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# Maximum Analysis of Human Resource Availability Units in the Construction of the Banjar Wongaya Betan Tabanan Multipurpose Center

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**ABSTRACT**: Human resources are very important in the implementation of construction projects. Improper allocation of human resources can lead to overallocation of human resources, which reduces work productivity. In the time schedule report for the realization of the Banjar Wongaya Betan Multipurpose Hall Development Project in Tabanan Regency, there was a discrepancy between the actual progress and the planned progress, resulting in delays in implementation. Based on these issues, research was conducted to determine the comparison between the maximum unit requirements and availability before and after Resources Leveling was carried out using Microsoft Office Project 2019. Based on the analysis results, it was found that the number of human resources that were initially over-allocated could be optimized after the leveling process was carried out using the resources leveling method with Microsoft Office Project 2019. The total human resource requirements and availability, which were initially 48.26 people and 37 people, became 32.13 people and 37.00 people after leveling, which means that human resources are sufficient for project implementation. The leveling results data can be used as evaluation material and benchmarks for subsequent projects.

**Keywords:** *Resources Leveling Method; Microsoft Office Project 2019; Overallocated; Human Resources;*

## I. INTRODUCTION

Construction projects are a series of interdependent activities with specific time, cost, and quality constraints. The success of a project is measured by its ability to achieve these targets optimally. However, project management is often faced with significant challenges, such as schedule delays, cost overruns, and inefficient use of resources [1].

One of the crucial problems that often occurs is the allocation of human resources that is not optimal. Insufficient labor availability often leads to over-allocated situations, where one worker is assigned to several jobs simultaneously. This condition can decrease productivity, disrupt workflow, and negatively impact the quality of work [2].

Most research in the field of project management has focused on aspects of project time control, such as the research by [3], [4]. However, the limitations and capabilities of resources, especially human resources, are often overlooked.

Inefficient allocation of human resources can directly hinder the smooth implementation of projects. This can cause delays in critical activities and trigger a domino effect that leads to delays in the overall project. Therefore, proper planning and scheduling of resources is vital to ensure the project goes as planned [5].

A clear example of this problem can be seen in the Advanced Development Project of the Banjar Wongaya Betan Multipurpose Center, Tabanan Regency. The project time schedule report shows that there is a discrepancy between the planned progress and the actual progress. This gap indicates that the project is experiencing delays, potentially due to ineffective resource management.

Given these delays, it is important to conduct an in-depth analysis of human resource scheduling and allocation. One technique that can be used to overcome unbalanced allocation is resource leveling. This technique aims to even out the use of resources so that there is no accumulation of work in a certain period of time, so that the project schedule can be optimized.

Therefore, this study aims to compare the maximum allocation of human resources needed and available before and after the implementation of resource leveling. This analysis was conducted using

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Microsoft Office Project 2019 software, with the aim of identifying potential improvements in human resource management on the project.

## II. THEORETICAL FRAMEWORK

### Project

According to [6] a project is a planned activity that aims to achieve a specific goal by utilizing the available budget and resources. Its success is measured by the ability of the project to be completed on time, within budget, and meet the quality standards that have been set.

### Project Objectives

According to [7], the main goal of the project is to satisfy the needs of customers. The goal of a project is to achieve what is already determined at the end of the project. Clear project objectives help to know the direction of the project.

### Resources

Resources are required to carry out the works that are components of the project. The use of these resources will have an impact on the cost and schedule of completion of the work. According to [6], resources are divided into two, namely project resources and activity resources. Project resources consist of Man (man), Machines (equipment), Money (cost), Method (method), and Materials (materials). Meanwhile, the activity resources consist of Man (human), Machine (equipment), and Materials (materials).

### Human Resources

According to [9], in the implementation of the project, one of the resources that determines its success is labor. The type and intensity of project activities change throughout its cycle, so the allocation of the amount of manpower, the type of skills and expertise must keep pace with the demands of ongoing changes in activities.

### Human Resource Optimization

According to [10], resource optimization is the process of allocating and managing resources in the most efficient way possible. The goal of resource optimization is to maximize productivity without increasing the number of available labors, reduce labor costs and other costs to ensure that labor and non-labor resources are adjusted to schedule. Human resources can be said to be optimal if the availability of human resources meets needs or is not overallocated.

### Overallocated

According to [11], Overallocated is a resource allocation that occurs when an organization has insufficient resources to complete all the important tasks assigned within a given time frame or too much work is assigned so that it will later hinder the progress of the project.

### Resources Leveling

The Resources Leveling method is a technique of leveling and distributing the frequency of resources, especially labor, with the aim of optimizing the allocation of project resources, so as to minimize the *overallocation* of resources.

According to [9], the human resource leveling *process* is carried out by changing the maximum limit of labor use in the resource sheet in the max section. *Units* are made changes in stages. Project scheduling has been crucial in any construction project since applying poor scheduling may lead to cost overruns and delays [12].

Resource levelling is a complex issue which needs to be resolved in order to avoid delays in the project [13]. Lack of resources can affect the project implementation time so it is necessary to distribute resources equally [14]. Resource leveling of labor (diggers, masons, blacksmiths, carpenters, and laborers) influences labor allocation in construction projects.[15]

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**Microsoft Office Project 2019**

According to [6], Microsoft Project is software that can be used to create project designs and manage projects. Microsoft Project works to manage work duration, milestones and constraints, manage relationships between work (predecessor), set work schedules, manage project resources, work with cost tables, work with resource conflicts, define project targets, work with visual reports, working with reports, working with table views, working with graph views, project progress and optimization.

In Microsoft Project, "unit maximum" refers to the number of resources (such as a worker or machine) that can be scheduled to work in a project. The maximum setting of these units is useful in project planning to take into account resource limitations and ensure that work can be adapted to the available capacity of each resource.

## III. METHODS

In this study, the author uses a descriptive research method with a quantitative approach to find out the comparison of the needs and availability of human resources before and after the Resource Leveling analysis with the help of Microsoft Office Project 2019.

This research is located in Banjar Wongaya Betan, Tabanan Regency with the location map shown in Figure 1 below:

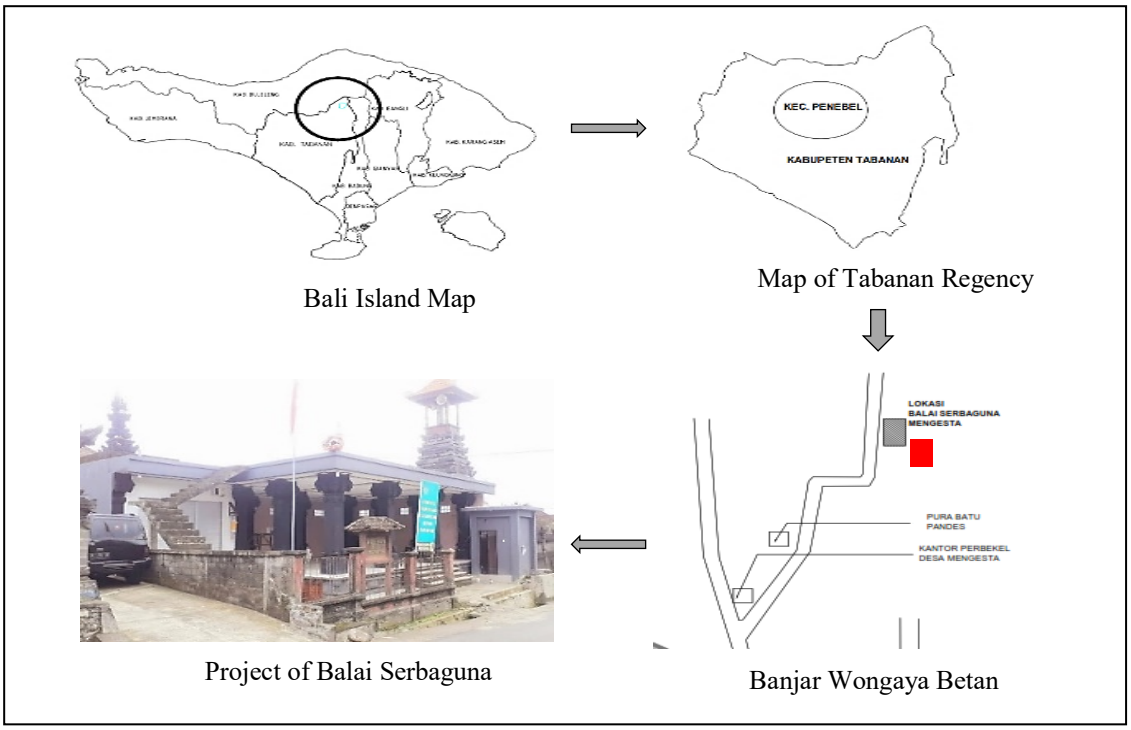


*Figure 1. Research Location*

The type of data used in this study uses secondary data from the implementing contractor, namely CV. Sustain Gold. The data used are:

1. Cost Budget Plan
2. Labor Wage List
3. Unit Price Analysis List
4. Daily Report
5. Time Schedule Planning and Realization
6. Work Calendar

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The flow chart of this research is shown in the Figure 2 below:

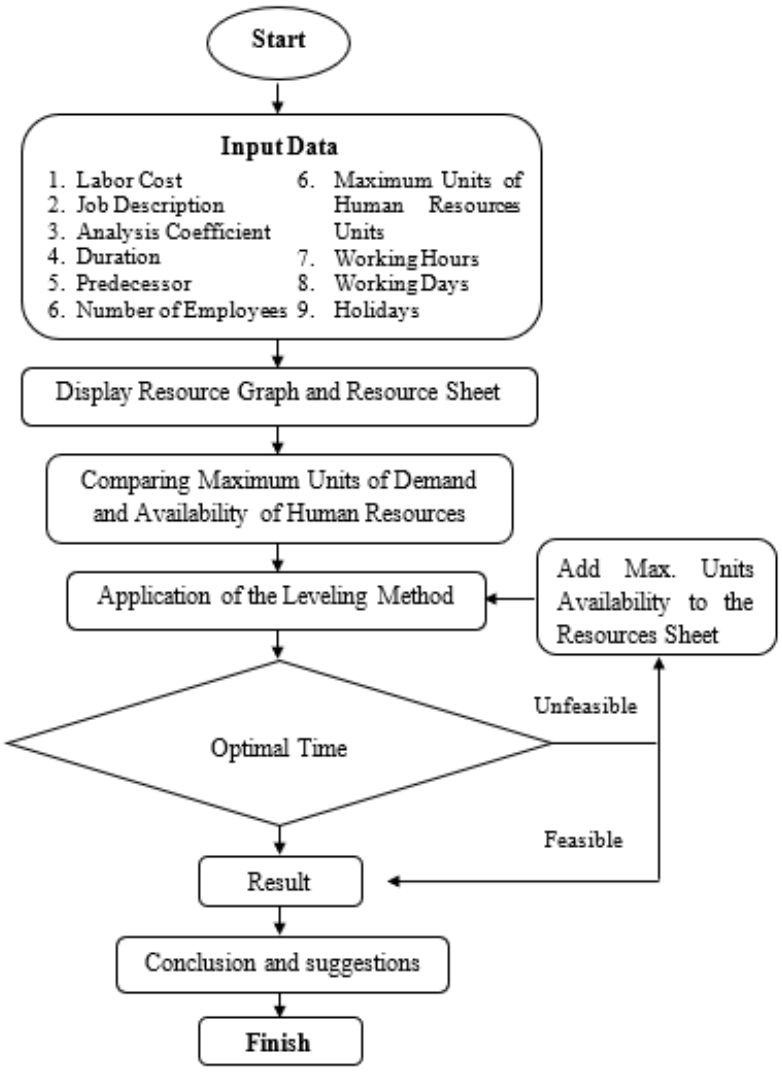


*Figure 2. Research Flowchart*

## IV. DISCUSSION

**Data Analysis**

To facilitate discussion, data analysis is divided into two stages, namely data analysis before Microsoft Project and data analysis during Microsoft Project.

**1. Data Analytics before Microsoft Project**

The data used in the analysis stage before the Microsoft Project are the Cost Budget Plan, Labor Wage List, Unit Price Analysis List, Daily Report, Plan and Realization Time Schedule, and Work Calendar. The data is then analyzed to obtain data that will be used in the analysis during the Microsoft Project.

a. Labor Unit Price Analysis

This analysis is sourced from the list of labor wage unit prices used to determine the unit price of each human resource.

b. Job Description and Job Volume Analysis

Analysis of job descriptions and work volume using data from the cost budget plan (CBP) used to determine job descriptions and work volumes. Analysis of job descriptions and volumes containing the items of each job performed, volume, and unit of work.

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c. Coefficient Analysis

The analysis coefficient analysis is sourced from the list of unit price analysis used to determine the coefficient of each work. The results of the coefficient analysis will be used to calculate the needs of the human resources used. The results of the analysis contain the work item, the name of the resource used, and the analysis coefficient.

d. Analysis of Duration of Work

Work duration analysis uses data from the plan's time schedule used to determine the duration. The analysis results contain work items, duration, and units.

e. Analysis of Job Predecessors

The analysis of the previous work uses data from the bar chart time schedule of the plan which is used to determine the relationship between work activities. Predecessor jobs are written using FS, SF, SS, and FF codes.

| | |
|---|---|
| FS = Finish to Start | FF = Finish to Finish |
| SF = Start to Finish | SS = Start to Start |

An example of the relationship between activities is that the 15/20 sloof begesting work is done after the measurement work is completed, then the FS code will be used, while the ironing work and k175 sloof concrete are carried out at the same time, then the SS code is used.

a. Human Resource Needs Analysis based on Analysis Coefficients

The analysis of human resource needs based on the analysis coefficient is calculated using data on the volume, duration and coefficient of analysis. The calculation of human resource needs based on the analysis coefficient can be done by multiplying the volume of work by the analysis coefficient and dividing it by the duration of the work. Example: Human resource requirements for 15/20 sloof ironing work with a volume of 157.83 kg.

| | | |
|---|---|---|
| Workers | = 157.83 × 0.007 / 7 days | = 0.158 |
| Blacksmith | = 157.83 × 0.007 /7 days | = 0.158 |
| Head Builder | = 157.83 × 0.001 /7 days | = 0.016 |
| Mandor | = 157.83 × 0.0004 /7 hari | = 0.009 |

b. Max. Analysis Available Human Resources Units

The analysis of Max. units is the highest value of each human resource used in the range of day 1 to day 56 or in a span of 8 weeks, according to the daily report made by the implementing contractor.

c. Work Calendar Analysis

The work calendar analysis uses data from the work calendar used at the time of project implementation. The work calendar is used to know working hours, working days, and holidays during the execution of a project. In this project, there are no holidays, where the work is carried out for 90 (ninety) full days, with 8 hours of work per day starting from 08.00 to 17.00. Break time at 13.00 WITA.

**2. Data Analytics during Microsoft Project**

Analysis when using *Microsoft Project* is divided into 2 (two) stages, namely, the data input stage into Microsoft Project and the analysis stage using Microsoft Project.

a. Stages of data input into Microsoft Project

1. Input project implementation time according to the work calendar on the project menu→ project information
2. Data input for working hours and working days according to working hours is 8 hours per day with a break time of 1 hour on the Project → change working time menu
3. Human resource input on the Resource Sheet, Resource Name → Select Type "work" for the human resource description → In the Max column, the maximum data input of the HR units available in the field based on the daily report → on Std. Rate, labor wage input.
4. Data input on the Gantt Chart sheet is carried out by entering the description of the activity in the Task Name column → entering the duration of the activity in the Duration column → input predecessors to get the start and finish time of each work item.
5. Input resources in Task Information by clicking 2x work items in the Task Name column → select Resources → Enter Resource Name → input HR needs based on the analysis coefficient in the Units column → OK

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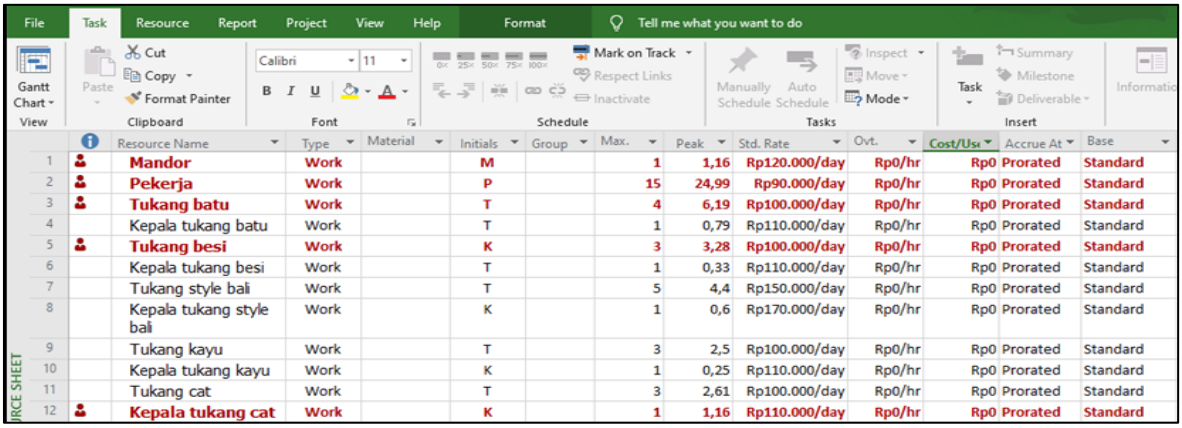
b. Analysis stage using Microsoft Project

1. Max. Analysis Human Resource Needs and Availability Units

Analysis max. human resource requirement units are automatically calculated by Microsoft Project and displayed on the Resource Sheet and Resource Graph menus. The Resources Sheet display shows a comparison in the form of numbers between the needs and the availability of human resources. The red sign indicates the overallocation of human resources, while the black color indicates that the needs of the resources have been met. To view the human resource comparison, Insert the column next to the Max. column and then select Peak. The Resource Graph displays a comparison graph between the needs and the availability of human resources. The red color indicates the occurrence of overallocated human resources, while the blue color graph indicates the available human resources. Here's an example of what the resource sheet (shown in Figure 3), resource graph (shown in Figure 4), and duration of work will look like before the leveling process using Microsoft Office Project 2019 (shown in Figure 5).



| | Resource Name | Type | Material | Initials | Group | Max. | Peak | Std. Rate | Ovt. | Cost/Use | Accrue At | Base |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Mandor | Work | | M | | 1 | 1,16 | Rp120.000/day | Rp0/hr | Rp0 | Prorated | Standard |
| 2 | Pekerja | Work | | P | | 15 | 24,99 | Rp90.000/day | Rp0/hr | Rp0 | Prorated | Standard |
| 3 | Tukang batu | Work | | T | | 4 | 6,19 | Rp100.000/day | Rp0/hr | Rp0 | Prorated | Standard |
| 4 | Kepala tukang batu | Work | | T | | 1 | 0,79 | Rp110.000/day | Rp0/hr | Rp0 | Prorated | Standard |
| 5 | Tukang besi | Work | | K | | 3 | 3,28 | Rp100.000/day | Rp0/hr | Rp0 | Prorated | Standard |
| 6 | Kepala tukang besi | Work | | T | | 1 | 0,33 | Rp110.000/day | Rp0/hr | Rp0 | Prorated | Standard |
| 7 | Tukang style bali | Work | | T | | 5 | 4,4 | Rp150.000/day | Rp0/hr | Rp0 | Prorated | Standard |
| 8 | Kepala tukang style bali | Work | | K | | 1 | 0,6 | Rp170.000/day | Rp0/hr | Rp0 | Prorated | Standard |
| 9 | Tukang kayu | Work | | T | | 3 | 2,5 | Rp100.000/day | Rp0/hr | Rp0 | Prorated | Standard |
| 10 | Kepala tukang kayu | Work | | K | | 1 | 0,25 | Rp110.000/day | Rp0/hr | Rp0 | Prorated | Standard |
| 11 | Tukang cat | Work | | T | | 3 | 2,61 | Rp100.000/day | Rp0/hr | Rp0 | Prorated | Standard |
| 12 | Kepala tukang cat | Work | | K | | 1 | 1,16 | Rp110.000/day | Rp0/hr | Rp0 | Prorated | Standard |

*Figure 3. Resource Sheet view before Leveling*

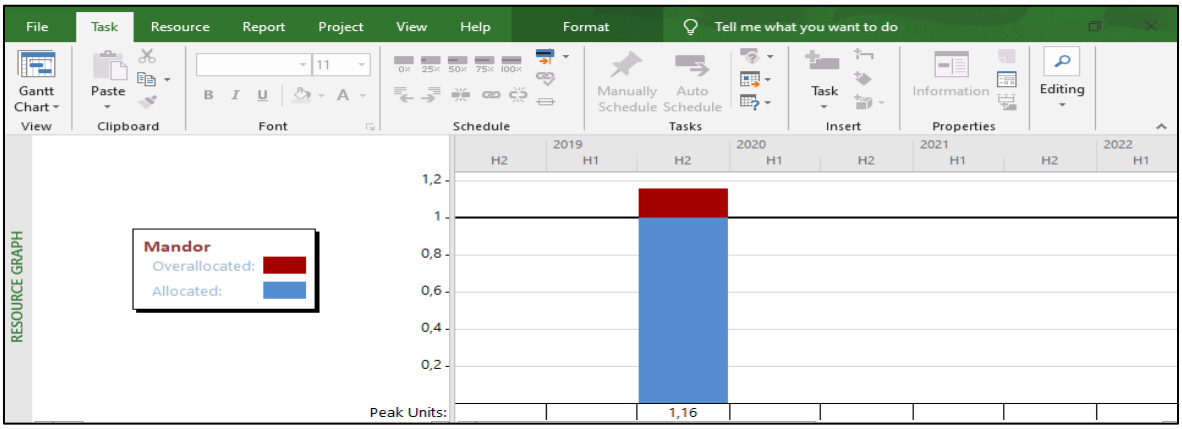
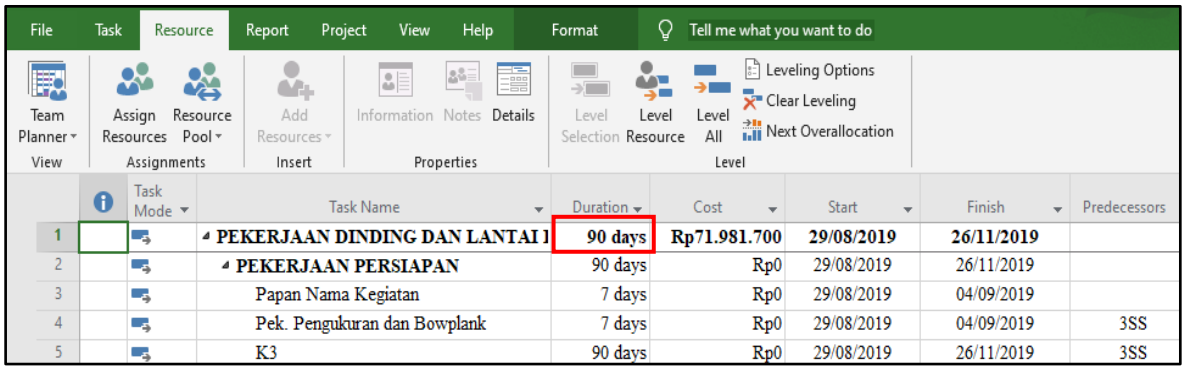



*Figure 4. Foreman Needs Chart before Leveling*



| | Task Mode | Task Name | Duration | Cost | Start | Finish | Predecessors |
|---|---|---|---|---|---|---|---|
| 1 | | PEKERJAAN DINDING DAN LANTAI 1 | 90 days | Rp71.981.700 | 29/08/2019 | 26/11/2019 | |
| 2 | | PEKERJAAN PERSIAPAN | 90 days | Rp0 | 29/08/2019 | 26/11/2019 | |
| 3 | | Papan Nama Kegiatan | 7 days | Rp0 | 29/08/2019 | 04/09/2019 | |
| 4 | | Pek. Pengukuran dan Bowplank | 7 days | Rp0 | 29/08/2019 | 04/09/2019 | 3SS |
| 5 | | K3 | 90 days | Rp0 | 29/08/2019 | 26/11/2019 | 3SS |

*Figure 5. Display of Activity Duration before Leveling*

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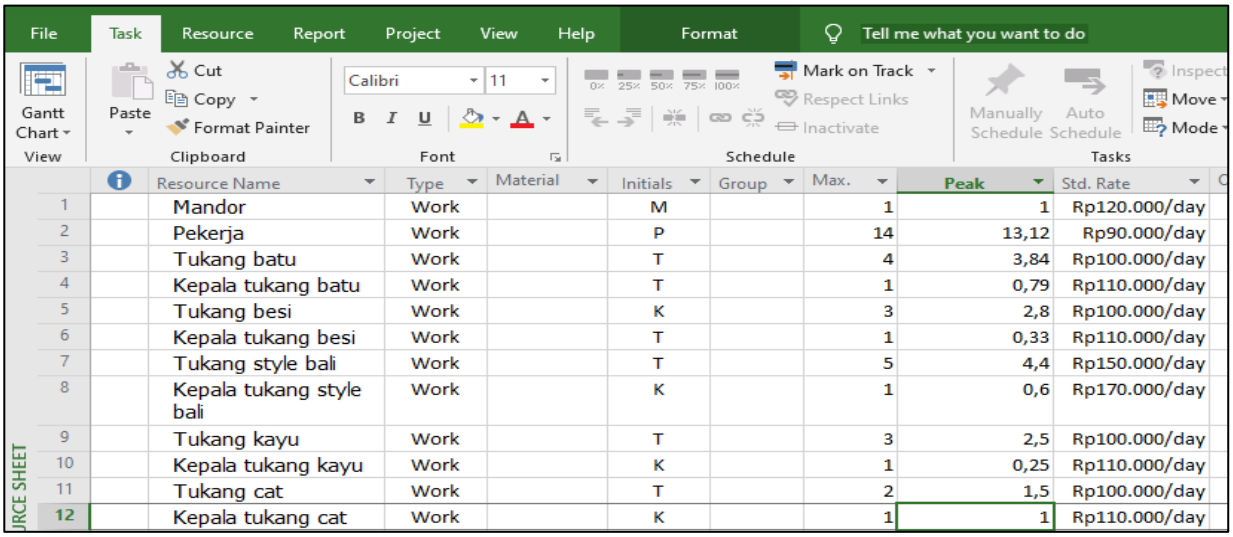
2. Analysis Resources Leveling

Resource leveling analysis is carried out if the available workforce is overallocated or lacks more human resources than needed. To overcome overallocation, click on the Resource → Level All menu.

Human resources that were previously overallocated can automatically meet the needs of human resources. If the leveling process has been carried out but human resources are still overallocated, then add the workforce to the max. units that are overallocated according to the amount needed.

Figure 6 shows the resource sheet after Leveling. When this data is displayed in a graph as shown in Figure 7, it can be seen that resources that were initially overallocated (shown in Figure 4) can now be allocated evenly in Microsoft Project and are no longer overallocated. After leveling, the project duration increased from 90 days to 103 days, as shown in Figure 7.




| | Resource Name | Type | Material | Initials | Group | Max. | Peak | Std. Rate |
|---|---|---|---|---|---|---|---|---|
| 1 | Mandor | Work | | M | | 1 | 1 | Rp120.000/day |
| 2 | Pekerja | Work | | P | | 14 | 13,12 | Rp90.000/day |
| 3 | Tukang batu | Work | | T | | 4 | 3,84 | Rp100.000/day |
| 4 | Kepala tukang batu | Work | | T | | 1 | 0,79 | Rp110.000/day |
| 5 | Tukang besi | Work | | K | | 3 | 2,8 | Rp100.000/day |
| 6 | Kepala tukang besi | Work | | T | | 1 | 0,33 | Rp110.000/day |
| 7 | Tukang style bali | Work | | T | | 5 | 4,4 | Rp150.000/day |
| 8 | Kepala tukang style bali | Work | | K | | 1 | 0,6 | Rp170.000/day |
| 9 | Tukang kayu | Work | | T | | 3 | 2,5 | Rp100.000/day |
| 10 | Kepala tukang kayu | Work | | K | | 1 | 0,25 | Rp110.000/day |
| 11 | Tukang cat | Work | | T | | 2 | 1,5 | Rp100.000/day |
| 12 | Kepala tukang cat | Work | | K | | 1 | 1 | Rp110.000/day |

*Figure 6. Resource Sheet view after Leveling*

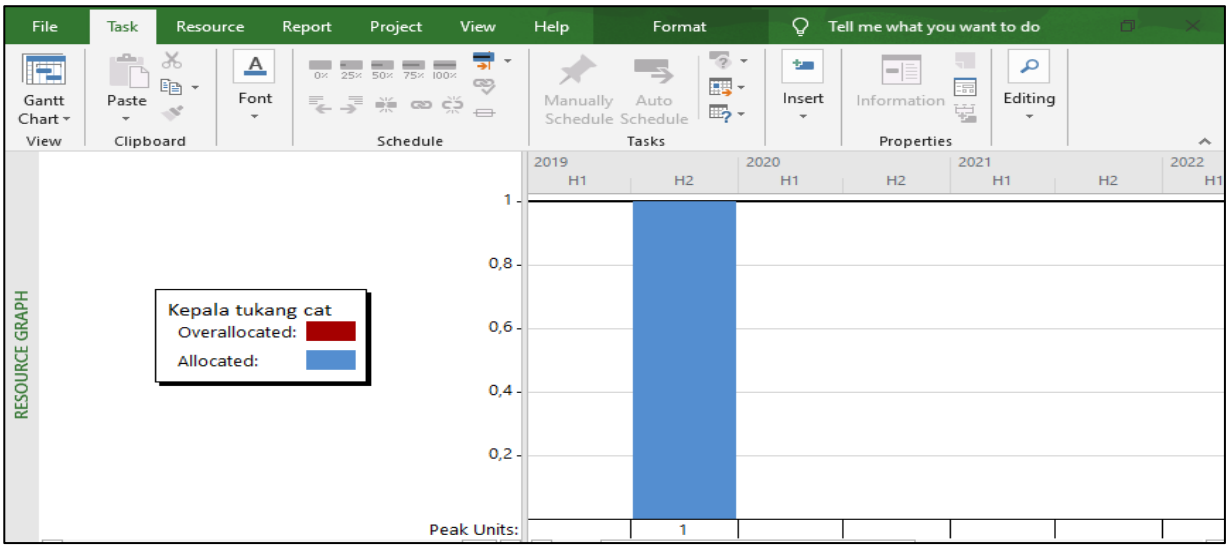



*Figure 7. Resource Graph view after Leveling*

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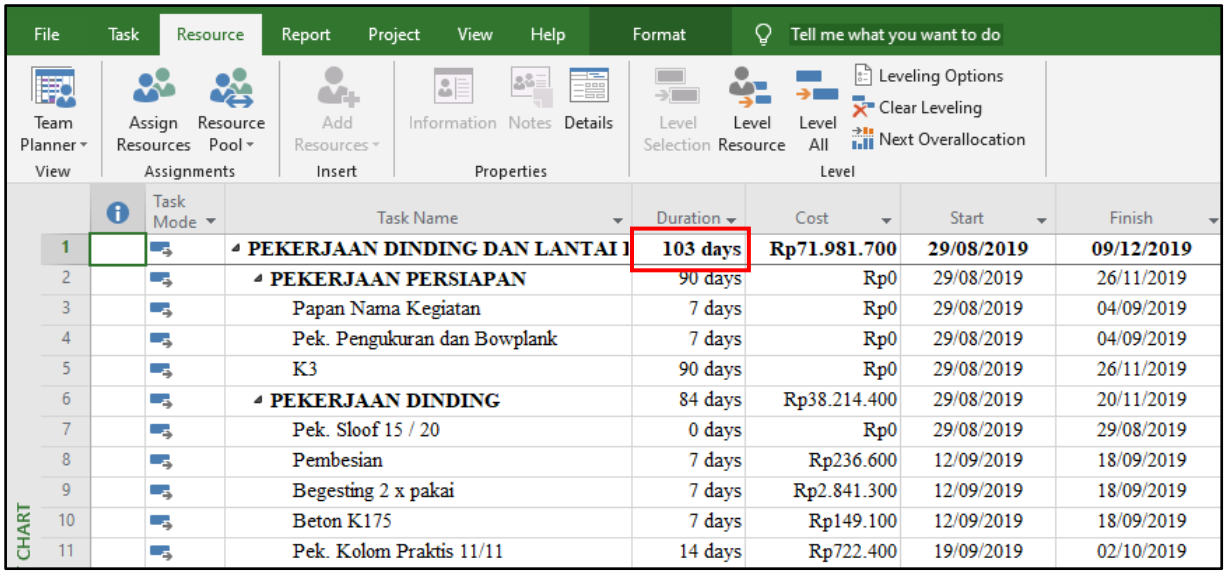


| | Task Mode | Task Name | Duration | Cost | Start | Finish |
|---|---|---|---|---|---|---|
| 1 | | PEKERJAAN DINDING DAN LANTAI 1 | 103 days | Rp71.981.700 | 29/08/2019 | 09/12/2019 |
| 2 | | PEKERJAAN PERSIAPAN | 90 days | Rp0 | 29/08/2019 | 26/11/2019 |
| 3 | | Papan Nama Kegiatan | 7 days | Rp0 | 29/08/2019 | 04/09/2019 |
| 4 | | Pek. Pengukuran dan Bowplank | 7 days | Rp0 | 29/08/2019 | 04/09/2019 |
| 5 | | K3 | 90 days | Rp0 | 29/08/2019 | 26/11/2019 |
| 6 | | PEKERJAAN DINDING | 84 days | Rp38.214.400 | 29/08/2019 | 20/11/2019 |
| 7 | | Pek. Sloof 15 / 20 | 0 days | Rp0 | 29/08/2019 | 29/08/2019 |
| 8 | | Pembesian | 7 days | Rp236.600 | 12/09/2019 | 18/09/2019 |
| 9 | | Begesting 2 x pakai | 7 days | Rp2.841.300 | 12/09/2019 | 18/09/2019 |
| 10 | | Beton K175 | 7 days | Rp149.100 | 12/09/2019 | 18/09/2019 |
| 11 | | Pek. Kolom Praktis 11/11 | 14 days | Rp722.400 | 19/09/2019 | 02/10/2019 |

*Figure 8. Activity Duration Display after Leveling*

3. Comparison of *Max Units* Human Resource Needs and Availability before Leveling

Based on the analysis results, the number of human resources that were initially allocated excessively can be optimized after the balancing process is carried out using the resource balancing method with the help of Microsoft Office Project 2019, as shown in Table 1. The total human resource requirement before balancing was 48.26 people, with human resource availability according to the daily report being 37 people, resulting in a human resource shortage of 11.26 people, which caused overallocation. After balancing, the total human resource requirement becomes 32.13 people. This means that the number of available human resources can meet the project implementation requirements, so that over-allocation can be overcome.

Optimizing the use of human resources with *the resource leveling* method can affect the time or duration of project implementation from 90 days to 103 days. This is due to *the max. Labor units* that are able to be provided by the contractor, cannot meet the max. units of project implementation needs. After the leveling process was carried out, the available human resources were able to meet the needs, but there was a delay in the project completion time of 13 days.

The application of resource leveling to the workforce results in an increase in project duration. This occurs because the limited number of available workers requires rescheduling activities to match the actual capacity of resources. Although the project duration increases, this method has the main advantage of distributing the workload more evenly among workers. Thus, there is no longer a condition of overallocation, where one worker has to perform several tasks simultaneously.

*Table 1. Comparison of Max. Units of Human Resources Needs and Availability before and after Leveling*

| NO. | RESOURCE NAME | Max Unit Requirements | Max Unit Availability | DIFFERENCE | Max Unit Requirements | Max Unit Availability | DIFFERENCE |
|---|---|---|---|---|---|---|---|
| | | Before leveling | | | After leveling | | |
| 1 | Mandor | 1,16 | 1 | (0,16) | 1,00 | 1 | - |
| 2 | Worker | 24,99 | 14 | (10,99) | 13,12 | 14 | 0,88 |
| 3 | Masons | 6,19 | 4 | (2,19) | 3,84 | 4 | 0,16 |
| 4 | Mason's head | 0,79 | 1 | 0,21 | 0,79 | 1 | 0,21 |
| 5 | Blacksmith | 3,28 | 3 | (0,28) | 2,80 | 3 | 0,20 |
| 6 | Blacksmith's Head | 0,33 | 1 | 0,67 | 0,33 | 1 | 0,67 |
| 7 | Tukang style bali | 4,40 | 5 | 0,60 | 4,40 | 5 | 0,60 |
| 8 | Balinese Style Head | 0,60 | 1 | 0,40 | 0,60 | 1 | 0,40 |

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| NO. | RESOURCE NAME | Max Unit Requirements | Max Unit Availability | DIFFERENCE | Max Unit Requirements | Max Unit Availability | DIFFERENCE |
|---|---|---|---|---|---|---|---|
| | | Before leveling | | | After leveling | | |
| 9 | Carpenter | 2,50 | 3 | 0,50 | 2,50 | 3 | 0,50 |
| 10 | Carpenter's head | 0,25 | 1 | 0,75 | 0,25 | 1 | 0,75 |
| 11 | Painter | 2,61 | 2 | (0,61) | 1,50 | 2 | 0,50 |
| 12 | Painter's head | 1,16 | 1 | (0,16) | 1,00 | 1 | - |
| | **Total Human Resources** | **48,26** | **37,00** | **(11,26)** | **32,13** | **37,00** | **4,87** |

## V. CONCLUSION

Based on the results of the maximum unit analysis of resource needs and availability using the resources leveling method using Microsoft Office Project 2019 is as follows:

1. Human resources that were initially overallocated, can be optimized by performing the leveling process using the resource leveling method with Microsoft Project 2019.
2. The total human resource needs before leveling are 48.26 people with the availability of human resources is 37 people, after the leveling process, the total human resource needs are 32.13 people so that the number of human resources availability is sufficient for the needs of project implementation.

The application of resource leveling using Microsoft Project 2019 has been proven to optimize workforce allocation so that in the future, time planning needs to be arranged more realistically by considering the actual capacity of the workforce. The leveling results data can be used as evaluation material and benchmarks for subsequent projects, and this method can be replicated in various other types of construction projects, thus having the potential to become a standard project management practice.

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