

Critical Path Analysis Using Microsoft Project 2016 on the Implementation Schedule of Residential House Construction Projects

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Abstract— A project requires good planning, careful execution and effective and efficient use of resources. The implementation of the development of a construction project consists of a series of activities that are interrelated with one another. This is where the importance of planning and scheduling projects properly to facilitate implementation in the field and development can be completed on time according to schedule. The existence of obstacles or obstacles that will occur in the process of implementing a construction project can be seen and predicted from the level of urgency of the work items to be carried out, the analysis that will be used to predict the constraints or obstacles that may occur is by analyzing the critical path of the project implementation schedule construction. The use of Microsoft Project is very effective in analyzing data and determining critical paths. Based on the critical path analysis that has been carried out on the construction project schedule for the construction of residential houses, it is found that several work sub-items are on the critical path, especially in preparatory work and structural work, which means that the work sub-item in this work must pay close attention to the implementation process both in terms of resource readiness. human and equipment.

Keywords— Microsoft Project, Critical Path, Construction Project Schedule

I. INTRODUCTION

In the implementation of a construction project there are various kinds of work activities, the time required to complete a construction work can usually be scheduled by managing existing resources both human and equipment, planning to implementing a project activity must always pay attention to the suitability of the implementation time with the costs incurred and the quality of the resulting construction.

The more types of work activities to be carried out, the more complex the relationship between each job, this is due to the limited implementation time and adjusting the

budget provided, the longer a project, the greater the costs that must be incurred. Often delays in the completion of construction projects lie in the timing of construction work that is not on schedule. This resulted in the delay of several other scheduled works. Delays in the implementation of construction work resulted in a significant increase in work costs (Perdana & Rahman, 2019). To be able to reduce the risk of cost overruns, it is necessary to schedule and control the time for carrying out work that is more carefully planned so that delays in work can be avoided, one way that can be done is to analyze the critical path in the schedule for carrying out construction project work, the results of the critical path analysis will provide an opportunity for project implementers to anticipate delays in the implementation of project work that is prone or has a high potential to be hampered. With the implementation of work on time will certainly be able to maintain the quality of the work. Current technological developments also influence the development of information technology in construction engineering management where many computer application programs are offered to assist construction engineering management in processing planning data, supervising and implementing construction project activities (Rizal et al., 2022). Current computer application programs make it very easy for construction engineering management to enter project data, manage project activities, project control, project reports and control project activity activities including those involving resources on the project.

Among the many applications or programs, one that is easy to access and use is the Microsoft Project developed by Microsoft. In this study the analysis was carried out using Microsoft Project version 2016 software to analyze the critical path in the schedule and duration of the construction project for the construction (Siddiq, 2022) of a residential house.

Microsoft Project is a project management software product. It is designed to assist project managers in

developing schedules, assigning resources to tasks, tracking progress, managing budgets, and analyzing workloads.

Scheduling in a construction project is a device for determining the activities needed to complete a project in a certain sequence and time frame, in which each activity must be carried out according to plan so that the project is completed on time at an economical cost (Derka & Ratnaningsih, 2019). Scheduling includes resources in the form of labor, materials, equipment, finance, and time. With proper scheduling, several types of losses can be avoided, such as delays, cost overruns, and disputes (Kamal et al., 2022). Control essential conditions to guide the success of a project is a good control of the factors of time, cost and quality. Control is a systematic effort to determine standards in accordance with planning objectives, design information systems, compare implementation with standards, analyze possible deviations between implementation and standards, then take corrective actions needed so that resources are used effectively and efficiently in the context of hit the mark.

II. RESEARCH METHODS

The main function of control is to monitor and analyze each step of the activity so that it is guided towards the goals that have been set (Siswanto & Salim, 2019). Control is monitoring whether the results of the activities that have been carried out are in accordance with the plans that have been made and ensure the effective and efficient use of resources (Kuntohadi et al., 2019). Control is also an attempt to avoid problems that are generally often encountered in a project implementation in its implementation, it is necessary to have a daily report as a tool that makes it easier to control the progress of a project as planned. The criterion used to measure project progress is time, within the work network that has been prepared, activities can be described in detail. The network plays a very important role because there is necessary information such as the time of activity, the practical logic between activities and project progress. In the control process (Herdiyanti & Musa, 2022), it is necessary to know early any symptoms that deviate from the plan so that action can be taken to resolve the problem. The second is Cost, cost control is needed to control and control the use of facilities over the existing project budget. Usually, the budget also states the presentation plan for spending per unit of time. The third is Quality, in general measuring the success or failure of a project is carried out at the end of the project by various means of testing as a control over the quality of a project, construction project implementers should need to take steps to avoid unwanted conflicts, namely: The third is Quality, in general the measurement of the success or failure of a project is carried out at the end of the project by various means of testing as a control over the quality of a project, construction project implementers should take steps to avoid unwanted conflicts, namely guaranteeing that there are no differences in the definition of standards and specifications between owners, consultants and contractors (Sulasti & Giatman, 2022).

Ensure that there is a testing method or process for quality or quantity regulation in accordance with the planned criteria. And planning temporary control results, so that the project can be controlled throughout the project.

In analyzing the preparation and planning of a construction, an analysis of risk management is needed which aims to find out and analyze the risks involved in carrying out the work which can affect the completion time, costs required and the quality of the final results of the construction project work.

Some steps that can be taken in construction project risk management include:

- 1) Risk Identification: Identify potential risks that may occur in a construction project. This can include material procurement issues, bad weather, design changes, planning errors, and more.
- 2) Risk Analysis: After identifying risks, conduct analysis to understand the impact and probability of each risk occurring. This helps in determining which risks need further attention.
- 3) Risk Response Planning: Create a response plan for each identified risk. This could be avoiding the risk, transferring the risk to another party (for example, with insurance), reducing the impact of the risk, or accepting the risk.
- 4) Implement Response Plan: Implement the response plan that has been created to manage risks. Make sure all parties involved understand this plan and are ready to act as needed.
- 5) Monitoring and Control: Continuously monitor risks throughout the project. Changes in the project environment or external conditions may affect risks, so it is important to stay in control and evaluate response plans.
- 6) Lessons from Experience: After the project is completed, learn from the experience of risk management that has been carried out. Review what worked and what can be improved for future projects.

The following are several examples of risk management that often arise in construction projects and how to manage them:

- 1) Delay in Material Delivery; risk of delays in material delivery due to production or transportation problems, the solution is to reserve alternative sources or suppliers. Create a looser delivery schedule to anticipate possible delays.
- 2) Design Changes; the possibility of design changes affecting work already started. The response that can be taken is to form a responsive team to handle design changes. Define a process for evaluating and approving changes before they are implemented.
- 3) Adverse Weather Conditions; Extreme weather can affect construction progress. The response that can be taken is to create a flexible schedule to accommodate days when work cannot be done. Use technology or protection to minimize the impact of weather.
- 4) Worker Safety and Health; Risk of work accidents or health problems on construction sites. The response that can be taken is to implement strict safety

protocols, provide appropriate training, and monitor working conditions regularly.

- 5) Changes in Regulations or Legal Requirements; Possible regulatory or legal changes affecting construction. The response that can be taken is to seek and study information about related legal changes, create flexibility in planning so that you can adapt to these changes.
- 6) Non-compliance with Quality Standards; The risk that construction results do not meet the expected quality standards. The response that can be taken is to carry out strict quality checks, implement regular testing and evaluation, and ensure contractors understand the required standards.

The things that need to be done when you have a project are :

- 1) Carry out planning and scheduling, as well as involving competent parties in the project.
- 2) After that, enter into the process of determining the types of work (task), the required resources (resources) both human and material resources, the required costs (cost), as well as the work schedule (schedule) when the work starts and when the work must be finished. If all of these things have been determined and agreed upon by all parties, then we already have a basic plan (baseline).
- 3) Furthermore, the plan must be implemented and its progress must be continuously monitored in a Tracking stage. If the work has not been completed, it must be rescheduled (Rescheduling). With Microsoft Project you can get details of all work components in detail.

The project is a series of construction work that is carried out only once and generally has a certain period of time.

Schedule planning and control can be carried out using Microsoft Project 2016 (Tombokan et al., 2022). The planning stages of a construction project require a baseline or project implementation framework. In this regard, the data stored in the project framework is considered as a target which includes;

- a. Define project start date and when a project ends.
- b. Arrange the types of existing tasks.
- c. Determine the time needed to complete each type of task.
- d. Establish a correlation or relationship between a task with another task.
- e. Make a resource plan that will be used on the project.
- f. Compile data from existing resources based on the types of tasks.
- g. Define a work calendar to compile the working days and working hours of the project.
- h. Enter the required cost data.
- i. Check if there are overlapping or conflicting resource usage schedules by leveling.

The several work items that must be included as initial data for scheduling and controlling a house or building construction project are as follows:

- 1) Preparatory work, including measuring work, land clearing work, leveling work, and bouw plank work.

- 2) Earthworks are excavation work, fill-in work, compaction work and soil disposal work.
- 3) Masonry and concrete works include foundation work, floor work, wall work and ladder work. To calculate the time of concreting and masonry work.
- 4) Roof and Ceiling work including roof installation, ceiling installation and installation of ceiling frames. To calculate the time of roofing work.
- 5) Electrical installation work is the installation of lamp housings, cable connection, lamp installation and fuse box installation.
- 6) Sanitary work is clean ILF installation work, dirty water installation work and septic tank work.
- 7) Finishing work is painting work.

To do a next job, usually the previous work has been completed, but there are some jobs that don't have to wait for the previous job to be completed 100% but can already be made (Sangadji, 2022). Sequences of construction work in determining the duration, as follows:

- a. Field cleaning work starts at the start of the project usually immediately after the contractor gets a work order from the project owner.
- b. The work of measuring and installing the bouwplank is carried out after the field cleaning work is 100% complete, after measuring the bouwplank points the location of the bouwplank can be determined.
- c. Work on making board directors is carried out after 50% of the work on measuring and installing bouw plank is complete.
- d. Excavation work, starting after bouwplank installation. Work floor work, can be started after 50% completion of excavation work.
- e. River stone foundation work, starting after the floor work is 100% complete.
- f. Sloof formwork installation work, started after the river stone foundation work was completed.
- g. Sloof casting work, starting after sloof formwork work is complete, backfill work, starting after sloof casting work is complete.
- h. Compaction work, starting after the backfill work is finished earth dumping work, starting together with compaction work.
- i. Brick wall installation work, starting after the earth dumping work is completed.
- j. Practical column installation work, starting after brick wall installation is 40% complete.
- k. Ringbalk formwork work is carried out after the brick wall installation work is complete.
- l. Ringbalk casting work is carried out after the ringbalok formwork work is complete.
- m. Plastering work, started after the installation of brick walls was completed.
- n. Installation of doors and windows, starting after the plastering work is finished.
- o. Roofing work, can be started after brick wall installation is complete, floor work, can be started after 50% wall installation

p. Ceramic installation, can be started after the floor work is finished painting, starting after the plastering is finished.

The job sequences are then made into a table that displays work items and job duration as in the table 1:

Table.1. Items and Duration

| Work Items | Duration |
|--|----------|
| Makassar Housing Project | 100 days |
| Preparatory work | 99 days |
| Land Clearing | 2 days |
| Measuring and Making Bouwplank | 2 days |
| Mobilization of Work Tools | 1 day |
| Demobilization of Work Tools | 1 day |
| Earthworks | 11 days |
| Soil Excavation (Foundation) | 3 days |
| Soil Fill (Foundation Side) | 1 day |
| Structural Work | 17 days |
| Foundation & Sloof Work | 5 days |
| Formwork Installation | 2 days |
| Iron Installation | 2 days |
| Casting | 1 day |
| Column Work | 3 days |
| Formwork Installation | 1 day |
| Iron Installation | 1 day |
| Casting | 1 day |
| Beam Work | 3 days |
| Formwork Installation | 1 day |
| Iron Installation | 1 day |
| Casting | 1 day |
| Ground Floor Plate Work | 4 days |
| Land Leveling | 1 day |
| Sand Fill | 1 day |
| Iron Installation | 1 day |
| Casting | 1 day |
| Roofing Work | 17 days |
| Frame Installation | 7 days |
| Roof Tiles Installation | 5 days |
| Wall Mounting Work and Floor | 44 days |
| Installation of brick walls | 11 days |
| Plastering work | 8 days |
| Acian job | 6 days |
| Installation of ceramics and natural stone | 26 days |
| Outdoor terrace floor tiles | 4 days |
| Main floor tiles | 8 days |
| Bathroom floor tiles | 2 days |
| Bathroom Wall Ceramics | 3 days |
| Natural Stone (outside wall decoration of the house) | 5 days |
| Frame Installation | 17 days |
| Window Frame Installation | 3 days |
| Installation of shutters + glass | 3 days |
| Door Frame Installation (Main Room & Room made of wood) | 4 days |
| Installation of Doors (main room & bedroom made of wood) | 2 days |
| Door Frame Installation (Aluminum bathroom) | 2 days |
| Door leaf installation (aluminum bathroom) | 1 day |
| Ceiling Work | 17 days |
| Ceiling Frame Installation | 8 days |
| Ceiling Installation | 9 days |
| Gypsum type ceiling (for main room) | 5 days |
| Calciboard type ceiling (for bathroom) | 1 day |
| Calciboard type ceiling (for outdoor terrace) | 3 days |
| Painting Work | 17 days |
| Main Room Wall Paint (Interior) | 8 days |

| | |
|---|---------|
| Outside Wall Paint (Exterior) | 6 days |
| Ceiling Paint | 7 days |
| Gypsum type ceiling (for main room) | 4 days |
| Calciboard type ceiling (for bathroom) | 1 day |
| Calciboard type ceiling (for outdoor terrace) | 2 days |
| Paint Window & Door Frames and Door Leaves (Main Room and Room) | 6 days |
| Sanitary Work | 81 days |
| Clean Water Pipe Installation | 43 days |
| Bathroom Faucet Installation | 1 day |
| Sitting Toilet Faucet Installation | 1 day |
| Zinc Kitchen Faucet Installation (Dish Washing Place) | 1 day |
| Garden Faucet Installation | 1 day |
| Dirty Water Pipe Installation | 21 days |
| Floor Drain Installation (Bathroom Drain) | 1 day |
| Installation of toilet waste to septic tank | 1 day |
| Kitchen Zinc Waste Installation (Dishwasher) | 1 day |
| AC waste installation | 1 day |
| Clean Water Pipe Installation from PDAM to Home | 1 day |
| Septic tank installation | 1 day |
| Installation of Sanitary Accessories | 30 days |
| Bathroom Faucets | 1 day |
| Sitting Toilet | 1 day |
| Zinc Kitchen Faucet | 1 day |
| Garden Faucet | 1 day |
| Electrical Work | 65 days |
| Installation Installation | 64 days |
| Light & Switch Installation | 4 days |
| Socket Installation | 2 days |
| CCTV installation | 1 day |
| AC installation | 1 day |
| Installation of connection from PLN to home | 1 day |
| Lightning Protection Installation | 3 days |
| Garden Light Installation | 2 days |
| Installation of Electrical Accessories | 63 days |
| Switch | 1 day |
| ectric socket | 1 day |
| Light | 1 day |
| CCTV | 1 day |
| AC | 1 day |
| Lightning Catcher | 1 day |
| Fuses and KWH meter | 1 day |
| Garden lamp | 1 day |
| Garden Work | 25 days |
| Fence Wall | 17 days |
| Brick Wall Installation | 6 days |
| Plastering | 4 days |
| Acian | 4 days |
| Painting | 3 days |
| Garden and Parking | 8 days |
| Paving block installation | 7 days |
| Grass & Plant planting | 4 days |

After scheduling and completing the duration of each job, a network is created and then the critical path is determined using Microsoft Project 2016. In the Microsoft Project Software there are three methods used (Putriana, 2019), namely:

1) PERT (Program Evaluation Review Technique)

This method uses statistical calculations to calculate the duration of a project. The PERT method refers more to a graphical representation that describes the interrelationships of each task in the project. This

method is often also called a Network Diagram or Network Diagram (Febriana & Aziz, 2021).

- 2) CPM (Critical Path Method) This method applies a mathematical calculation of the total time duration based on the duration of each task and its dependencies and determines critical tasks. This method is a fundamental method used to develop scheduling system software, including Microsoft Project.

- 3) Gantt chart

The principle applied in this method is the depiction of work activities in graphical form on a time scale (Firno, 2019)

Stages of Using Microsoft Project Arrange a Schedule To be able to develop a project schedule, list is required work and duration of time needed for each work In Microsoft Project one types of work can be grouped again into small parts that form tasks with time details each. Once it's done deciding which tasks to do completed before the assignment other. Microsoft Project will calculate the total time requirement needed for project completion and will develop a timetable framework become one unified whole. Enter Personnel and Equipment After the schedule is arranged, process it Next is entering data necessary personnel and equipment for each task (Efendi et al., 2020)

Setting a Schedule By using software Microsoft Project, re-evaluation process and correcting the schedule that has been arrangement will be very easy to do. When the schedule has been set before will result miss the achievement of goals then that need to do is analyze order The steps for determining the critical path in a network are:

- 1) Make descriptions of the work to be carried out in the construction of a project, in this case a residential house construction project
- 2) Determine the logic of dependency between one activity and another so that sequences of work are obtained.
- 3) Based on the two things above (activities and their dependency relationships) a critical path diagram can be made.

- 4) Enter the time element for each work activity on the critical path diagram. The duration of the project can be determined by calculating the Earliest Completion Time (EF) if using a forward countdown or calculating the Latest Completion Time (LF) if using a countdown. The calculation results are made in a table
- 5) Determine the critical path, namely the path or path that has a project completion time that must be according to plan, marked in red.

III. RESULTS AND DISCUSSION

The previously created work item data and work duration are then carefully and carefully entered into the Microsoft Project worksheet in the Gantt chart section because it will impact the results in the table if there are input errors, then adjustments are made to the Microsoft Project worksheet which consists of from setting the project name and work item name, setting the working of work, change order work or adjust its duration. After this is done Microsoft Project will rearrange the schedule as a whole (Erlina et al., 2022).

Project Information Publications Microsoft Project will easily update information about the project. Specifics regarding progress projects can be displayed with more good use of existing facilities in Microsoft Project, for example regarding schedules, financial reports, responsibility for a task Project Progress Controlling New data on progress execution of tasks will be processed by Microsoft Project so that progress will be able to describe the percentage work that has been completed. When there is a task to carry out haltingly, Microsoft Project will provide immediate information about the task which is critical in nature, so the whole project is not experiencing lateness.

days per week, setting the project start month, work start and finish hours, setting the daily working time and overtime work time as well as the type of unit measurement

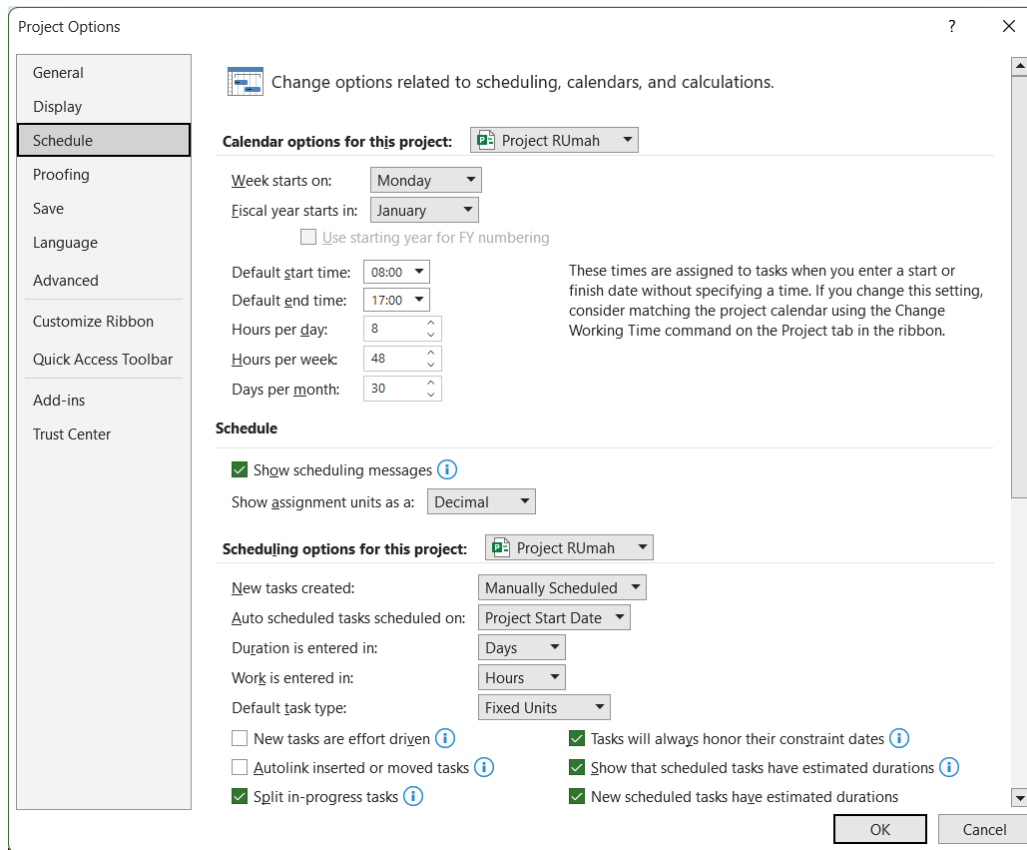
Table 2. Work Item Data and Work Duration that has been made then entered into the Microsoft Project gantt chart

| Task Name | Duration | Start | Finish | Predecessors |
|------------------------------------|----------------|---------------------|---------------------|--------------|
| Makassar Housing Project | 100 days | Wed 19/07/23 | Sat 11/11/23 | |
| Preparatory work | 99 days | Wed 19/07/23 | Fri 10/11/23 | |
| Land Clearing | 2 days | Wed 19/07/23 | Thu 20/07/23 | |
| Measuring and Making Bouwplank | 2 days | Fri 21/07/23 | Sat 22/07/23 | 2 |
| Mobilization of Work Tools | 1 day | Fri 21/07/23 | Fri 21/07/23 | 3SS |
| Demobilization of Work Tools | 1 day | Fri 10/11/23 | Fri 10/11/23 | 105 |
| Earthworks | 11 days | Mon 24/07/23 | Fri 04/08/23 | |
| Soil Excavation (Foundation) | 3 days | Mon 24/07/23 | Wed 26/07/23 | 3 |
| Soil Fill (Foundation Side) | 1 day | Fri 04/08/23 | Fri 04/08/23 | 13FS+2 days |
| Structural Work | 17 days | Thu 27/07/23 | Tue 15/08/23 | |
| Foundation & Sloof Work | 5 days | Thu 27/07/23 | Tue 01/08/23 | |
| Formwork Installation | 2 days | Thu 27/07/23 | Fri 28/07/23 | 7 |
| Iron Installation | 2 days | Sat 29/07/23 | Mon 31/07/23 | 11 |

| | | | | |
|---|----------------|---------------------|---------------------|-------------------------------------|
| Casting | 1 day | Tue 01/08/23 | Tue 01/08/23 | 12 |
| Column Work | 3 days | Wed 02/08/23 | Fri 04/08/23 | |
| Formwork Installation | 1 day | Thu 03/08/23 | Thu 03/08/23 | 16 |
| Iron Installation | 1 day | Wed 02/08/23 | Wed 02/08/23 | 13 |
| Casting | 1 day | Fri 04/08/23 | Fri 04/08/23 | 15 |
| Beam Work | 3 days | Sat 05/08/23 | Tue 08/08/23 | |
| Formwork Installation | 1 day | Sat 05/08/23 | Sat 05/08/23 | 17 |
| Iron Installation | 1 day | Mon 07/08/23 | Mon 07/08/23 | 19 |
| Casting | 1 day | Tue 08/08/23 | Tue 08/08/23 | 20 |
| Ground Floor Plate Work | 4 days | Fri 11/08/23 | Tue 15/08/23 | |
| Land Leveling | 1 day | Fri 11/08/23 | Fri 11/08/23 | 69 |
| Sand Fill | 1 day | Sat 12/08/23 | Sat 12/08/23 | 23 |
| Iron Installation | 1 day | Mon 14/08/23 | Mon 14/08/23 | 24 |
| Casting | 1 day | Tue 15/08/23 | Tue 15/08/23 | 25 |
| Roofing Work | 17 days | Mon 21/08/23 | Fri 08/09/23 | |
| Frame Installation | 7 days | Mon 21/08/23 | Mon 28/08/23 | 21FS+10 days;26 |
| Roof Tiles Installation | 5 days | Mon 04/09/23 | Fri 08/09/23 | 32FS-1 day;28 |
| Wall and Floor Installation Work | 44 days | Wed 16/08/23 | Thu 05/10/23 | |
| Installation of brick walls | 11 days | Wed 16/08/23 | Mon 28/08/23 | 26 |
| plastering work | 8 days | Sat 26/08/23 | Mon 04/09/23 | 31FS-2 days |
| acian job | 6 days | Thu 07/09/23 | Wed 13/09/23 | 32FS+2 days |
| Installation of ceramics and natural stone | 26 days | Wed 06/09/23 | Thu 05/10/23 | |
| outdoor terrace floor tiles | 4 days | Tue 26/09/23 | Fri 29/09/23 | 36 |
| main floor tiles | 8 days | Sat 16/09/23 | Mon 25/09/23 | 26FS+5 days;33FS+2 days;29FS+2 days |
| bathroom floor tiles | 2 days | Sat 09/09/23 | Mon 11/09/23 | 38;69 |
| Bathroom Wall Ceramics | 3 days | Wed 06/09/23 | Fri 08/09/23 | 32FS+1 day |
| Natural Stone (outside wall decoration of the house) | 5 days | Sat 30/09/23 | Thu 05/10/23 | 35 |
| Frame Installation | 17 days | Wed 13/09/23 | Mon 02/10/23 | |
| Window Frame Installation | 3 days | Wed 13/09/23 | Fri 15/09/23 | 33FS-1 day |
| Installation of shutters + glass | 3 days | Sat 16/09/23 | Tue 19/09/23 | 41 |
| Installation of Door Frames (Main Room & Rooms from wood) | 4 days | Sat 16/09/23 | Wed 20/09/23 | 41 |
| Installation of Doors (main room & bedroom from wood) | 2 days | Sat 30/09/23 | Mon 02/10/23 | 43;35 |
| Door Frame Installation (Aluminum bathroom) | 2 days | Thu 21/09/23 | Fri 22/09/23 | 43 |
| Door leaf installation (aluminum bathroom) | 1 day | Sat 23/09/23 | Sat 23/09/23 | 45;37FS+2 days |
| Ceiling Work | 17 days | Sat 09/09/23 | Thu 28/09/23 | |
| Ceiling Frame Installation | 8 days | Sat 09/09/23 | Mon 18/09/23 | 29 |
| Ceiling Installation | 9 days | Tue 19/09/23 | Thu 28/09/23 | |
| Gypsum type ceiling (for main room) | 5 days | Tue 19/09/23 | Sat 23/09/23 | 48;83FS+1 day |
| Calciboard type ceiling (for bathroom) | 1 day | Mon 25/09/23 | Mon 25/09/23 | 50 |
| Calciboard type ceiling (for outdoor terrace) | 3 days | Tue 26/09/23 | Thu 28/09/23 | 51 |
| Painting Work | 17 days | Fri 22/09/23 | Wed 11/10/23 | |
| Main Room Wall Paint (Interior) | 8 days | Fri 22/09/23 | Sat 30/09/23 | 33FS+7 days |
| Outside Wall Paint (Exterior) | 6 days | Sat 30/09/23 | Fri 06/10/23 | 54FS-1 day |
| Ceiling Paint | 7 days | Wed 27/09/23 | Wed 04/10/23 | |
| Gypsum type ceiling (for main room) | 4 days | Wed 27/09/23 | Sat 30/09/23 | 50FS+2 days |
| Calciboard type ceiling (for bathroom) | 1 day | Mon 02/10/23 | Mon 02/10/23 | 51FS+2 days;57 |
| Calciboard type ceiling (for outdoor terrace) | 2 days | Tue 03/10/23 | Wed 04/10/23 | 52FS+2 days;58 |
| Paint Window & Door Frames and Door Leaves (Main room) | 6 days | Thu 05/10/23 | Wed 11/10/23 | 44;59 |
| Sanitary Work | 81 days | Wed 09/08/23 | Fri 10/11/23 | |
| Clean Water Pipe Installation | 43 days | Tue 29/08/23 | Tue 17/10/23 | |
| Bathroom Faucet Installation | 1 day | Tue 29/08/23 | Tue 29/08/23 | 31 |
| Sitting Toilet Faucet Installation | 1 day | Wed 30/08/23 | Wed 30/08/23 | 63 |
| Zinc Kitchen Faucet Installation (Dish Washing Place) | 1 day | Thu 31/08/23 | Thu 31/08/23 | 64 |
| Garden Faucet Installation | 1 day | Tue 17/10/23 | Tue 17/10/23 | 96SS |
| Dirty Water Pipe Installation | 21 days | Wed 09/08/23 | Fri 01/09/23 | |
| Floor Drain Installation (Bathroom Drain) | 1 day | Wed 09/08/23 | Wed 09/08/23 | 21 |
| Installation of toilet waste to septic tank | 1 day | Thu 10/08/23 | Thu 10/08/23 | 68 |
| Kitchen Zinc Waste Installation (Dishwasher) | 1 day | Thu 31/08/23 | Thu 31/08/23 | 65SS |
| AC waste installation | 1 day | Fri 01/09/23 | Fri 01/09/23 | 70 |
| Clean Water Pipe Installation from PDAM to Home | 1 day | Fri 10/11/23 | Fri 10/11/23 | 85FF |
| Septic tank installation | 1 day | Sat 09/09/23 | Sat 09/09/23 | 90FS+7 days |
| Installation of Sanitary Accessories | 30 days | Thu 14/09/23 | Wed 18/10/23 | |
| Bathroom Faucets | 1 day | Mon 02/10/23 | Mon 02/10/23 | 63;54 |
| Sitting Toilet | 1 day | Thu 14/09/23 | Thu 14/09/23 | 37FS+2 days;69 |
| Zinc Kitchen Faucet | 1 day | Wed 04/10/23 | Wed 04/10/23 | 54FS+2 days;65 |
| Garden Faucet | 1 day | Wed 18/10/23 | Wed 18/10/23 | 66 |
| Electrical Work | 65 days | Tue 29/08/23 | Sat 11/11/23 | |
| Installation Installation | 64 days | Tue 29/08/23 | Fri 10/11/23 | |
| Light & Switch Installation | 4 days | Tue 29/08/23 | Fri 01/09/23 | 31 |
| Socket Installation | 2 days | Thu 31/08/23 | Fri 01/09/23 | 81SS+2 days |
| CCTV installation | 1 day | Mon 04/09/23 | Mon 04/09/23 | 84 |
| AC installation | 1 day | Sat 02/09/23 | Sat 02/09/23 | 82 |
| Installation of connection from PLN to home | 1 day | Fri 10/11/23 | Fri 10/11/23 | 105 |
| Lightning Protection Installation | 3 days | Mon 18/09/23 | Wed 20/09/23 | 29FS+7 days |
| Garden Light Installation | 2 days | Sat 14/10/23 | Mon 16/10/23 | 99SS+2 days |
| Installation of Electrical Accessories | 63 days | Thu 31/08/23 | Sat 11/11/23 | |
| Switch | 1 day | Tue 05/09/23 | Tue 05/09/23 | 81FS+2 days |
| Electric socket | 1 day | Thu 31/08/23 | Thu 31/08/23 | 82SS |
| Light | 1 day | Sat 02/09/23 | Sat 02/09/23 | 81 |
| CCTV | 1 day | Tue 05/09/23 | Tue 05/09/23 | 83 |
| AC | 1 day | Sat 02/09/23 | Sat 02/09/23 | 82 |
| Lightning Catcher | 1 day | Thu 21/09/23 | Thu 21/09/23 | 86 |
| Fuses and KWH meter | 1 day | Sat 11/11/23 | Sat 11/11/23 | 85 |

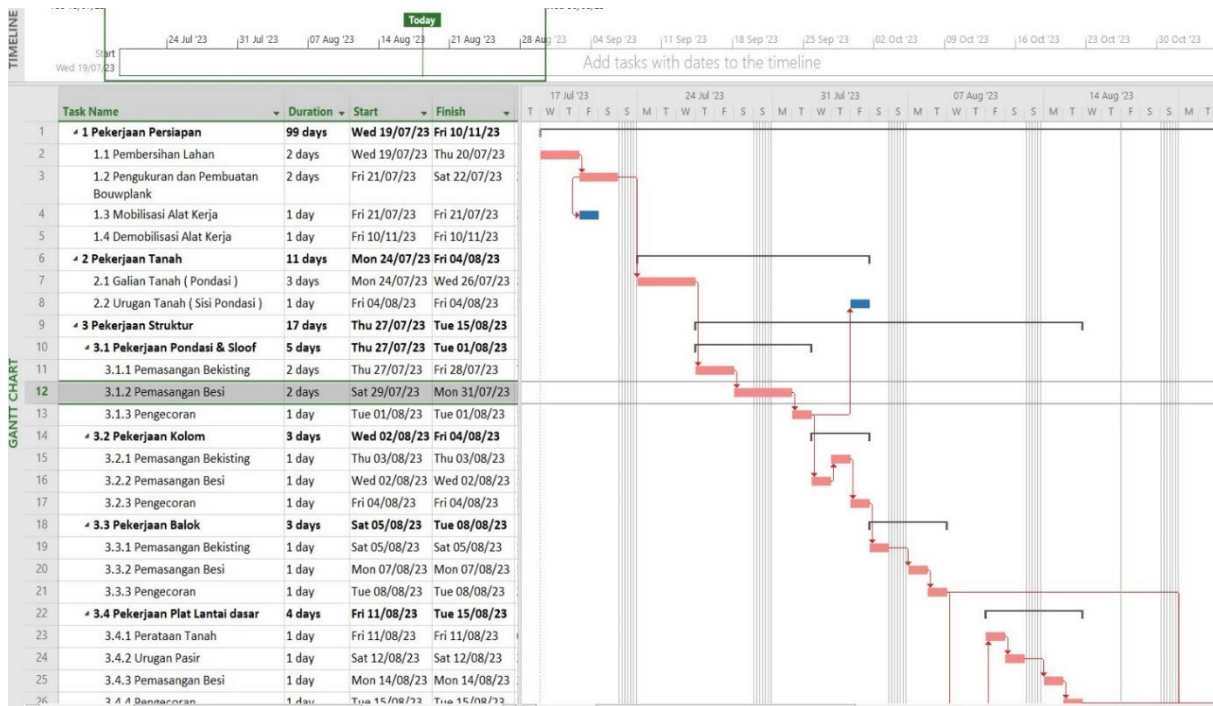
| | | | | |
|---------------------------|----------------|---------------------|---------------------|--------------|
| Garden Lamp | 1 day | Tue 17/10/23 | Tue 17/10/23 | 87 |
| Garden Work | 25 days | Thu 12/10/23 | Thu 09/11/23 | |
| Fence Wall | 17 days | Thu 12/10/23 | Tue 31/10/23 | |
| Brick Wall Installation | 6 days | Thu 12/10/23 | Wed 18/10/23 | 60 |
| Plastering | 4 days | Thu 19/10/23 | Mon 23/10/23 | 99 |
| Acian | 4 days | Tue 24/10/23 | Fri 27/10/23 | 100 |
| Painting | 3 days | Sat 28/10/23 | Tue 31/10/23 | 101 |
| Garden and Parking | 8 days | Wed 01/11/23 | Thu 09/11/23 | |
| Paving block installation | 7 days | Wed 01/11/23 | Wed 08/11/23 | 102 |
| Grass & Plant planting | 4 days | Mon 06/11/23 | Thu 09/11/23 | 104FS-3 days |

Table 2 shows data on work items and work duration that have been entered into the Microsoft Project Gantt chart, then data on the relationship between work items is also entered into the predecessor graph, then the start and finish times of the work will appear on the start and finish graph.



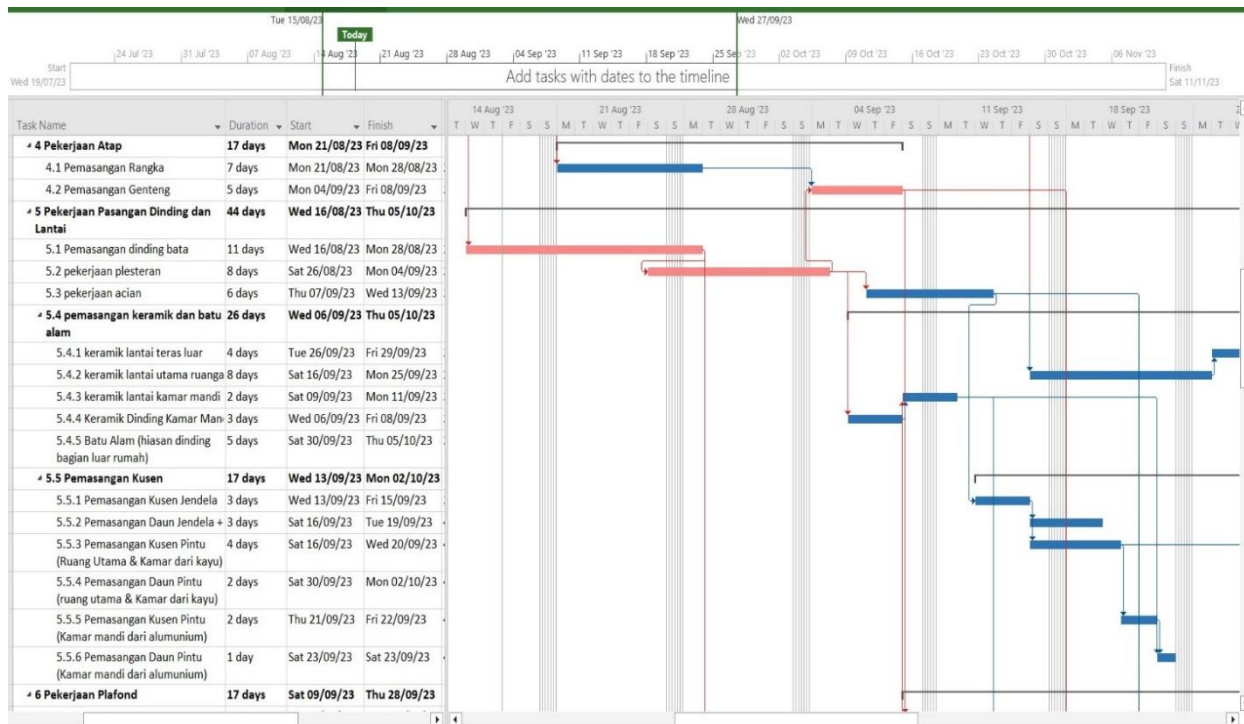
Picture 1. Initial project, time, and unit settings

Picture 1 the basic settings for processing the data that have been obtained, After the related data between work items are also entered into the predecessors chart, then enter the format menu in the gantt chart tools, then select and check the critical tasks section, it will appear the results of the critical path description on the graph beside the gantt chart.



Picture 2. critical path from preparatory work items to structural work items

Picture 2 shows the critical path from preparatory work items to structural work items, where almost all work sub-items are on the critical path, preparatory work sub-items with long duration and large work weights require readiness and prevention plans if problems occur later.



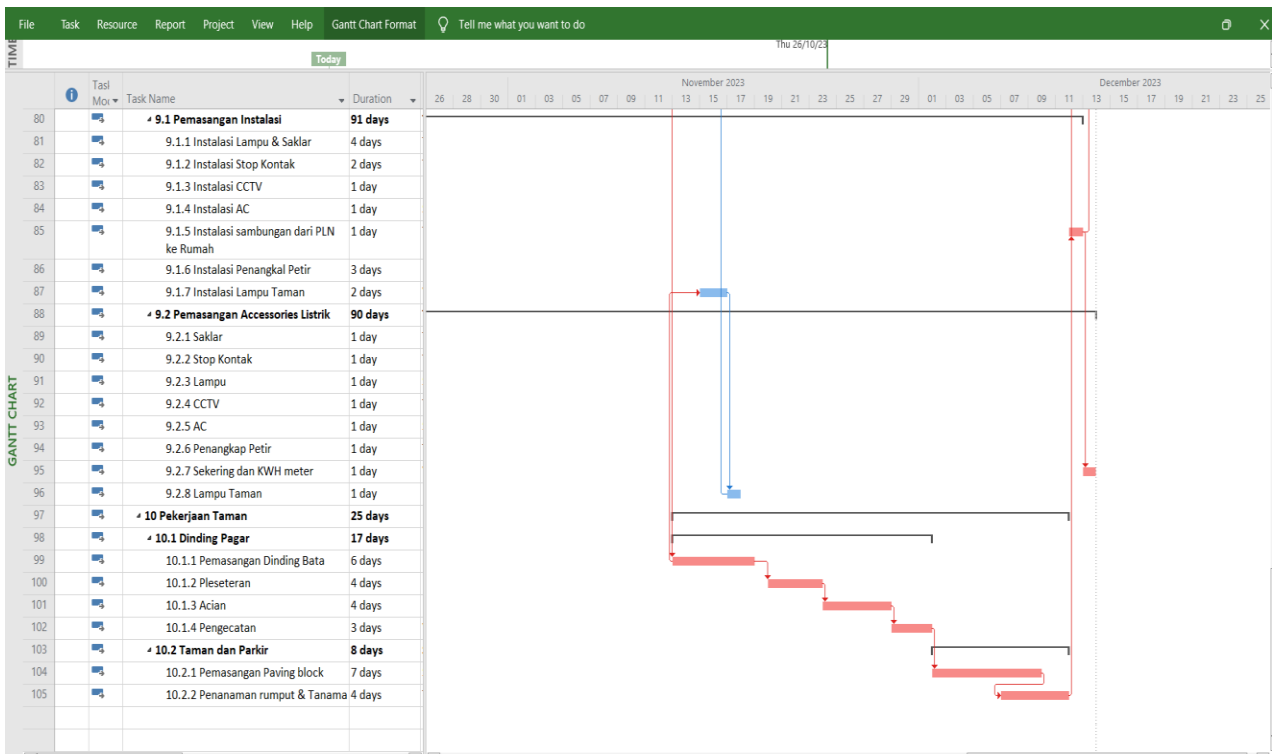
Picture 3. critical path from roofing work items to ceiling work items

Picture 3 shows the critical path from the roof work item to the ceiling work item, in the roof work item only the roof tile installation work is on the critical path, the wall and floor work is on the critical path, while the floor tile installation work and frame installation work are included in safe work if delays occur.



Picture 4. critical path from ceiling work items to sanitary work items

Picture 4 shows the critical path from the ceiling work item to the sanitary work item, the work sub items for installing ceiling frames, installing gypsum ceilings and the work sub items for all ceiling painting are on the critical path



Picture 5. critical path from electrical work items to garden work items

Picture 5 shows the critical path from electrical work items to garden work. In the picture it can be seen that electrical installation work items and others are still considered safe if there is a delay in previous work, garden work items are on the critical path because this work is included in the final part of the construction project work.

Based on the results of the critical path analysis used Microsoft Project 2016 that has been carried out, it appears that there are several work sub items that enter the critical path. The critical path on the bar chart is marked in red, while work items in blue indicate that the work is safe if there is a delay in work time.

In the preparatory work item, only the tool mobilization work sub item is not on a critical path, which means that if there is a delay in the work, it will not cause delays and affect the implementation of other work sub items.

For earthwork and structure work items, all sub-items are on the critical path, which means that there should be no delay in the implementation of the work sub-item because it will cause delays in the implementation of other activities which will have a significant impact on work delays.

In the roofing work item, the sub-work is not included in the critical path so that if there is a delay in this work, it will not affect the process of other work activities.

Wall, floor and ceiling pairing work items, there are many work sub items that are included in the critical path, which means there should be no delay in the implementation of the work sub items because it will cause delays in the implementation of other activities which will have a significant impact on work delays. Meanwhile, sanitary work items and electrical work items are not on the critical path, which means that the sub items in the work are still safe and do not have a significant effect on delays in construction project work. The existence of critical paths in several activities means that project work implementers need to carry out or take several anticipatory steps, including:

1. Ensure that the resources needed for critical path activities are available and well managed, evaluate whether there is a shortage of resources, needs to be rescheduled, or needs to be outsourced.
2. Make backup plans for activities on the critical path. This can be a contingency plan to deal with possible delays or obstacles that may arise.
3. Communicate clearly to the entire project team about the critical path, deadlines, and how each team member can help prevent delays.
4. Give extra priority to critical path activities, ensuring the project team's focus and key resources are properly allocated to complete those activities on time.
5. Regularly monitor the progress of critical path activities and implement controls to manage the risk of delays, making changes or adjustments if necessary.

6. Identify risk factors that may affect the critical path and create a plan to mitigate or manage them early on.

IV. CONCLUSION

Microsoft Project is very helpful in critical path analysis of construction project implementation schedules. By using Microsoft Project 2016, the critical path was obtained for the sub-items of land clearing work, measuring and making bouwplank, earth excavation (foundation), a series of activities for installing formwork, ironwork, and casting at certain stages. Stages of leveling the land, filling with sand, installing iron and casting. Installation of brick walls, plastering, plastering, installation of ceramics, installation of frames and paint, as well as installation of elements such as floor drains, septic tanks, electrical connections and KWH meters. Installation of paving blocks, planting grass and plants. Anticipating the critical path is not only about responding to problems as they arise, but also about being prepared and doing careful planning to mitigate their impact. With the right strategy, projects have a better chance of running on schedule.

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