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Cost Budget Analysis for Equal Distribution of Labour for Multi-Storey Buildings Construction

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Abstract: Although all resources on a construction project have their respective roles, the availability of labour significantly impacts how far the project moves forward and is completed. Calculating the number of workers according to the construction schedule is crucial because, without this consideration, the resulting schedule may not be effective and efficient. process used for construction project resources to reduce fluctuations. This research compares labour allocation, duration, and labour wage cost budgets under several conditions. These conditions include actual project conditions, planning, and results after levelling using an auto schedule. In project planning, the fluctuations obtained are pretty sharp. After the auto schedule levelling, the manpower no longer experienced overallocation, but fluctuations between weeks were still relatively high. This can happen because the quantity of work and labour in the construction projects under review is not comparable to the effects of project delays. The results obtained from the comparisons analyzed on the X-storey building construction project are that the auto schedule does not change the initial planning duration, which remains at 133 days. There was a disparity of 0.02% in auto schedule planning costs from 1,098,345,000.00. Meanwhile, in actual conditions, the labour cost budget increased by 0.12% from IDR 967,880,000.00 after the auto-schedule levelling process. It can be concluded that before resource levelling is carried out, it is necessary to review project scheduling and accelerate the duration of implementation, specifically if construction projects experience delays and other factors, so as not to cause fluctuations caused by the uneven quantity of work over some time.

Keywords: Manpower, Resource Levelling, Cost Budget.

Introduction

Embarking on a construction project is akin to orchestrating a symphony of interconnected tasks, each harmonizing to actualize a singular vision - be it erecting towering skyscrapers or laying down intricate networks of roads. Success hinges on meticulous planning, resource allocation, and unwavering commitment to meeting predefined benchmarks of time, cost, and quality (Retno, Astuti, & Tamimi, 2018). Developments in the construction sector require careful, efficient, fast, and safe project management to ensure the final results are to plan. The focus is to achieve optimal project performance by maximizing time efficiency, speed, savings, and work safety (Siswanto & Salim, 2019). It was divided into five aspects of resources that are crucial in the construction project cycle, namely materials (building materials), labour (human resources), methods (how to implement), equipment (machines), and finance (funds). Although these five resources each have an important role in the running of a construction project, the availability of labour in the construction projects under review significantly impacts the project's progress and completion. If a project experiences problems, this will impact the course of project implementation. Failure in project implementation also means failure in achieving the planned goals, which also means wasting time and money (Wohon, Mandagi, & Pratasis, 2015).

According to Yudha, Widiastini, and Rahmawati (2023), planning labour requirements and planning time schedules effectively and efficiently are the two main challenges in running a construction project. However, the actuality is that contractors tend to ignore the needs and allocation of resources and choose to focus only on optimizing time and costs (Listiani & Kamandang, 2023). Kastor and Sirakoulis (2009) explains that calculating the number of workers according to the construction schedule is crucial because, with this consideration, the resulting schedule may be effective and efficient. Mistakes in calculating labour requirements in the construction project can result in soaring operational costs for construction projects and often give rise to labour problems (Mulyono, Haryono, & Puspita, 2020). Variations in resource allocation from one period to another are endeavored to ensure that they do not exceed the maximum requirement (Maulana & Sari, 2024). This aims to ensure that the results achieved are based on the capabilities and availability of existing resources (Raja & Kumanan, 2007). To increase the efficiency of resource use, one approach that can be taken is to reduce the number and time of unemployed workers (El-Sayegh, 2018).

Fluctuation is one of the huge challenges in construction project manpower management. For example, on certain days, work needs to be done with a small amount of labour, but on other days, large amounts of work only occur unevenly for a short time. The consequence of this frequent occurrence in construction projects is sharp and significant fluctuations in the labour demand graph from time to time. Carrying out and reviewing resource allocation on construction development projects is a way to manage resource distribution efficiently (Minarosi, Putra, & Nauli, 2023). Resource levelling is the process of levelling the use of construction project resources to reduce fluctuations (Waluyo & Aditama, 2017). Resource allocation certainly involves scheduling work and providing the resources needed to carry out the work, considering the availability of resources on the project and the previously planned time duration. The principle of resource allocation has

two different categories, depending on the purpose of the resource levelling method and the factual conditions that occur in the project being reviewed. Suppose there is a condition where the level of resource requirements exceeds the maximum number of resources available on the project. In that case, this situation is described as a limited manpower situation. The resource levelling method orchestrates labour allocation in construction projects, harmonizing workforce demand to ensure steady progress without undue peaks or valleys. Resource levelling here strives to meet project resource demands with minimal impact on the project's duration. Resource levelling can also be a solution when different situations occur on a project. Suppose that, on a project, there is a situation where the level of labour requirements is much lower than the amount of resources available in the actual condition of construction projects under review. In that case, unlimited resource allocation can be carried out with a fixed total duration limit, but there is an increase in project implementation duration.

Utilizing technological advances by allocating human resources can provide benefits and make it easier for project planners to plan construction development project schedules (Sholeha & Kamandang, 2024). In carrying out the method of equalizing human resources (Resource Levelling), software in the form of Microsoft Office Project 2013 can support analyzing using this method. This software can support manpower management by creating graph histograms, planning and compiling schedules, and controlling and managing projects, even with many types of work.

Methodology

Labour Resources

Referring to Law of the Republic of Indonesia no. 13 of 2003 concerning employment, labour can be defined as every individual who can carry out work that can produce services and goods to meet personal needs and those of the wider community. Based on their skills, functions, and duties, workers are divided into several qualifications, including the following:

1. Foreman: an individual with expertise in a particular field and is responsible for direct guidance and supervision of workers on a construction project.
2. Chief craftsman: n individual with carpentry expertise in a certain type of work and is responsible for providing direction to craftsmen and workers involved in certain work. In this case, the chief craftsmen involved in the analysis carried out in this research were the chief carpenter, the chief blacksmith, and the chief mason.
3. Craftsman: An individual with certain work skills who directly carries out work on the orders and instructions of the chief craftsman in the same field. Even though the craftsman has skills, this individual is a type of manpower that generally has few skills. In this case, the craftsmen involved in the analysis carried out in this research include carpenters, blacksmiths, and mason.
4. Workers (labourers): individuals who help craftsmen and chiefs of craftsmen in various types of work. These individuals are not required to have special skills in a particular job.

Labour is generally divided into two types (Adianto & Putro, 2007). This difference is divided based on the wages received, including labour with a fixed wage and wages per unit of time. Workers included in the fixed-wage manpower are project managers, project supervisors, and other permanent workers. Meanwhile, workers paid per unit of time are chiefs of craftsmen, craftsmen, and others paid based on the length of time they work, both in days and hours. From this statement, it can be concluded that labour wages on a project will not be separated from the scheduling of the project itself. Scheduling delineates the start, delay, and completion times of activities, enabling funding and resource utilization adjustments to align with predetermined requirements (Jaya & Dewi, 2012).

Project Primary and Secondary Data Analysis

Primary data was obtained by conducting interviews and verification with field parties involved in the project under review to obtain information about the work carried out, the number of workers used, and daily reports about the construction project activities. Meanwhile, secondary data was obtained by collecting secondary data related to the X-storey building construction project, such as schedule, daily reports, weekly progress, and many more, which support research processing.

Research data

In compiling work details and labour requirements, it is necessary to process actual project-based data into detailed and structured research data. The research data required includes work bar charts, work details, and unit price analysis of project work (AHSP).

Bar chart Activities Project																						
NO	JOB DESCRIPTION	JOB LOAD (%)	September		October				November				December				January				February
			9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
I	MAIN STRUCTURAL WORK		9-25-2023	10-2-2023	10-9-2023	10-16-2023	10-23-2023	10-30-2023	11-6-2023	11-13-2023	11-20-2023	11-27-2023	12-4-2023	12-11-2023	12-18-2023	12-25-2023	1-1-2024	1-8-2024	1-15-2024	1-22-2024	1-29-2024
			10-1-2023	10-8-2023	10-15-2023	10-22-2023	10-29-2023	11-5-2023	11-12-2023	11-19-2023	11-26-2023	12-3-2023	12-10-2023	12-17-2023	12-24-2023	12-31-2023	1-7-2024	1-14-2024	1-21-2024	1-28-2024	2-4-2024
1	FLOOR Elv. -0.050	7.95%																			
2	FLOOR Elv. +4.450	8.23%																			
3	FLOOR Elv. +7.950	8.02%																			
4	FLOOR Elv. +13.450	7.99%																			
5	FLOOR Elv. +17.950	4.95%																			
6	FLOOR Elv. +21.000	0.21%																			

Figure 1. Bar Chart Activities

The bar chart above shows that the implementation of the main structural work will last for 19 weeks, starting in the last week of September 2023 until the beginning of February 2024.

Labour Details

In this research, the manpower reviewed is the manpower involved in the X-storey building construction project. The manpower involved includes the foreman, chief mason, chief blacksmith, chief carpenter, mason, blacksmith, carpenter, and workers. Calculations can be made using the volume, duration of work, and labour coefficient listed in the project's Work Unit Price Analysis (AHSP) as a benchmark to determine the labour required in a development project. The following is an example of a calculation to determine the quantity of labour in a period:

Table 1. Example of Labour Quantity Calculation

Period Quantity (Total Quantity x Weekly Quantity)	Labour	Coefficient	Weekly Labour Requirements (Coef x Period Quantity)	Results P/W	Results P/D
60.59 x 0.09 = 5.32	Foreman	0.04	0.04 x 5.32	2.42	0.35
	Chief Mason	0.01	0.01 x 5.32	0.61	0.09
	Mason	0.1	0.01 x 5.32	6.06	0.87
	Worker	0.4	0.4 x 5.32	24.24	3.46

Connecting Between Work on a Project

In allocating resources for construction projects, it is important to consider the logic of interdependence between activities. The more activities or work there are in a project, the more complicated the allocation of resources (Yuliana, Kartadipura, & Wijaya, 2019). According to Sodikin, Hani, and Susetyo (2023), by knowing the list of jobs and the duration of start and finish times included in the project scope, dependency relationships between jobs can be identified. Apart from that, determining the relationship between works also refers to the weekly project progress report. Such information helps validate and adjust relationships between jobs according to the actual progress of the project.

Maximum Number of Workers

The maximum number of workers can be taken from two main sources: contractor data and weekly progress analysis results. Contractor data comes from daily reports and the results of interviews with building construction planning consultants, while the results of the weekly progress analysis include calculations based on the labour coefficient listed in the project Work Unit Price Analysis (AHSP), as well as the period quantities and quantities referred to in the weekly progress report project under review.

Table 2. Maximum Labour Comparison

Manpower Qualifications	Foreman	Chief Blacksmith	Chief Carpenter	Chief Mason	Blacksmith	Carpenter	Mason	Worker
Contractor	10.44	15.48	1.03	0.19	154.84	10.77	3.09	181.44
Analysis	8	8	3	3	78	10	9	75

Generally, data that has a smaller value will be chosen as a reference because it can help avoid wasted costs and excess labour that is not needed. From the maximum labour comparison table above, it can be seen that the contractor data has a smaller value than the analysis results. So, using contractor data as a reference for the maximum manpower in the levelling process is a rational decision.

Resource Levelling Process in Microsoft Office Project 2013

Data related to labour requirements, relationships between jobs, work duration, and maximum labour limit per day is entered into the Microsoft Office Project 2013 software. The resource levelling process can be carried out using the features provided by the software (auto schedule and manual schedule). The goal is to adjust resource allocation to be optimal, avoid "overallocated resources," and ensure efficiency in completing work

according to schedule. After levelling, the data results are processed into a summary comparison between conditions before and after the resource levelling analysis. In this recap, the analysis will examine several changes that have occurred, including adjustments to the workload on certain resources and their impact on the overall project schedule and costs. The X-storey building construction project analysis will only use the auto schedule feature.

Result and Discussion

Manpower Allocation Planning Before Resource Levelling

Figure 2. Manpower allocation graph for foremen, chief mason, chief blacksmiths, chief carpenters, mason, blacksmith, carpenters, and workers based on planning

The red graph indicates that a labour allocation exceeded the maximum labour availability limit per day. The planning manpower allocation by the recapitulation analysis of project calculations (before resource levelling was carried out) was over-allocated in

weeks 7 and 8. The graph above is a weekly bar chart with daily labour quantities. To reflect weekly labour allocation, the percentage must be multiplied by 7 (the number of working days a week). Labour costs can be estimated by knowing the wages and number of workers required daily. The following is an analysis of the labour cost budget according to planning:

Table 3. Planning Labour Cost Budget

Manpower Qualifications	Wages (days)	Amount	Total price
Foreman	IDR 150,000.00	315	IDR 47,250,000.00
Chief Mason	IDR 145,000.00	133	IDR 19,285,000.00
Chief Blacksmith	IDR 145,000.00	322	IDR 46,690,000.00
Chief Carpenter	IDR 145,000.00	126	IDR 18,270,000.00
Mason	IDR 140,000.00	224	IDR 31,360,000.00
Blacksmith	IDR 140,000.00	2352	IDR 329,280,000.00
Carpenter	IDR 140,000.00	525	IDR 73,500,000.00
Worker	IDR 135,000.00	3946	IDR 532,710,000.00

Manpower Allocation Planning After Resource Levelling (Auto Schedule)

After levelling with the auto schedule feature, the eight resources involved in the X-storey building construction project were compared with the results of the planning data. The following are the results of labour allocation after levelling the planning data:

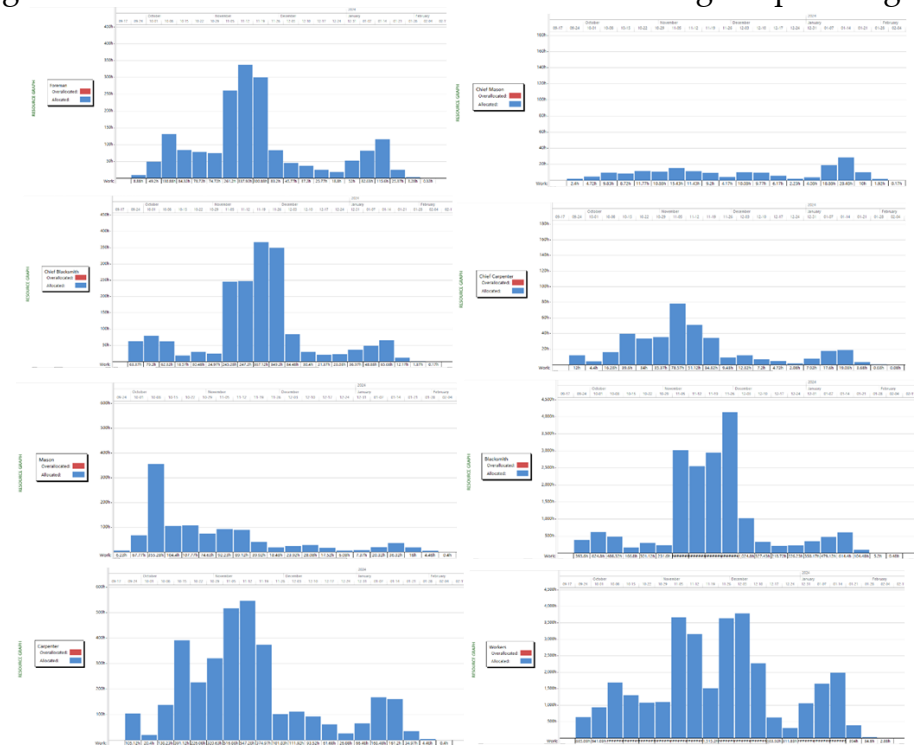

Figure 3. Graph of labour allocation for foremen, chief mason, chief blacksmiths, chief carpenters, mason, blacksmith, carpenters and workers based on the results of the auto schedule levelling

The auto schedule resource levelling process above produces graphs that are no longer over-allocated. However, the fluctuations obtained between weekly periods are still quite sharp. This is because there are delays in implementing construction development projects. The effect of this is that the quantity of work to be carried out each day is much less than the availability of labour in the actual condition of construction project under review. The fluctuations that occur in this case will cause a large number of workers to be unemployed, and there will be a buildup of workers during certain week periods. The duration of project implementation after auto schedule levelling does not increase or decrease but is the same as the implementation duration in planning, namely 133 working days. Of course, fluctuations that occur throughout the duration of project implementation will also have an impact on soaring labour costs. From the cases that occurred in this analysis, it is necessary to review project rescheduling more effectively and efficiently so that the work quantity can be more evenly distributed each day. By rescheduling the X-storey building construction project, the cost budget regarding labour wages will no longer experience a significant increase compared to the labour cost budget on the auto-levelling schedule. The following table shows the labour cost budget analysis results according to the auto-levelling schedule.

Table 4. Labour Cost Budget Levelling Auto Schedule

Manpower Qualifications	Wages (days)	Amount	Total price
Foreman	IDR 150,000.00	308	IDR 46,200,000.00
Chief Mason	IDR 145,000.00	133	IDR 19,285,000.00
Chief Blacksmith	IDR 145,000.00	308	IDR 44,660,000.00
Chief Carpenter	IDR 145,000.00	140	IDR 20,300,000.00
Mason	IDR 140,000.00	224	IDR 31,360,000.00
Blacksmith	IDR 140,000.00	2.359	IDR 330,260,000.00
Carpenter	IDR 140,000.00	518	IDR 72,520,000.00
Worker	IDR 135,000.00	3.818	IDR 515,430,000.00

Comparison Before and After Resource Levelling

Labour Allocation Results

A comparison of the allocation of workers, mason carpenters, blacksmith, chief mason, chief carpenters, chief blacksmith, and foremen each day shows significant differences between planning, actual conditions in the field, and after the auto schedule levelling process was carried out. A comparison graph of the three processes is shown in the bar chart below in different colors:

Figure 4. Comparative graph of labour allocation for foreman, chief manson, chief blacksmiths, chief carpenters, mason, blacksmith, carpenter, and workers

Significant differences in the number of workers, mason, carpenters, blacksmith, chief mason, chief carpenters, chief blacksmiths, and foremen between planning, actual conditions, and after-auto levelling schedules show striking disparities. The following is a comparison of the number of workers for multi-story building construction projects:

Table 5. Comparison of Workers Number Based on Planning

Manpower	Planning	Auto Schedule	Disparity
Foreman	315	308	-0.02
Chief Mason	133	133	0.00
Chief Blacksmith	322	308	-0.04
Chief Carpenter	126	140	0.11
Mason	224	224	0.00
Blacksmith	2352	2359	-0.003
Carpenter	525	518	-0.01
Worker	3946	3818	-0.03

In this case, resource levelling analysis using auto schedule does not increase the job duration (133 working days). However, the number of workers has increased and decreased; some have even remained unchanged. This refers to the disparity figures, which have decreased in several types of workforce qualifications, such as chief blacksmiths, which decreased by 0.04% from 322 people to 308 people. Apart from that, there was an increase of 0.11% from 126 people to 140 people in chief carpenters. Meanwhile, the chief of masons and the masons experienced neither a decrease nor an increase.

Table 6. Comparison of the Labour Needs Based on Actual Conditions

Manpower	Actual Condition	Auto Schedule	Disparity
Foreman	390	308	-0.21
Chief Mason	170	133	-0.22
Chief Blacksmith	376	308	-0.18
Chief Carpenter	187	140	-0.25
Mason	255	224	-0.12
Blacksmith	1890	2359	0.25
Carpenter	470	518	0.10
Worker	3237	3818	0.18

The table above shows that after the auto schedule resource levelling, almost all workforce qualifications decreased (except for blacksmiths, carpenters, and workers who experienced an increase). The workforce of blacksmiths experienced an increase in plans by 0.25% from 1890 people to 2359 people. This proves that the availability of labour in actual conditions still needs to be improved in planning. Meanwhile, the workforce of chief carpenter experienced a decrease in plans by 0.25% from 187 people to 140 people. Resource levelling serves as a solution to mitigate the accumulation of idle workers and curly spikes in labour wage expenses.

Labour Costs Estimated Before and After Levelling

The labour price used refers to the labour wages set by the service provider for the multi-story building construction project being reviewed.

Table 7. Comparison of Labour Cost Budgets Based on Planning

Planning	Auto Schedule	Disparity
IDR 1,098,345,000.00	IDR 1,080,015,000.00	-0.02%

From the table above, it can be seen that there was a decrease in the planning labour cost budget as a result of the auto schedule levelling by 0.02% from IDR 1,098,345,000.00 to IDR 1,080,015,000.00. This can happen because labour requirements also experience an increase and decrease after the auto-schedule resource levelling is carried out.

Table 8. Comparison of Labour Cost Budgets Based on Actual Condition

Actual Condition	Auto Schedule	Disparity
IDR 967,880,000.00	IDR 1,080,015,000.00	0.12%

From the table above, it can be seen that there was an increase in the planning labour cost budget as a result of the auto schedule levelling by 0.12% from IDR 967,880,000.00 to IDR 1,080,015,000.00. This can happen because even though there is a decrease in disparities in some labour allocations, there is also a significant increase after the auto-schedule resource levelling is carried out.

Duration of Project Implementation Before and After Levelling

After comparing the allocation of labour and wages, the duration of the main structural work is compared. The following table compares the results of auto-schedule levelling for project duration planning and actual conditions:

Table 9. Comparison of planning duration and actual conditions after levelling

Planning & Actual Condition	Auto Schedule	Disparity
133 days	133 days	0.00%

After auto-schedule levelling, the planned and actual activity duration did not increase but remained at 133 working days. This can happen because, during the equalization process, equalization is only carried out on activities that experience overall labour allocation so that no additional time is needed for labour equalization. However, in this case, it is necessary to review the project schedule because the quantity of work distributed each week is uneven due to project delays. This makes fluctuations in workforce allocation planning adjusted to weekly progress unavoidable.

Conclusion

Based on the cost budget analysis carried out on the distribution of labour in the construction of the X-storey building, the following conclusions were obtained, the resource levelling method with the support of Microsoft Office Project 2013 software in the allocation of labour for the X-storey building construction project has been proven to be able to equalize labour according to the maximum capacity of available resources. Microsoft Office Project 2013 is able to shift the start and finish times of work automatically, taking into account critical paths in the work network. As a result, the duration of start and finish times on a job after the levelling process may change. The previously fluctuating labour graph has become more even, ensuring optimal use of labour and avoiding unwanted spikes. Automatic equalization of labour (auto-schedule) can only equalize jobs that experience over allocation in a certain period. It is necessary to review project scheduling so there will

be no accumulated unnecessary labour in a period where the quantity of work is not proportional to the number of workers in actual conditions.

The results of labour analysis in actual conditions, planning, and levelling using auto schedules produce comparisons in terms of duration, labour allocation, and labour cost budgets. The resource planning graph results show very significant fluctuations. With a duration of 133 days, labour allocation is inefficient and exceeds the maximum availability of daily labour in the actual condition of construction project. After the auto schedule resource levelling was carried out, it was obtained that the implementation duration did not change from the planning (133 days) with a more even distribution of labour. However, fluctuations in the auto schedule are still relatively sharp due to project delays, which make the work quantity per week smaller than the availability of labour in the actual condition of construction project. So, it is necessary to review and further research on rescheduling or, if possible, accelerate the scheduling of projects that are experiencing delays, especially before the resource levelling process is carried out because project delays have a huge impact on manpower fluctuations.

From the results of labour allocation in planning, implementation of actual conditions in the construction projects under review, and after the auto schedule levelling process, there is a comparison of labour costs, which shows a significant disparity. The total labour cost budget after the auto schedule levelling process decreased by 0.02% from IDR 1,098,345,000.00 from planning. Meanwhile, in actual conditions, the labour cost budget increased by 0.12% from IDR 967,880,000.00 after the auto-schedule levelling process. From this analysis, it can be concluded that the increase or decrease in the labour wage cost budget can occur because the total labour requirement also experiences the same thing after the auto schedule resource levelling. Therefore, the more significant the disparity in a labour allocation, the more likely the wage budget will increase significantly compared to the cost budget, which refers to allocating the number of planned labour requirements and actual conditions.

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