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A comparison allocation of labor qualification on real, plan, and regulation calculation using resource-leveling method

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ABSTRACT

Labor is a crucial resource in industrial construction projects. A common issue is the uneven number of laborers who are overallocated. This study uses the resource-leveling method to compare and determine the optimal number of labor and project duration based on plan, real, and regulation conditions. In this study, the data required in real conditions is obtained from daily report data. In planned conditions, data is obtained from the scheduled manpower made by the contractor, while in conditions based on regulations, the calculation of the number of laborers uses the coefficient values listed in the Regulation of the Minister of Public Works and Public Housing No. 1 of 2022. This research is measured through disparity values, which show an imbalance in the allocation of labor caused by the uneven allocation of labor based on its workload. The results showed a significant difference in the number and distribution of labor. Regulation conditions resulted in higher labor numbers due to detailed calculations on each type of work and labor qualifications. The highest disparity occurs in workers, with a value of 0.93 in the plan condition and -0.51 in the regulation condition. The resource leveling helped balance labor allocation but increased project duration from 98 to 112 working days. These findings provide practical insights for project managers to optimize worker planning and distribution, improve efficiency, and reduce overallocated risks.

1. INTRODUCTION

With time, the advancement of information technology has also progressed rapidly. This significantly impacts the development of project management systems in the construction industry. This technological advancement plays an important role in assisting project management in managing data, both during planning, implementation, and closing, so that it can facilitate the running of projects more efficiently. Construction management plays a very important role in planning, controlling the progress of a project, and determining the number of laborers according to their qualifications, such as foreman, workers, stonemasons, hammersmiths, and carpenters. At present, the field of construction management is not solely focused on ensuring the smooth execution of projects but also requires a comprehensive approach that considers multiple critical factors. These include effective time management to optimize project schedules, economic value to ensure cost efficiency and financial feasibility, social responsibility to uphold ethical and community-oriented practices, as well as environmental benefits to promote sustainability and minimize the ecological impact [1], [2], [3].

A construction project is a complex and interconnected series of processes aimed at achieving a specific objective, which is the development of a physical structure such as a building, bridge, or other infrastructure [4], [5], [6]. This process involves various stages, including planning, design, resource allocation, and execution, all of which require coordination among multiple stakeholders to ensure the successful completion of the project by quality, safety, and efficiency standards. To achieve these goals of a construction project, the project requires several resources, the use of which must be considered so that the construction project can run according to plan and be completed on time. According to the research conducted by Abdel-Basset *et al.* [7], resources are classified into two classes: renewable and non-renewable. The difference between the two resources can be seen in Fig. 1. Renewable resources consist of manpower (labor), power, machines, and fuel flow, which are managed using resource-leveling, resource aggregation, and resource allocation. Non-renewable resources consist of money, fuel, energy, and materials. The management method of using non-renewable resources is the time-cost trade-off method.

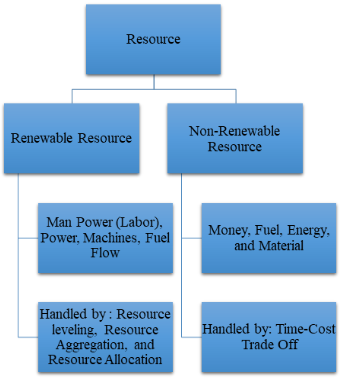

Fig. 1. Resource category

Problems often arise in implementing a construction project are related to costs, time, and resources [8], [9]. Labor is one of the most crucial resources in maintaining a construction project's continuity and overall success [10]. Due to the limited number of workers, this condition often becomes a problem. In addition, a suboptimal number of labor, such as too many or too few, can have fatal consequences because it can cause issues such as project delays and lead to increased costs experienced by the contractor [11]. The inefficient allocation of labor can significantly impact labor productivity [12]. When a construction project has an excessive number of laborers, it can lead to overcrowding at the job site, resulting in underutilized labor and periods of inactivity. This not only reduces efficiency but also increases operational costs.

On the other hand, if the number of laborers is insufficient compared to the workload, tasks will take longer to complete, causing delays in project milestones. Consequently, this can disrupt the overall project timeline, pushing back the completion date and affecting the project's cost, quality, and stakeholder expectations. In addition, a problem that often occurs and is related to human resources in the construction industry environment is the problem of uneven allocation of labor, which causes radiation levels to rise and fall very sharply [13]. Fluctuations occur because the workload fluctuates and will cause problems in the future, which can hinder project progress. Most projects provide a limit on the number of laborers (maximum) required to complete a construction project. If the labor required to complete a project exceeds the maximum labor capacity, it can cause resources to be overallocated. Labor allocation can be said to be effective and efficient if it can optimize the use of resources and duration during the project [14]. Based on these problems, contractors need to make careful planning and control efforts in determining the most optimal number of laborers so that construction projects can run well and minimize losses [15], [16], [17].

There are two ways used to manage project resources based on the existing schedule, namely resource allocation and resource-leveling [18]. Resource allocation assumes that the number of available resources is based only on assumptions, but the project work duration becomes more flexible. Resource leveling assumes that the available resources are evenly distributed with a fixed project duration. According to several researchers [19], [20], [21], [22], resource-leveling aims to minimize the level of fluctuation in the number of workers needed in the field. Resource leveling is crucial for optimizing construction resources, particularly manpower and machinery, to minimize project costs [23]. The traditional way of resource-leveling is by moving or minimizing the use of the highest number of labor to activities with lower labor usage [24]. The labor coefficient plays an important role in determining the number of laborers for each job in a construction project. However, in practice, sometimes the contractor does not plan the number of laborers, which can result in the need for labor in the field not being met by the calculation requirements based on regulations.

Contractors in Indonesia usually refer to the Minister of Public Works and Public Housing Regulation 1/2022 (Regulation of the Minister of PWPH No.1/2022) when determining the number of workers. Regulation of the Minister of PWPH No.1/2022 is a regulation in planning a construction project's Labor Unit Price Analysis (LUPA) because it contains coefficients for each construction labor qualification.

The main objective of this research is to obtain the most optimal number of labor and duration of work

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between a comparison of three conditions, namely during the plan, real, and by using the regulation calculations stated in Regulation of the Minister of PWPH No.1/2022 with the help of an application, namely Microsoft Project. The main contributions of this research are:

1) Optimizing the labor allocation for each hammersmith and carpenter using the resource-leveling method. The resource-leveling process is carried out using the features available in the Microsoft Project application.
2) This study compares three conditions: real conditions, plan conditions, and regulation-based conditions listed in the Regulation of the Minister of PWPH No.1/2022. This comparison aims to obtain the optimal conditions for labor allocation and work duration.
3) This research can be a recommendation for project managers when creating a project management strategy.

2. RELATED WORK

Numerous previous studies on resource-leveling have been conducted since the 1960s, exploring various approaches to optimizing resource allocation in construction projects. These studies primarily focused on traditional resource-leveling methods, aiming to achieve a more balanced distribution of labor to enhance project efficiency, minimize downtime, and reduce potential scheduling delays. By analyzing different techniques, researchers sought to improve labor management strategies, ensuring that labor resources are neither underutilized nor excessively concentrated at any given project stage. A detailed summary of these past studies, their key findings, and their contributions to the field is presented in Table 1.

Based on a review of previous studies, there are still several studies that only focus on equalizing the number of labor as a whole, without differentiating the proportions of each labor qualification, such as foreman, workers, stonemasons, hammersmiths, and carpenters [21], [25], [26], [27], [28]. Meanwhile, in the implementation of construction projects, each labor qualification has different roles, expertise, and workloads, so more specific allocation arrangements are needed so that the work can run according to schedule. Therefore, in this study, a more detailed resource-leveling analysis calculation was carried out by considering the labor for each qualification to produce a more optimal labor allocation according to the construction project's needs.

In previous studies, there were still research limitations. Most studies only perform labor allocation calculations under planning conditions [29], without carrying out calculations on real conditions and regulatory calculations based on the Regulation of the Minister of PWPH No.1/2022. The study's results do not adequately describe the real conditions of the project. Therefore, this study was conducted to fill the gap by conducting a resource-leveling analysis on three conditions, namely real conditions, planned conditions, and conditions based on regulatory calculations, so that the results obtained are more applicable to workforce management efforts on construction projects.

3. RESEARCH METHODS

The object of this study is a high-rise building construction project. This study focuses on several main work elements, namely the lower structure, upper structure, Sewage Treatment Plant (STP), Ground Water Tank (GWT), and pit lift work. In this study, several secondary data sources are needed from two main sources, namely, documents of the high-rise building construction project that is currently underway. The data are daily reports, manpower plans, Bill of Quantity (BOQ), and time schedules. In addition, data related to the labor coefficient value listed in the Regulation of the Minister of PWPH No.1/2022 is also needed. All project data used is original and has been validated by the project supervisor, so it has a high level of accuracy and is worthy of being used as a basis for research analysis.

In real conditions, the data needed to calculate the number of laborers is the daily project report prepared routinely by the contractor during the work implementation period. The daily report contains information about the types of work carried out daily in the field, the number of laborers involved, and the weather conditions. The number of laborers in real conditions is calculated by directly calculating the number of laborers recorded in the daily project report. Because the daily report records the activities and number of laborers every day, the calculation process is done by grouping the number of workers based on the type of work done on that day.

In the planning condition, the data used to calculate the number of laborers is the scheduled manpower prepared by the construction project contractor. This document is part of the initial project planning, which functions as a reference in determining the labor requirements needed during the implementation period based on the ideal needs estimate. In the document, the number of laborers needed for each month is listed and grouped based on the type of labor qualification, such as foreman, worker, stonemason, hammersmith, and carpenter. The number of laborers in the planning condition is calculated by adjusting to the manpower schedule that the project contractor has prepared.

In the regulation-based calculation conditions, the calculation of the number of labor refers to the value of the labor coefficient listed in the Regulation of the Minister of PWPH No.1/2022. The value of this coefficient varies depending on the characteristics of the work and the type of labor required. In addition, the

Table 1. Literature review

No.	Author	Year	Method	Main focus	Gap research
1.	Yan *et al.* [25]	2016	Resource-leveling	Optimization model for the multi-resource-leveling problem	Not considering differences in labor allocation based on qualifications, such as foremen, workers, stonemasons, hammersmiths, and carpenters.
2.	Nikoofal *et al.* [21]	2018	Metaheuristic Algorithms	Minimize project duration and overall resource fluctuation cost within the specified range of project duration while considering NPV.	Not considering the differences in labor allocation based on qualifications, such as foremen, workers, stonemasons, hammersmiths, and carpenters.
3.	Azim Eirgash [26]	2020	Resource-leveling and Resource Allocation	A straightforward scheduling technique, the resource histogram, is utilized to allocate and level the available resources.	Not considering the differences in labor allocation based on qualifications, such as foremen, workers, stonemasons, hammersmiths, and carpenters.
4.	Sodikin *et al.* [27]	2023	CPM, PERT, and Resource-leveling	Optimize existing human resources to improve the efficiency and effectiveness of the company's performance.	Not considering the differences in labor allocation based on qualifications, such as foremen, workers, stonemasons, hammersmiths, and carpenters. This research was only carried out based on the condition of the plan.
5.	Ding *et al.* [28]	2024	Takt-time Planning Method	Establish four fast-track simulation models using a three-step optimization.	Not considering the differences in labor allocation based on qualifications, such as foremen, workers, stonemasons, hammersmiths, and carpenters.
6.	Faradilla and Putra [29]	2024	Resource-leveling	Analyze labor based on labor qualifications by examining labor allocation in planning and labor in the field based on the contractor's daily report.	Not taking into account calculations on real conditions and regulations.
7.	This Research		Resource-leveling	Optimization of allocation for each labor qualification by comparing 3 conditions, namely plan, actual, and regulatory calculations.	Taking into account real conditions, plans, and regulatory calculations as stated in the Regulation of the Minister of PWPH No.1/2022, and equalizing resources for each labor qualification, namely foremen, laborers, stonemasons, hammersmiths, and carpenters.

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Table 2. Maximum limit of labor qualification

Maximum Threshold	Real	Plan	Regulation
Foreman	4	2	26
Workers	4	25	952
Stonemasons	26	11	48
Hammersmiths	16	25	41
Carpenters	26	30	414

coefficient value functions as a standard in analyzing labor productivity to complete a particular unit of work. In addition, this calculation also requires other supporting data, namely the Bill of Quantity (BOQ), to obtain the total quantity of work and the weight of the plan per week contained in the project schedule. The number of workers can be calculated using the calculation formulation:

$$Daily\ weight: \frac{weekly\ weight}{working\ days\ in\ 1\ week\ (7\ day)} \quad (1)$$

$$Daily\ quantity: total\ quantity\ x\ daily\ weight \quad (2)$$

$$Daily\ labor: daily\ quantity\ x\ coefficient\ labor \quad (3)$$

In this study, the resource-leveling method is applied with the help of Microsoft Project software. The leveling process is carried out automatically by utilizing the "Auto Level" feature available in the application. The selection of Microsoft Project is based on its ability to schedule and adjust resources efficiently. The resource-leveling method was chosen because its main focus is to level the distribution of labor during project implementation without changing the total volume of work. Compared to alternative methods such as heuristic models or more complex optimization algorithms (e.g., Genetic Algorithm or Minimum Moment Heuristic), this approach is considered more appropriate to the needs of practical analysis in construction projects that use real data and allow for direct comparisons between plan condition, real, and applicable regulations.

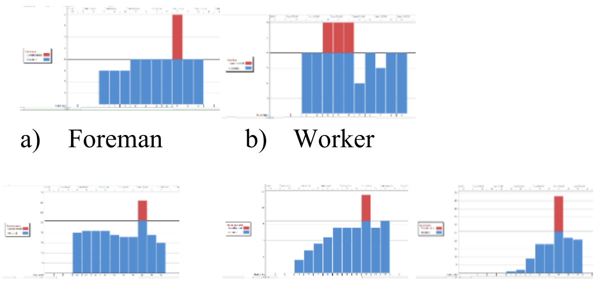
During the resource-leveling process, a histogram analysis is performed to observe the distribution of labor in each period based on each condition (plan, real, and regulation). In this analysis, the allocation of labor is considered excessive if the number of workers exceeds the maximum labor capacity each day for each qualification. Table 2 shows the maximum limit of daily labor requirements.

The maximum limit used in this analysis is determined based on the smallest value of the three conditions. Selecting the lowest value aims to avoid wasteful costs and prevent excess labor. The table above shows that real conditions have a lower maximum value compared to plan and regulation conditions. Therefore, real conditions are used as a reference for the maximum labor limit in the resource-leveling process.

4. RESULTS AND DISCUSSION

4.1. Labor requirements before resource-leveling

After data analysis, the next step is to look at the histogram of labor allocation, which functions to determine whether there is overallocation in each labor qualification. Overallocated is an error in labor allocation, where the number of available laborers is unable to meet the existing workload within the specified time limit [30]. The histogram presents data on labor usage throughout the project, from the first day to the last day, based on the time of the research implementation. The histogram of labor allocation before the resource-leveling process was carried out in the three research conditions: real condition (Fig. 2), plan condition (Fig. 3), and regulation calculation (Fig. 4).



a) Foreman b) Worker

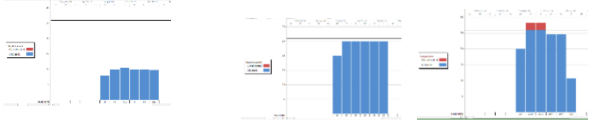
c) Stonemason d) Hammersmith e) Carpenter

Fig. 2. Histogram of real labor qualification before resource-leveling

Each labor qualification (foreman, worker, stonemason, hammersmith, and carpenter) in real conditions experienced overallocated labor, which is indicated by the red histogram bar (Fig. 2). The foreman experienced an accumulation of labor in October. The worker experienced an accumulation of labor from August to September. The stonemason, hammersmith, and carpenter experienced an accumulation of labor in October.

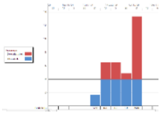
Workers and carpenters experience overallocated labor in the plan condition, which is indicated by the red histogram bars. Workers experienced an accumulation of labor from July to November, while carpenters experienced an accumulation of labor in September (Fig. 3). The regulation-based conditions, almost all labor qualifications experience overallocated labor (Fig. 4). This is indicated by the presence of red histogram bars in foreman, workers, hammersmiths, and carpenters. Foreman and carpenters experience labor accumulation from September to November. Workers experience labor accumulation from July to November. Blacksmiths experience labor accumulation in October.

a) Foreman b) Worker



c) Stonemason d) Hammersmith e) Carpenter

Fig. 3. Histogram of plan labor qualification before resource-leveling



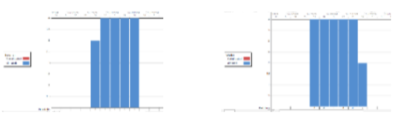
a) Foreman b) Worker

c) Stonemason d) Hammersmith e) Carpenter

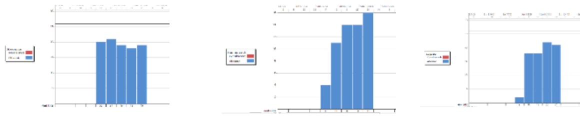
Fig. 4. Histogram of labor qualification according to the regulation before resource-leveling

4.2. Labor requirement after resource-leveling

The problem of overallocated labor can be overcome by equalizing the available labor resources. One method commonly used to overcome this is the resource-leveling method. The histogram of labor allocation based on qualifications in each research condition after resource-leveling is presented in Fig. 5, Fig. 6, and Fig. 7.



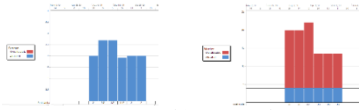
a) Foreman b) Worker



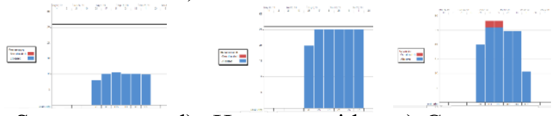
c) Stonemason d) Hammersmith e) Carpenter

Fig. 5. Histogram of real labor qualification after resource-leveling

Fig. 5 shows that all labor qualifications are no longer allocated after automatic resource-leveling analysis using the application in real conditions. However, this process causes an increase in the duration of work, from 98 days to 112 working days. Fig. 6 shows that the results of the resource-leveling analysis are still not fully effective in overcoming the overallocated problem. Two labor qualifications are still experiencing overallocated, namely workers and carpenters. This excess allocation is caused by the number of workers exceeding the maximum daily capacity set for the construction project implementation. Workers experienced overallocation consistently during the period from July to November. Meanwhile, for carpenters, the allocation occurred in September. In addition, due to the resource-leveling process carried out, the duration of the work increased from the original 98 days to 112 working days.

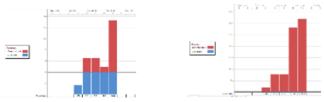


a) Foreman b) Worker

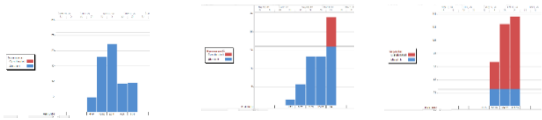


c) Stonemason d) Hammersmith e) Carpenter

Fig. 6. Histogram of plan labor qualification after resource-leveling



a) Foreman b) Worker



c) Stonemason d) Hammersmith e) Carpenter

Fig. 7. Histogram of labor qualification according to the regulation after resource-leveling

Fig. 7 shows that after auto resource-leveling was carried out under regulation-based conditions, almost all labor qualifications were still overallocated. The number of workers caused this excess allocation to exceed the maximum number of workers available in the construction project. This condition occurs because, in the regulation-based approach, the number of workers for each qualification is calculated based on the weekly work weight and labor coefficient stated in the Regulation of the Minister of PWPH No.1/2022. As a result of this resource-leveling process, the duration of the work increased from the original 98 days to 112 working days.

4.3. Comparison of labor allocation

A comparison of the allocation of foreman, workers, stonemasons, hammersmiths, and carpenters each week in three analysis conditions: plan, real, and regulation. Fig. 8 and Fig. 9 compare the allocation of foremen before and after the auto-leveling process. The

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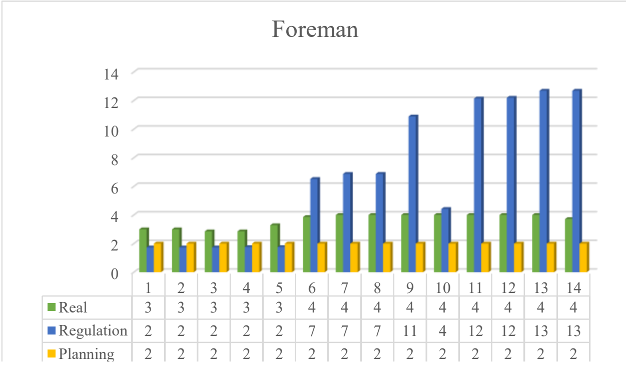

Fig. 8. Foreman allocation before resource-leveling

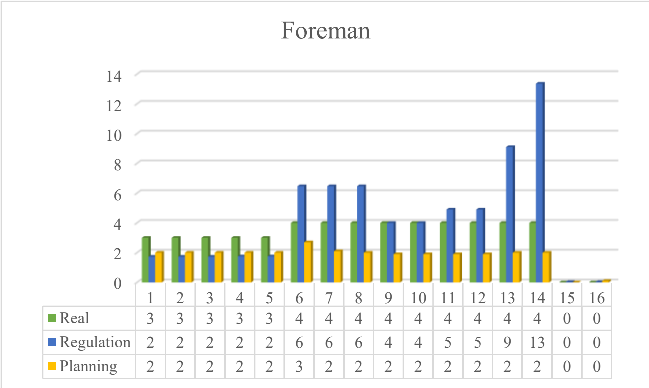

Fig. 9. Foreman allocation after resource-leveling

allocation of foremen describes the need for labor per day for each week of project implementation. After leveling, the allocation of foremen in the three research conditions showed different peak needs. In real conditions, the highest need for a foreman was 4 people. In planned conditions, the highest need for foremen reached 3 people. In calculations based on regulations, the peak need for foremen reached 13 people.

Fig. 10 and Fig. 11 compare worker allocation before and after the leveling process. Worker allocation describes the need for labor per day each week during the construction project. This picture shows a very significant disparity. The highest worker needs in the third research condition also vary. In real conditions, the peak worker need is 4 people. In planned conditions, the peak worker need reaches 20 people. In the regulation-based calculation, the peak worker need

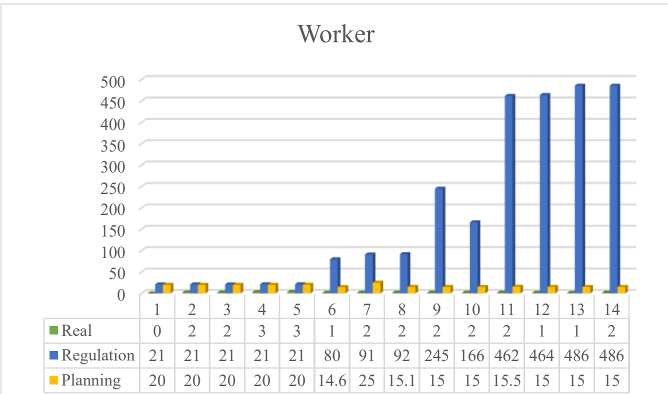

Fig. 10. Worker allocation before resource-leveling

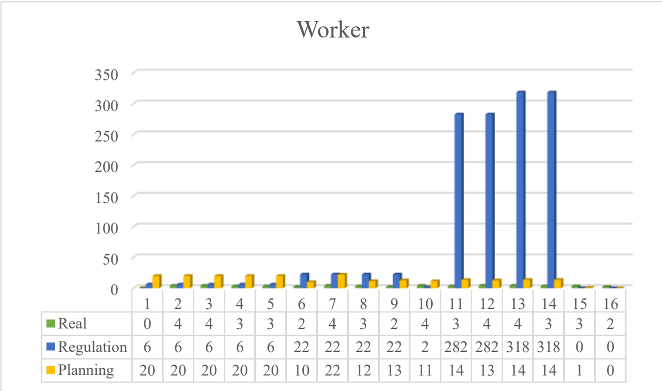

Fig. 11. Worker allocation after resource-leveling

is 318 people. This difference occurs because, in regulation-based calculations, the calculation analysis is carried out based on each labor qualification for each type of work. In contrast, in real and planned conditions, the calculation is only based on daily reports and available project schedule manpower.

Fig. 12 and Fig. 13 compare the allocation of stonemasons before and after the leveling process. This allocation illustrates the number of stonemason labor requirements per day for each week during the project. After the leveling process, the peak need for stonemasons shows no significant differences or disparities. This indicates that the distribution of stonemason labor tends to be stable, even though there are differences in the calculation approaches. In real conditions, the peak need for stonemasons reaches 21 people per day. Meanwhile, in planned conditions, the highest need for stonemasons is 10 people per day. Meanwhile, in conditions based on regulation-based calculations, the highest peak need is 11 people.

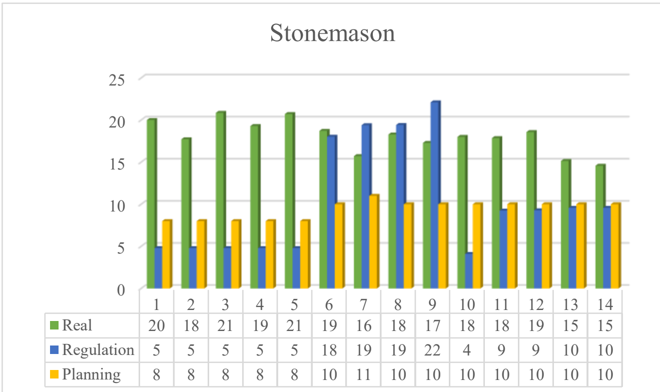

Fig. 12. Stonemason allocation before resource-leveling

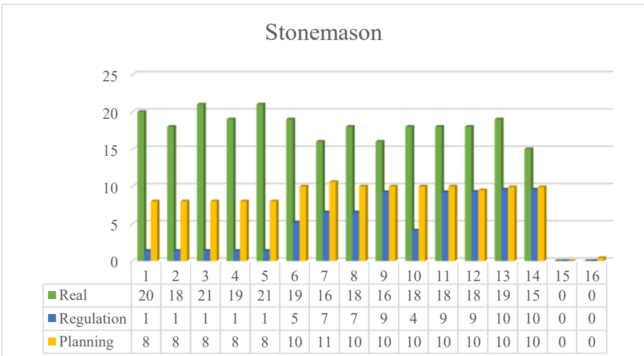

Fig. 13. Stonemason allocation after resource-leveling

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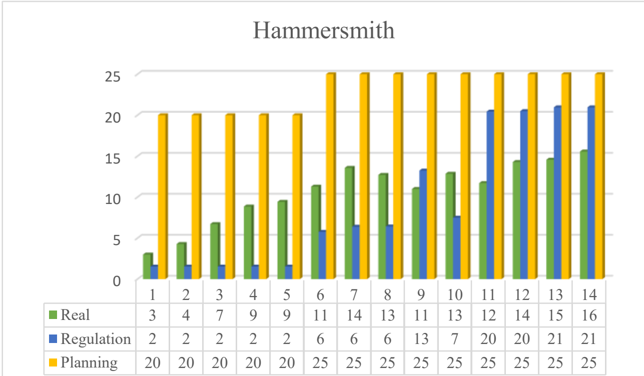

Fig. 14. Hammersmith allocation before resource-leveling

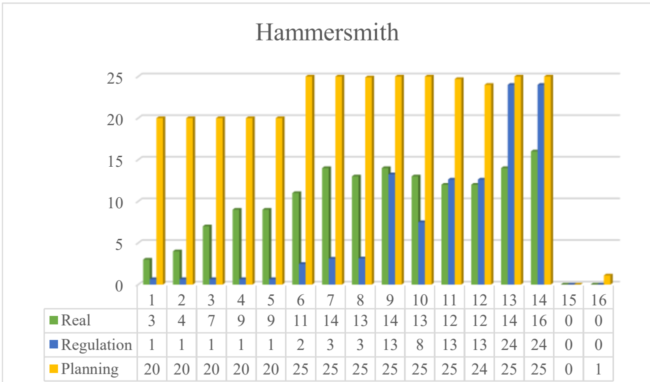

Fig. 15. Hammersmith allocation after resource-leveling

Fig. 14 and Fig. 15 compare the Hammersmith allocation before and after the leveling process. This allocation describes the number of hammersmiths needed daily each week during the construction project implementation period. After the leveling process, the analysis results show that the conditions of the three studies do not show a striking disparity. In real conditions, the peak number of hammersmiths needed reaches 16 people per day. Meanwhile, in the planned conditions, the peak need reaches 24 people daily. In conditions based on regulation-based calculations, the peak need reaches 25 people per day.

Fig. 16 and Fig. 17 compare carpenter allocation before and after the leveling process. This allocation describes the number of carpenters needed daily for each week during the construction project implementation period. After the leveling process, the analysis results show that the conditions of the three studies show very significant disparity values. The peak need for carpenters in the three conditions shows different values. In real conditions, the peak need for carpenters reaches 22 people per day. In planned conditions, the peak need for carpenters reaches 28 people. In conditions based on regulation-based

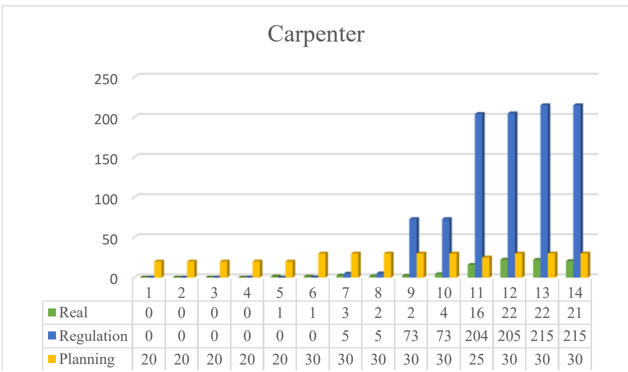

Fig. 16. Carpenter allocation before resource-leveling

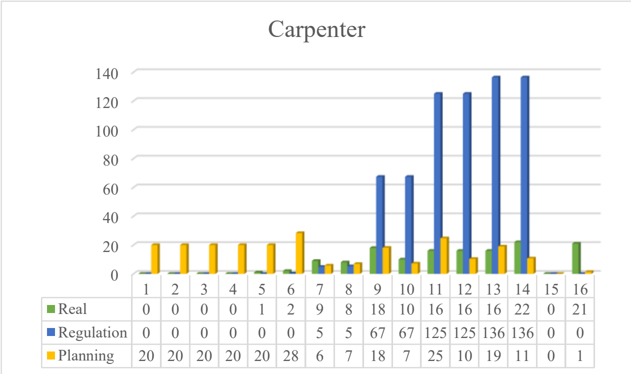

Fig. 17. Carpenter allocation after resource-leveling

calculations, the peak need for carpenters reaches 136 days.

Table 3 compares the total number of laborers from three research conditions: real conditions, planned conditions, and regulation-based calculations before and after the leveling process. There is a significant disparity in value in conditions with regulation-based calculations compared to the other two conditions. This difference occurs because the calculation method used in this condition is a detailed calculation based on the qualifications of each worker (foreman, worker, stonemason, hammersmith, and carpenter) according to the type of work carried out. This calculation refers to the value of the labor coefficient per unit of work listed in Regulation of the Minister of PWPH No.1/2022. Meanwhile, in real and planned conditions, there is no significant disparity. This is because the number of workers in both conditions is based directly on actual data in the project, without detailed classification based on worker qualifications.

4.4. Comparison duration work

After analyzing resource-leveling, we noticed a change in the work schedule from the initial planning. The additional duration before and after resource-leveling in the plan, real, and regulation calculation conditions can be seen in Table 4. After the leveling process was carried out, the duration of work in the three research conditions, namely real conditions, plans, and calculations based on regulations, experienced the same increase in implementation time. The initial duration of the project implementation, which was recorded at 98 working days, changed to 112 working days after the leveling process was applied. This increase in duration is a direct consequence of using the leveling method, which aims to equalize the distribution of labor throughout the project implementation period. The leveling process is carried out by adjusting the labor allocation so that the workload each week becomes more balanced and the occurrence or shortage of labor in certain periods is avoided.

Compared with research conducted by Prayogo and Kusuma [31], who carried out resource-leveling analysis using several functions and only carried out the entire labor. This research discusses labor optimization from a comparison of three conditions, and it is carried out for each labor qualification, namely, foreman,

Table 3. Comparison of labor allocation

Labor qualification	Before resource-leveling			After resource leveling			Disparities		
	Plan	Real	Regulation	Plan	Real	Regulation	Plan	Real	Regulation
Foreman	354	196	682	357	200	479	0.01	0.02	-0.30
Workers	174	1645	18975	336	1557	9262	0.93	-0.05	-0.51
Stonemason	1769	910	1012	1792	912	533	0.01	0	-0.47
Hammersmith	1049	2275	1149	1057	2273	742	0.01	0	-0.35
Carpenters	661	2590	6966	973	1627	4675	0.47	-0.37	-0.33

Table 4. Comparison duration of work

Description	Duration		Disparities
	Before leveling	After leveling	
Planning	98 days	112 days	-0.14
Real	98 days	112 days	-0.14
Regulation	98 days	112 days	-0.14

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worker, stonemason, hammersmith, and carpenter.

4.5. Research implication

This research provides several important insights that companies should consider when planning and managing their processes to determine the number of laborers.

1) Based on this study's findings, contractors can use it to prepare a labor allocation strategy for each worker based on qualification to minimize project delays.
2) Pay attention to the level of labor fluctuations shown in the labor histogram. This research shows how to see the level of labor fluctuation by looking at the labor histogram in the application. This research can make it easier for contractors to read and analyze the conditions of labor allocation in projects through labor histograms so that if there is excessive fluctuation, it can be immediately addressed.
3) This research explains how to minimize the occurrence of overallocated labor by using the resource-leveling method. In addition, a simulation-based testing approach can also be applied, where various maximum numbers of laborers are tested until the optimal combination that aligns with project conditions is found.

5. CONCLUSION

Based on this study's findings, the plan's conditions and regulations still affect the entire labor force, even though the leveling process has been carried out. This is caused by the need for labor that exceeds the maximum limit that the project can provide. This problem can be overcome by manually carrying out the resource-leveling process by simulating various scenarios of the maximum number of labor until the most optimal combination is found. However, this simulation approach has weaknesses. Testing at various maximum daily labor limits can increase the number of laborers per day. This condition can potentially increase project implementation costs, which will ultimately hurt the contractor.

The next finding after the resource-leveling process was carried out on each labor qualification in three research conditions in a high-rise building construction project found that there were still quite significant differences in the allocation of workers between real conditions, plan, and regulation-based calculations. Conditions with regulation-based calculations showed a higher disparity value than the other two conditions. The highest disparity value occurred in the worker category in the plan and regulation conditions, each of 0.93 and -0.51. This disparity value indicates an imbalance in the distribution of workers in several types of jobs. Negative disparity indicates the potential for excess workforce capacity in a certain period. Differences in calculation methods cause a high disparity in the value of workers. In real conditions, the number of workers is not calculated in detail based on their respective qualifications. However, in regulation-based calculations, the number of workers is calculated in detail based on the qualifications of workers for each type of job, resulting in higher labor requirements compared to real and planned conditions. Therefore, further research is needed to calculate the number of laborers based on each qualification in planned and actual conditions to obtain more accurate and balanced results.

The activity of equalizing labor through the resource-leveling process has been proven to affect the duration of work completion in construction projects. Based on the results of this study, it is known that all research conditions (real, planned, and regulation) experienced an increase in the duration of work, namely from the initial duration of 98 days to 112 working days after the leveling process was carried out.

The practical implications of this study are very relevant for a project manager in developing a more adaptive and efficient workforce planning and management strategy. By utilizing data on the mismatch between planned and actual workforce allocation in the field, project managers can improve their ability to anticipate fluctuations in workforce needs and minimize the risk of overallocation. This can increase operational efficiency and cost control and help achieve project implementation time targets.

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