fibre cement boards ceiling, size 120 x 240 cm	17	2.01	10	24%
XI	PAINTING AND VARNISHING WORK				
1	Painting of new wooden surfaces	8	4.46	3	38%
2	Painting of new walls	9	10.61	3	44%
3	Painting of new ceilings	8	6.94	6	13%

Source: Researcher's Compilation, 2025

Table 4. Crash Duration and Acceleration Percentage (2)

No	Job Description	Number of Staff	Pn	DC+4 Power	DC
		Addition	m2/OH	Day	Acceleration (%)
I	MEASUREMENT AND DEMOLITION WORK				
1	Demolish 1 m² of roof truss/battens/wooden structure	13	9.5	3	54%
2	Dismantle 1 m² of ceiling including wooden/hollow frames	12	6.0	4	42%
3	Dismantle 1 m³ of wooden trusses/girders/beams	10	0.1	3	50%
4	Dismantle 1 m³ of brickwork manually	7	2.3	1	57%
5	Dismantle 1 m³ of low-strength concrete f'c < 20 MPa with a jackhammer	7	6.3	1	71%
II	LAND WORK				

No	Job Description	Number of Staff	Pn	DC+4 Power	DC
		Addition	m2/OH	Day	Acceleration (%)
1	Excavation of soil	6	1.0	1	67%
2	Backfilling of excavated soil	5	1.0	1	60%
3	Compaction of compacted soil	8	3.1	2	50%
IV	**CONCRETE WORK**				
1	Installation of formwork for sloof	8	0.8	3	38%
2	Installation of formwork for columns	14	1.8	2	64%
3	Installation of formwork for beams	11	0.8	4	36%
4	Reinforcement with plain steel or threaded steel	13	72.8	4	46%
5	Making 1 m3 of concrete with a strength of f'c = 21.7 MPa (K 250)	12	0.9	1	67%
V	**WALL PANELLING WORK**				
1	Installation of 1m2 of stone wall 1/2 mixed stone 1SP: 5PP	17	3.0	6	41%
VI	**PLASTERING AND RENDERING WORK**				
1	Installation of plaster 1SP: 4PP, 15 mm thick.	19	3.0	5	47%
2	Installation of plaster.	17	4.7	4	53%
VII	**FLOOR FINISHING WORK**				
1	Installation of 40cm x 40cm coloured floor tiles	17	2.9	6	41%
VIII	**DOOR AND WINDOW WORK**				
1	Manufacture and installation of door frames and window frames, Kempas wood	9	0.0	5	22%
2	Manufacture and installation of panel doors, Kempas wood	13	0.3	4	46%
3	Manufacture and installation of glass windows, Kempas wood	11	0.4	1	64%
4	Installation of 5 mm thick glass	7	3.2	1	50%
5	Installation of door hinges	8	6.0	1	50%
6	Installation of 1 wind catcher	7	3.0	1	50%
7	Installation of butterfly window hinges	8	6.0	1	50%
8	Installation of window spring clips/latches	7	3.0	1	50%
9	Installation of door handles	7	1.0	1	50%
IX	**ROOF FRAMEWORK & ROOF COVERING WORK**				
1	Installation of 1 m² of small palentong roof tiles.	16	4.2	6	38%
2	Installation of roof ridge tiles.	13	0.5	5	38%
3	Installation of 1 m of (2 x 25) cm lisplank, Kempas boards.	13	3.3	4	46%
4	Installation of conventional truss construction, Gelam wood.	12	0.1	4	42%
5	Installation of 1 m³ of gordeng construction, Gelam wood	9	0.1	4	33%
6	Installation of tile roof frame, Gelam wood	15	4.2	7	33%
X	**CEILING WORK**				
1	Installation of 1 m² ceiling frame (60 x 60) cm, Gelam wood	19	2.0	9	32%
2	Installation of 5 mm Kalsiboard ceiling, size 120 x 240 cm	19	2.0	9	32%
XI	**PAINTING AND VARNISHING WORK**				
1	Painting new wooden surfaces	10	4.5	3	50%

No	Job Description	Number of Staff	Pn	DC+4 Power	DC
		Addition	m2/OH	Day	Acceleration (%)
2	Painting new walls	11	10.6	2	55%
3	Painting new ceilings	10	6.9	5	30%

Source: Researcher's Compilation, 2025

4.1.3. Crashing Productivity (Pc) Bricklaying Work

1) Crashing Productivity (Pc) 15 workers

Pc = *Pn x* (Total crash workforce)/(Total normal workforce) = 29.98 x 15 = 34.40 m²/day

2) Crashing Productivity (Pc) 17 workers

Pc = *Pn x* = 29.98 x 17 = 39.0 m²/day

4.1.4. Crashing Productivity (Pc) Floor Tile Installation Work

Crashing Productivity (Pc) 15 workers

1) Pc = *Pn x* (Total crash workers)/(Total normal workers) = 28.70 x 15 = 33.10 m²/day

Crashing Productivity (Pc) 17 workers

2) Pc = *Pn x* (Total crash workforce)/(Total normal workforce) = 28.70 x 17 = 37.50 m²/day

Table 5. Crashing Productivity

No.	Job Description	Number of Workers	Number of Workers	Pn	PC (2)	PC (4)
		Addition of 2	Addition of 4	m²/ OH	m²/ day	m² / day
I	SURVEYING AND DEMOLITION WORK					
1	Dismantle 1 m² of roof truss/battens/wooden structure	11	13	57.2	69.9	82.6
2	Dismantle 1 m² of ceiling including wooden/hollow frames	10	12	42.3	52.9	63.5
3	Dismantle 1 m³ of trusses/girders/wooden beams	8	10	0.3	0.4	0.5
4	Dismantle 1 m³ of brickwork manually	5	7	7.0	11.7	16.3
5	Dismantle 1 m³ of low-grade concrete f'c < 20 MPa with a jackhammer	5	7	12.5	20.9	29.2
II	LAND WORK					
1	Excavation of soil	4	6	2.1	4.1	6.2
2	Backfilling of excavated soil	3	5	2.0	5.9	9.9
3	Compaction of compacted soil	6	8	12.5	18.8	25.1
IV	CONCRETE WORK					
1	Installation of formwork for sloof	6	8	3.8	5.7	7.7
2	Installation of formwork for columns	12	14	9.0	10.8	12.6
3	Installation of formwork for beams	9	11	5.5	7.1	8.6
4	Reinforcement with plain steel or threaded steel	11	13	509.7	623.0	736.2
5	Making 1 m3 of concrete with a strength of f'c = 21.7 Mpa (K 250)	10	12	3.6	4.5	5.4
V	WALL PANELLING WORK					
1	Installation of 1m2 of stone wall 1/2 mixed stone 1SP: 5PP	15	17	29.8	34.4	39.0
VI	PLASTERING AND RENDERING WORK					

No.	Job Description	Number of Workers	Number of Workers	Pn	PC (2)	PC (4)
		Addition of 2	Addition of 4	m²/ OH	m²/ day	m² / day
1	Installation of plaster 1SP: 4PP, 15 mm thick.	17	19	29.8	33.8	37.7
2	Installation of plaster.	15	17	37.3	43.0	48.7
VII	FLOOR FINISHING WORK					
1	Installation of 40cm x 40cm coloured floor tiles	15	17	28.7	33.1	37.5
VIII	DOOR AND WINDOW WORK					
1	Manufacture and installation of door frames and window frames, Kempas wood	7	9	0.1	0.2	0.2
2	Manufacture and installation of panel doors, Kempas wood	11	13	1.9	2.3	2.8
3	Manufacture and installation of glass windows, Kempas wood	9	11	1.5	1.9	2.3
4	Installation of 5 mm thick glass	5	7	6.4	10.6	14.9
5	Installation of door hinges	6	8	12.0	18.0	24.0
6	Installation of 1 wind catcher	5	7	6.0	10.0	14.0
7	Installation of butterfly window hinges	6	8	12.0	18.0	24.0
8	Installation of window spring clips/latches	5	7	6.0	10.0	14.0
9	Installation of door handles	5	7	2.0	3.3	4.7
IX	ROOF FRAMEWORK & ROOF COVERING WORK					
1	Installation of 1 m² of small palentong roof tiles.	14	16	41.9	48.9	55.8
2	Installation of roof ridge tiles.	11	13	4.0	4.8	5.7
3	Installation of 1 m of (2 x 25) cm lisplank, Kempas boards.	11	13	23.1	28.2	33.4
4	Installation of conventional truss construction, Gelam wood.	10	12	0.4	0.5	0.5
5	Installation of 1 m³ of curtain construction, Gelam wood	7	9	0.3	0.4	0.5
6	Installation of tile roof frame, Gelam wood	13	15	41.8	49.5	57.1
X	CEILING WORK					
1	Installation of 1 m² ceiling frame (60 x 60) cm, Gelam wood	17	19	26.2	29.6	33.1
2	Installation of 5 mm fibre cement boards ceiling, size 120 x 240 cm	17	19	26.2	29.6	33.1
XI	PAINTING AND VARNISHING WORK					
1	Painting new wooden surfaces	8	10	22.3	29.7	37.1
2	Painting new walls	9	11	53.0	68.2	83.4
3	Painting new ceilings	8	10	48.6	64.8	81.0

4.2. Discussion

Based on the above calculations, it can be concluded that the analysis of workforce requirements under normal conditions shows that the number of workers for each job item has been determined based on the Unit Work Price Analysis (AHSP) coefficient. Work with a large volume and high level of complexity, such as brick wall installation, plastering, rendering, roof framing, ceiling work, and roof covering, requires more workforce than work with a small volume. This is reflected in the table of resource requirements per day, where the number of workers, craftsmen, and foremen is adjusted to the characteristics of each job.

Based on the results of workforce productivity calculations under normal conditions, the productivity per day, productivity per worker per day, and productivity per hour for all work items were obtained. For example, brick wall installation work with a volume of 298.02 m^2 and a normal duration of 10 days results in productivity of 29.80 m^2/day, productivity per worker of 2.98 m^2/OH, and productivity per hour of 0.298 m^2/hour/person. Meanwhile, tile floor installation work with a volume of 286.51 m^2 and a duration of 10 days resulted in productivity of 28.65 m^2/day, productivity per worker of 2.87 m^2/OH, and productivity per hour of 0.287 m^2/hour/person. These results show that workforce productivity varies depending on the type and characteristics of the work.

An analysis of project execution time acceleration was carried out by applying the crashing method through the addition of 2 and 4 workers to each job, respectively. The crash duration calculation was carried out by comparing the volume of work to workforce productivity after the addition of workers. In the brick wall installation work, the addition of workforce resulted in a crash duration of 7 days with an acceleration percentage of 33% for the addition of 2 people, and a crash duration of 6 days with an acceleration percentage of 41% for the addition of 4 people. Similar results were also found in tile floor installation work, where the duration of the work could be shortened to 7 days and 6 days with the same acceleration percentage.

Based on the crash duration and acceleration percentage tables for all work items, it is known that the addition of workforce is generally able to accelerate the duration of project implementation. However, the amount of acceleration produced is not linear. In some jobs, the acceleration percentage is relatively small even though the number of workers has been increased, indicating a decrease in work effectiveness due to limited workspace, worker coordination, and activity density in the field.

Overall, the analysis results show that the application of the crashing method with the addition of workforce to the classroom rehabilitation project is effective in reducing the duration of work implementation, but has an impact on increasing workforce costs. Therefore, the acceleration of project implementation time needs to be optimally planned by considering the balance between time savings and additional costs incurred, so that project objectives can be achieved efficiently and economically.

5. Conclusion

The results of the duration acceleration analysis after applying the crashing method to the construction project of Murtajih 2 Public Elementary School show that the addition of workforce can accelerate the duration of the work. For the installation of brick walls and tile floors, which normally takes 10 days, adding 15 workers resulted in a crash duration of 7 days, or an acceleration of 33%, while adding 17 workers accelerated the duration to 6 days, or 41%.

Further research is recommended to involve more than one similar project so that the results obtained are more comprehensive and generalisable. It is also recommended to use acceleration methods other than crashing to obtain a broader picture of acceleration strategies. In addition, data collection needs to be supplemented with more structured interviews and field documentation. This should be accompanied by direct evaluation of work quality so that acceleration does not negatively impact construction quality. External factors such as material price dynamics, inflation, and economic conditions also need to be considered. Incorporating these factors will ensure that the acceleration cost analysis is more realistic and in line with current market conditions.

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