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Optimization of Cost ad Time for Heavy Equipment in Revetment Construction Projects in Buol Regency

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ABSTRACT: *In undertaking implementation, numerous situations may rise up that can bring about venture delays and financial losses. Buol Regency is an area characterized through an extended coastline. along this coastline, particularly in Kelurahan Leok, tidal waves pose a serious threat to public infrastructure and residential regions positioned close to the shore. one of the most commonplace reasons of delays within the subject is the overdue deliver of creation materials. on this coastal revetment production task, the delivery of materials, first of all scheduled to arrive within 7 days, became behind schedule up to 21 days because of detrimental climate conditions and excessive sea waves. This have a look at goals to decide the most reliable values of time and value for heavy equipment usage within the coastal revetment creation task in Buol Regency. The research technique hired involves accelerating vital path activities by way of including hard work sources, primarily based on a community diagram evolved using the priority Diagram approach (PDM), to acquire gold standard time and fee results. The outcomes of the examine indicate that the challenge can be completed within 30 weeks, with a total price of IDR 19,504,611,620.forty six. This represents a fee efficiency of IDR 110,767,752.sixty six (zerofifty six%) as compared to the whole fee beneath regular situations, thatIDR 19,615,379,373.12. those findings show the importance of applying time-price exchange-off evaluation in task scheduling. through this method, undertaking scheduling may be optimized in terms of both execution time and value*

KEYWORDS-*Optimization, Revetment, Construction, Project, Financial*

I.INTRODUCTION

A undertaking is a sequence of interrelated activities that ought to be accomplished within a sure time frame, at a certain value and are specific. projects are unitary due to the fact there are no same initiatives between one venture and another[1]. because of the specific nature of the task, the handling and management methods used in a mission are extraordinary from different initiatives[2].

Management is an attempt made to arrange sure assets to gain a purpose[3]. In a undertaking, time and expenses inside the assignment implementation technique can be confined. This requires the provider company to perform a good management process in order that with confined time and charges the mission may be applied on time and make a profit[4].

In undertaking implementation, diverse situations can arise that could bring about the mission being finished past due and experiencing losses. The reasons of delays and losses may be caused by several factors, particularly worker elements, cloth factors, device elements, beside the point making plans factors, weak supervision factors, weak communication elements, vulnerable coordination factors and others[5].

To triumph over undertaking delays, provider companies want to boost up projects on certain activities. project delays will genuinely have an effect on growing charges in order that project acceleration wishes to be accomplished with the aid of considering rapid time and most excellent prices. task acceleration can be executed by way of including employees, changing shifts and adding operating hours or time beyond regulation. by accelerating the assignment, it's far expected that the undertaking charges and time may be most advantageous so one can have a high quality impact on the carrier company.[6]

Assignment management is the software of understanding, skills, tools and strategies in venture sports to fulfill wishes. mission control is done thru process stages including starting up, planning, executing, tracking and controlling and ultimately remaining the entire undertaking technique. In its implementation, each undertaking is always constrained by way of constraints that have an impact on each different, particularly the scope of work, time and cost. in which the stability of the 3 constraints will determine the great of a undertaking. changes in a single aspect will have an effect on other factors. The corporation additionally wishes to make sure that within the implementation of the project it keeps to pay attention to the constraints of time, cost, and scope of work by using utilizing the assets it has[7].

A production undertaking is a procedure where plans/designs and specifications are converted into physical systems and facilities. the development system includes the corporation and coordination of all

undertaking sources (exertions, creation gadget, permanent and brief materials, supplies and facilities, money, generation and methods, time) to finish the challenge on time, on price range, and in accordance with the first-class and overall performance requirements distinctive with the aid of the planner[8]. A task is a series of interrelated activities and events to obtain sure dreams and convey consequences within a positive duration by means of making use of available assets[9]. it's far a chain of sports which might be best performed as soon as and are generally quick-time period and feature a clear start and quit time. on this series of sports, there's a process that procedures venture resources into a end result of the activity inside the shape of a building[10]. The method that takes place in this series of activities without a doubt involves associated events each immediately and the main characteristics of a creation mission are as follows: (1) has a selected aim, give up product or very last work result. (2) the amount of costs, agenda objectives and great criteria within the procedure of reaching the above dreams are determined. (3) is brief, which means typically confined with the aid of the completion of the venture, the start and quit points are sincerely decided. (4) non-habitual, now not repetitive. the sort and depth of sports change in the course of the assignment[11]

II.LITERATURE REVIEW

WBS is a way of organizing a challenge into a hierarchical reporting structure. WBS is used to interrupt down or spoil down every work method into extra element. that is intended in order that the undertaking planning manner has a higher stage of accuracy[4]. WBS is prepared based at the studying foundation of all challenge files consisting of contracts, drawings, and specs. The project is then damaged down into components via following a certain structural and hierarchical sample into pretty certain paintings gadgets, called WBS. The greater regularly we do the breakdown, the extra targeted the making plans in an effort to be made[12]. There are not any preferred pointers to what volume WBS ought to be executed. however what wishes to be remembered is that the greater often the breakdown is executed, the greater complex the schedule is made, so that the extra time and charges incurred are greater. There are three advantages of WBS in the mission planning and control system. Scheduling is an implementation of planning that may provide statistics about the undertaking plan agenda and development together with sources (fees, hard work, device, substances), period and time development to complete the undertaking. project scheduling follows the improvement of the venture with its various troubles. The monitoring and updating manner is always executed to achieve a realistic schedule to fit the mission's objectives. There are several methods for handling undertaking scheduling, particularly S Curve Barchart, and community planning (network)[13].

Inside the implementation of creation projects, delays regularly occur due to numerous elements that cause losses. consequently, value and time optimization is executed. The cause of optimizing the time and value of a challenge is to obtain better earnings without lowering the nice of a creation..undertaking costs are grouped into two additives[14], namely direct costs and oblique expenses

a. Direct costs are all expenses related to the implementation of production paintings within the field
b. indirect costs are all assignment costs that are not directly related to construction inside the field.

The sum of direct fees and indirect fees is referred to as the full fee in order to be used for the duration of the implementation of the task. the amount of general fees depends at the period of time the task is carried out. Direct charges and oblique expenses will change consistent with the development of the undertaking. In widespread, the longer the undertaking runs, the better the cumulative oblique prices required[15].The relationship between direct expenses and indirect fees can be seen in determine 1 underneath.

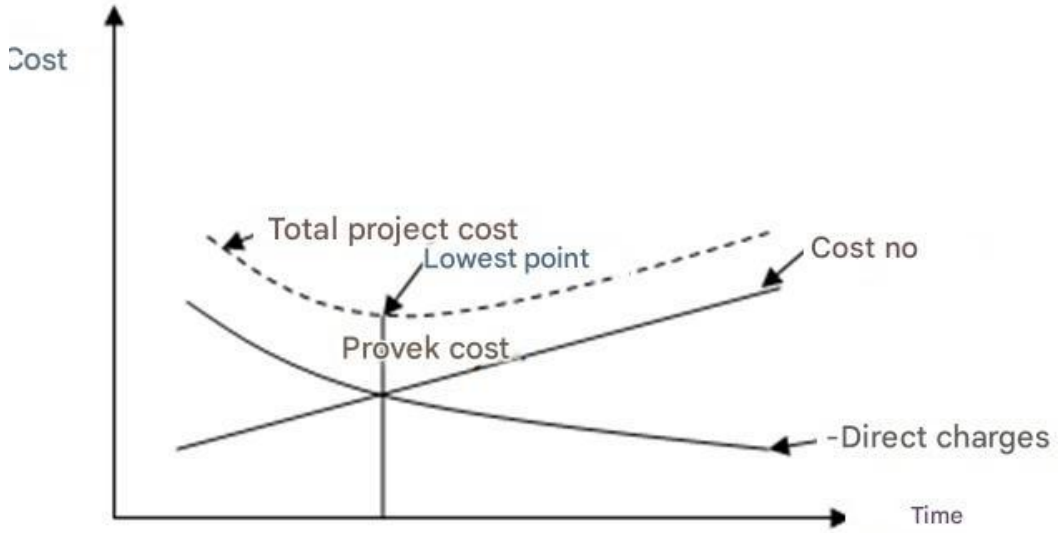

Figure 1 Graph of the relationship between total, direct, indirect and optimal costs

On the entire value graph, there's an best point that suggests the minimal challenge fee and the maximum top-rated challenge implementation time. This top of the line factor is what the contractor is attempting to reap in implementing a venture.A community is a tool used to plot, schedule, and display the progress of a task. In terms of scheduling, a community is visible as a step to improve the block chart technique, due to the fact it can provide answers to unsolved questions[4], [16]

CPM and PERT are networks with activities at the arrow (AOA) while PDM is a community with activities on the node (AON).The building fee finances Plan (RAB) is an estimate or estimation, specifically a value plan before the building/mission is applied. it's miles required with the aid of both the building owner or owner and the contractor because the executor of the construction. Construction fee estimates may be distinguished as rough estimates (approximate estimates or preliminary estimates) and exact estimates or distinctive estimates. rough estimates are usually needed for budget proposals or submissions to corporations, for instance inside the suggestion of DIP (project list) for authorities initiatives, and also are used within the feasibility study stage of a project[17], [18].

Particular estimates are basically whole precise RABs inclusive of oblique fees or overhead, contractor earnings and taxes. usually overhead charges, earnings and taxes are calculated based on a percent (%) of the development price.The S-curve is one of the project progress manage strategies the use of a mixture of the "S" curve and milestones. A milestone is a point that marks an event this is taken into consideration essential inside the collection of undertaking paintings implementation. The event may be the begin or end of the paintings. The milestone point is decided when getting ready the fundamental making plans as a benchmark for task control sports[3].[19]

The performance curve or "S" curve is a picture of the connection or summation among the cumulative development of labor implementation (in percent zero% - one hundred%) on the *Y* axis and the time of work implementation. on the *X* axis or a cumulative development of work in opposition to the implementation time[17]. To collect the "S" curve, you need to first realize the time table of every activity, the weight (percent) of the hobby to its distribution. The curve made with the vertical axis because the cumulative price of fees or guy-hours or of entirety of labor and the horizontal axis as the calendar time each from zero to a hundred, will usually be inside the form of the letter "S"[20].

Erosion is the system of the coastline retreating from its unique function. Erosion happens because of sediment delivery along the coast where sediment is transferred from one vicinity to every other. The non-stop shifting of sediment causes the coastline to recede. The harm because of coastal erosion will increase over time. And what we often see these days is the problem of erosion caused by erosion with the aid of the power of ocean waves and ocean currents which might be unfavourable to the coast[21].

Coastal walls and revetments are systems that separate land and coastal waters, which often feature as coastal safety against erosion and wave runoff (overtopping) to land[22]. The blanketed vicinity is the land without delay behind the building. The coastal wall is mostly a vertical wall, at the same time as the revetment has sloping facets. This shape is placed parallel to the coastline, and can be made from stone masonry, concrete, concrete pipe piles, sheet piles, timber or stone piles[23].

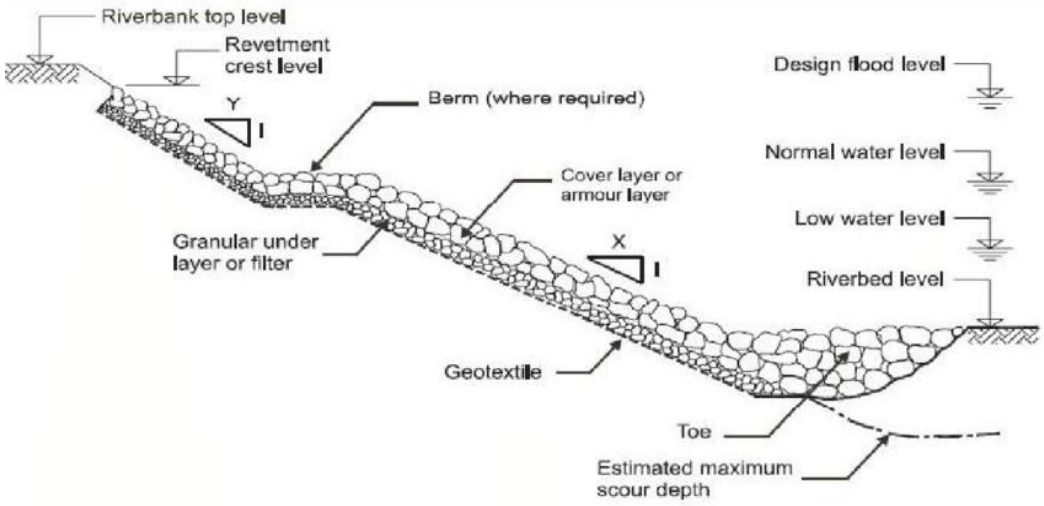

Figure 2. Armor Stone Type Revetment Components

Technical context, including heavy system will boom the manufacturing capacity of the work. as an instance, in excavation or earthmoving work, including the quantity of excavators or unload trucks will increase the each day work volume, so that the period of the paintings may be decreased substantially[24]. but, this addition will have an effect on the challenge price, so a slope analysis is wanted, namely the ratio between extra acceleration prices and time discounts. activities with the smallest slope are prioritized for acceleration due to the fact they offer the high-quality time efficiency with minimum cost.[25], [26]

project control software which include Microsoft challenge and Primavera can help visualize the effect of adding gadget on adjustments in mission period and charges. further, technologies including BIM (constructing information Modeling) and GPS sensor-based monitoring systems can offer real-time information on heavy system productiveness and the distribution of labor time within the field. The challenge management Institute (2017) states that integrating generation into the assignment choice-making technique can enhance the accuracy of TCTO calculations and help assignment managers make facts-based totally acceleration selections.[27]

in the implementation of revetment production initiatives, sudden demanding situations frequently rise up and feature the ability to prevent the clean running of creation activities. one of the principal boundaries is the put off inside the delivery of production cloth substances. substances that had been at the beginning scheduled to arrive inside seven days were not on time via up to three weeks. The postpone become particularly due to awful weather situations and excessive sea waves. The delay no longer only impacted the delay of work inside the discipline, but also induced an growth in project charges because of the boom in work duration and the capability for rescheduling sports. This problem shows that outside elements such as climate and sea situations greatly affect the achievement of venture implementation in coastal areas. consequently, this examine is relevant to study intensive the effect of cloth deliver delays on project implementation time and charges. hence, it is expected that an optimization approach may be discovered that can be applied to minimize the terrible impact of these elements. The technique used on this look at is the priority diagram approach (PDM)[16], [28].

III. METHODELOGY

This type of studies is applied studies. The research method begins with a literature review to determine the extent of the study of the trouble to be studied, the subsequent manner is to look for projects with the intention to be used as a medium for enforcing the trouble. the specified information is acquired immediately from events related to the challenge. After all the required information is acquired, the subsequent method is to manner the statistics. The results of the facts processing are analyzed and mentioned to then be concluded[29].

The varieties of records used on this look at are number one records and secondary records. number one facts is received by using accomplishing interviews with respondents inside the form of questions related to the research (relationships among jobs). Secondary statistics is acquired at once from the workplace of the provider issuer inside the shape of a cost budget Plan (RAB), wide variety of employees, daily wages of people and time agenda[30].

The facts assets for this look at are workers and superiors from the contractor, specifically PT. Saboda Indo Perkasa, specialists, specifically CV. Ramayana Rancang Bangun Konsultan and the owner, specifically Balai Wilayah Sungai III Palu who are concerned within the coastal protection embankment construction project in Buol Regency (revetment kind[20]).

From the data that has been obtained, records evaluation is then performed the usage of the subsequent methods:

1. creating a community diagram the use of the PDM approach.
2. Accelerating vital jobs through including heavy system.
3. Calculating most suitable time and value

Precendence Diagram Technique (PDM) is a network with activities on the AON (pastime On Node) node. right here, activities are written in nodes which might be typically rectangular, at the same time as arrows are most effective a demonstration of the relationship among the sports concerned. consequently, Dummy, which in CPM and PERT is an important signal to expose dependency relationships, isn't always wished in PDM.

The primary policies of CPM and AOA (hobby On Arrow) kingdom that an interest may be commenced after the previous activity (Predecessor) is completed, so for tasks with overlapping and repetitive series, lots of dummy traces might be required, making it impractical and complicated.

sports and occasions in PDM are written in nodes inside the shape of square bins. The field marks an activity, so the interest identification and term must be protected. whilst events are the ends of the activity. each node has events, specifically the start and stop activities. the distance inside the node is divided into small components containing particular information from the activities and occasions concerned and called attributes. a few attributes which are regularly indexed encompass the activity period (D), pastime identification (wide variety and name), start and stop of the hobby (ES, LS, EF, LF) and others.

Description:

ES = earliest start time of an activity (Earliest Start)
EF = earliest finish time of an activity (Earliest Finish)
LS = latest start time of an activity (Latest Start)
LF = latest finish time of an activity (Latest Finish)
D = time required to carry out the activity (duration)
TF = Total Float, which is the total grace time for an activity or the delay allowed for an activity so as not to interfere with the overall completion time of the activity.
i = no activity or activity

Review of the relationship between activity 4 and activity 1:
ES4 = EF1 + FS14 – D4 = 17 + 1 – 11 = 7
EF4 = ES4 + D4 = 7 + 11 = 18
Review of the relationship between activity 4 and activity 2:
ES4 = EF2 + FS24 = 19 + 0 = 19
EF4 = ES4 + D4 = 19 + 11 = 30
Review of the relationship between activity 4 and activity 2:
ES4 = EF3 + FS34 = 14 + 3 = 17
EF4 = ES4 + D4 = 17 + 11 = 28
From the calculation above, the ES4 and EF4 taken are:
ES4 = max (ES4) = 19
EF4 = max (EF4) = 30

IV.RESULTS AND DISCUSSION

Inside the value finances Plan in Appendix three, there are numerous records which might be useful to support the evaluation manner. The statistics includes the extent of work, overall price of work, and fee information for tools, substances, and materials. facts at the quantity of labor is presented in table 1.

Table 1. Volume and Cost of Work

No	Activity Type	Volume	Unit	Cost
1.	Mobilization and Demobilization	1,00	Ls	Rp. 71.125.000,00
2.	Construction Safety Management System Implementation	1,00	Ls	Rp. 48.980.000,00
3.	Sandy Soil Excavation	6.150,24	M^3	Rp. 114.320.661,12
4.	Revetment Stone Installation	20.085,25	M^3	Rp. 18.617.821.635,00
5.	Installation of Non Woven Geotextile	12.655,59	M^2	Rp. 763.132.077,00

Tabel 2. Project Work Duration.

No	Activity Type	Duration (Weeks)	Duration (Days)
1.	Mobilization and Demobilization	10	70
2.	Construction Safety Management System Implementation	30	210
3.	Sandy Soil Excavation	26	182
4.	Revetment Stone Installation	27	189
5.	Installation of Non Woven Geotextile	27	189

Table 3. Equipment Rental Cost Per Hour

No	Labor Type	Price	Unit
1.	Excavator	Rp. 342.150,00	O'clock
2.	Wheel Loader	Rp. 448.467,30	O'clock

PDM (*Precedence Diagram Method*)

Based totally on these facts, an analysis is then finished by way of compiling a piece network diagram the use of the PDM (precedence Diagram technique) method. The period completion of each activity and the relationship among jobs are decided primarily based on facts from the Time schedule displayed in Appendix 2. information of the of completion time and relationship between jobs are provided in table four underneath.

Table 4. Inter-Occupational Relations Normal Conditions.

PDM Number	Type Activity	Predecessor
1	Mobilization and Demobilization	-
2	Construction Safety Management System Implementation	1SS+0
3	Sandy Soil Excavation	1SS+2
5	Revetment Stone Installation	3SS+2
4	Installation of Non Woven Geotextile	2SS+2, 3SS+1
6	Mobilization and Demobilization	4FF+1, 5FF+1

Based on Table 4, a network diagram can be prepared in PDM format as shown in the Appendix. From the diagram in Appendix 6, the Early Start (ES), Early Finish (EF), Latest Start (LS), Latest Finish (LF), and Float (F) values can then be calculated, the results of which are presented in Table 5 below.

Table5. Critical Work

No	Jenis Kegiatan	Waktu Normal (Minggu)						Keterangan
		DN	ES	EF	LS	LF	F	
1.	Mobilization and Demobilization	8	0	8	0	8	0	Kritis
2.	Construction Safety Management System Implementation	30	0	30	2	32	2	-
3.	Sandy Soil Excavation	26	2	28	2	28	0	Kritis
4.	Revetment Stone Installation	27	4	31	4	31	0	Kritis
5.	Installation of Non Woven Geotextile	27	3	30	4	31	1	0
6.	Mobilization and Demobilization	2	30	32	30	32	0	Kritis

Calculation of Direct Costs and Indirect Costs

From the total project cost listed in the Budget Plan, a separation is made between direct costs and indirect costs. Details of direct costs can be seen in Table 6 below.

Heavy Equipment Quantity Calculation
The number of Heavy Equipment / day can be calculated using the following formula:
Sandy Soil Excavation Work
Duration = 182 Days
Volume = 6,150.24 m2
Excavator Index = 0.0354 Hours / m2
Calculating the Total Working Hours of Equipment Required:
Total Working Hours = Volume x Equipment Index
Total Working Hours = 〖6,150.24 m〗^2 x 0.0354 Hours / m^2
Total Working Hours = 217.5 Hours
Calculating the Total Capacity of 1 Equipment for 189 Days
Capacity of 1 Equipment = 8 hours x 189 Days
Capacity of 1 Equipment = 1512 Hours
Number of Equipment Required
Number of Heavy Equipment = (Total Working Hours) / (Total Hours Per Equipment)
Number of Heavy Equipment = 217.5 / 1512
Number of Heavy Equipment = 0.1494 = 1 tool
4.2.4 Time Cost Trade Off Addition of Heavy Equipment
At this stage, heavy equipment is added to the critical work, namely the revetment stone masonry work.
Revetment Stone Masonry Work
Normal Duration: 189 Days
Volume: 20,085.25 m3
Number of Excavators: 1 Unit
Addition of Manpower: 1 Unit

The approach of adding heavy system focuses on accelerating the revetment masonry hobby which is assessed as a vital course. although it succeeded in lowering the length of the hobby considerably, the general time efficiency remains restrained because no longer all activities may be improved via adding gadget.In evaluation, the constraint trade method has a widespread impact on the whole mission duration by way of rearranging the dependencies among activities. This lets in some work to begin in advance, with out growing the direct price burden.

The very best time effectiveness is finished via the constraint change technique, which indicates that efficiency can be acquired now not best thru adding assets, however also through optimizing the time table.A contrast of the two acceleration strategies — adding heavy device and converting constraints — suggests that each have their own benefits and limitations. adding heavy equipment offers substantial effects on one essential pastime, however its domino effect on the full period and fee of the undertaking is constrained.

In comparison, the constraint change strategy is demonstrated to be extra powerful general. This method lets in for extra green use of time with out converting resource allocation, because it's far based at the logic of pastime dependencies and does no longer require additional prices.However, each method requires consideration of discipline conditions and human useful resource readiness. including equipment is greater suitable if workspace and coordination allow, while converting constraints is extra suitable for tasks with complex work systems. the choice of acceleration strategy have to be adjusted to the characteristics of the challenge, and consider the dangers and influences at the great of work.

The implementation of the time cost exchange off method need to be considered cautiously because it has risks in task implementation. in the method of including workers, the dangers that get up encompass extra complex work coordination, capability conflicts between employees, and impacts on productivity. extra labor that isn't always balanced with the provision of gear and workspace can motive decreased performance. In addition, mission acceleration has the capacity to reduce the nice of work results. production tasks which includes coastal embankments require precision and lengthy-time period sturdiness, so that rushed implementation instances can increase the danger of technical mistakes.In converting constraints, the principle chance lies in schedule management and simultaneous implementation. activities that begin in advance than standard require greater intense cross-group coordination. This calls for a very good venture monitoring and conversation system.

Standard, the implementation of an acceleration approach should usually be preceded via an in-depth study of human resources, logistics, and their capacity impact on the general quality and safety of the project. Undertaking acceleration can placed pressure at the first-class of labor if now not controlled properly. In situationsof extra labor, multiplied productivity in quantity does not always produce equivalent fine. The implementation manner that is too fast can motive negligence in important stages consisting of compaction, structural supervision, or cloth trying out.Reduced productiveness in keeping with person is likewise a real

hazard when the number of workers will increase, due to the fact work effectiveness isn't always constantly linear. extra workers require adequate training, coordination, and supervision in order that the consequences meet requirements.On the other hand, changes in constraints that pressure work to take place in a short time also can disrupt the point of interest of the challenge group. The strain to complete more work at the identical time can purpose fatigue, work pressure, and potential injuries.

Consequently, in choosing an acceleration approach, pleasant and protection components should be the principle precedence. mission fulfillment isn't always most effective measured by period and cost, however also by way of the durability and excellent of the final result.

The results of the analysis of 3 undertaking implementation situations offer several essential instructions for project control. First, the venture acceleration strategy must now not simplest awareness at the final outcomes in the form of time and fee, but ought to bear in mind threat and great. adjustments in constraints have validated to be the maximum green strategy with out additional prices.

V.CONCLUSION

Based at the results of the evaluation and dialogue, it may be concluded that venture scheduling the usage of the PDM (priority Diagram approach) method indicates greater most suitable consequences when changes are made to the prevailing constraints. From these outcomes, the project of entirety length is obtained for 30 weeks with a complete price of Rp 19,504,611,620.46. This price indicates a price performance of Rp a hundred and ten,767,752.66 (0.fifty six%) while as compared to the whole challenge cost beneath everyday situations, that's Rp 19,615,379,373.12. the share parent (zero.56%) may additionally seem minimal, but in big construction projects, savings of > Rp one hundred billion are very financially relevant.n section must be included and should indicate clearly the advantages, limitations, and possible applications of the paper. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extentions.

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