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CPM for Project Scheduling: Case Study in Karbala Metal Silo

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Abstract:
The understanding of techniques called project scheduling methods, and the delay in the completion of the Karbala metal silo in the holy province of Karbala is the non-use of modern techniques in implementation, so the research sought to provide the use of project scheduling using one of the advanced scientific methods that have proven the extent of its ability to schedule any project and its projects are the trade-off between time and the cost of completing the project. The objective of this research is to find the time and cost of completing the silo project in normal and crash conditions using CPM, which will facilitate the marketing of local wheat from the farmer and export it to mills. MS-Project was used to find the critical path. The cost distribution method was also used according to early start (ES) and latest start (LS) method for calculating the process of distributing the costs of project activities and determining the area of financial savings when implementing project activities. The results obtained showed the importance of CPM and its efficiency in project scheduling, as the project was completed in normal conditions in 396 days and a total cost of 5,012,811,028 ID. However, when activities were crashed, the project completion time was 307 days and a total cost of 5,043,894,328 ID. The results also proved that using the method of allocating costs according to the LS method helped the decision maker to determine the area of financial abundance and the limits of financial maneuvering that he can perform during the completion of the project activities

Research Type: Research Paper
Keywords: Project Scheduling, Critical Path Method, Tradeoff between Time and cost, Scheduling costs.

1. Introduction:

There has been a great development and interest, especially in recent years, in the use of project management in the countries of the world and this is a way to achieve the objectives of the organization, as project management and methods help to provide an effective force to develop the capabilities of the organization and its ability to plan, organize, implement and monitor various activities, including making the most of the organization capabilities and resources, with an accurate calculation of the time and cost of project completion using project scheduling methods, which is the critical path method (CPM), The Silo Karbala mineral project is one of the huge projects that the Ministry of Commerce / State Company for Grain Trading seeks to accomplish to achieve a set of general objectives, including expanding the storage capacity of the strategic storage in Iraq of the wheat crop, And increasing the marketing area of the farmer in the province of Karbala In this research, one of the best scheduling methods was used for the Silo Karbala metal project in the presence of non-traditional relationships for the project activities with the determination of the values of the lead and lag periods between them, which is the CPM critical path method to find time and natural and accelerated cost, for the purpose of facilitating the process of front and back calculations to extract the critical path CPM for the project, As used the cost calculations of the activities per day and then extracted the cumulative costs for the early start (ES) and late start (LS) methods, from which the financial abundance for each activity in the project is calculated and this work is a benefit to the executing authority to manage the costs of activities and is considered as financial advances for him, and use ready-made computer programs to find the desired time and cost, which is the MS-Project program, and this gives importance in scheduling the completion of the project and helping the project manager to make the right decision for the goal of achieving the desired time to complete the project.

A number of researchers have addressed the subject of project scheduling and the critical path method, including:

Hawi (2005) developed by the study of this researcher using the critical path method (CPM) and the Program Evaluation and Review Technique method (PERT) method in planning and following up the completion of boats, and used the PERT method in calculating the total completion time of boats depending on three times, namely (pessimistic time, the most likely time, and optimistic time) and then extracted the expected time for each activity, and reached the most important results that the use of operations research methods in the implementation of the project such as the critical path and PERT gave a difference and decrease in the planned time and cost and between implementation together.

A study by Al-jazaeri (2008) used project scheduling methods, and the Program Evaluation and Review Technique method (PERT) and critical path method (CPM) in the comparison between time and cost to complete projects. It found that the use of each of the methods PERT -CPM has achieved tremendous fame among experts in the field of planning, and the benefits of these methods have increased more and beyond what we imagine through the use of computer systems for the achievement, analysis and control of the network of projects.

Aziz et al. (2011) developed a sophisticated study on the design of a critical path-finding algorithm (CPM) in project work (Gaocpn) as it suffers from the design of the genetic algorithm to solve optimization problems related to business networks and reach the most important conclusion that the proposed genetic algorithm is superior to operations research and that the algorithm method is independent and completely different from traditional methods as one of the intelligence techniques.

Khader and Khalaf (2015) developed project scheduling using the objective programming method for the Modern Village project in Wasit Governorate, where the Modern Village project was implemented without the use of modern scientific methods by the executing company in the implementation of the project and reached the most important results by obtaining a solution to the mathematical model of this study, which gives the ability to provide multiple decisions to manage the project in proportion to its available budget.

Al-Mawashi and Dawood (2016) the studied came on the role of the critical path method (CPM) and the Program Evaluation and Review Technique method (PERT) in enhancing the performance of construction projects for Baghdad Governorate projects, and its problem lies in increasing the costs and duration of its construction than estimated and reaching the most important results that determine the important critical activities in the implementation of the project at the lowest cost within the specified time, as well as the use of PERT contributes to calculating the most likely time for the project and thus increasing the success rate of the project.

Al-Baldawi and Khalaf (2016) suggested using the critical path method to schedule the work of the Balad sewage project in Salah al-Din governorate, which suffers from delays in completing the project, and through studying the project again according to modern scientific methods and choosing the critical path method (CPM), the total time for the completion of the project was found in both natural and accelerated cases.

Hassan and Abed (2018) used planning and scheduling the implementation of government projects and found that scientific methods in setting a schedule for the implementation of works at the level of each of the construction activities did not use, based on the standard concepts referred to in the resident engineer’s guide for parts one and two. Furthermore, a schedule for the progress of work based on realistic foundations by relying on the work progress curriculum within feasibility studies and bidding through a comparison of the bid execution periods with the periods that should be sufficient to complete the work did not set. Likewise, there were the lack of coordination among the project executing authorities, the planning authorities, and the legal authorities for each contractor. This might constitute a weakness in the process of supervision and follow-up and determining the rights and obligations of both the employer and the contractor represented by the executing companies.

Ahmed and Ashour (2019) suggested the use of dynamic programming and smart algorithm to solve the problems facing project management by comparing traditional and modern methods, and thus the optimal solution is obtained using dynamic programming and smart algorithms, where they reached the most important results that divided the project into multiple stages using the dynamic programming method helps to know the completion time of the project and know the free path.

Kazem and Jawad (2020) used the critical path method to schedule the work of the Al-Amel neighborhood sidewalk project next to Al-Eyab Street with a length of 1.25 km to reduce the time required to complete the project, as the Holy Municipality of Karbala suffers from delays in completing its projects, and they recommended preparing the guess statements correctly and pre-planning helps in implementing the work in a timely manner.

Saleh and Khalaf (2023) used the critical path method in light of operational risks, for the project to establish a helicopter airport in the oil fields to study is that the Maysan Oil Company suffers from the high costs of transporting foreign cadres and equipment from Iraq's airports to its fields and vice versa, and they reached the most important results that the establishment of the airport in question reduced the time required to transport foreign cadres and reduce costs, which encourages investment and achieves financial returns for the country.

The research problem lies in the failure of the executing company to complete the Karbala metal silo to rely on scientific methods in planning the project and scheduling its activities, as well as monitoring when it is implemented, and not using the critical path method (CPM) to find the total time for the completion of the project, which led to delaying the completion period from its scheduled date.

The objective of the research is to find the time and cost to complete the project in the natural and accelerated conditions of the Karbala Mineral Silo of the General Company for Grain Trading at the Ministry of commerce, using the critical path method (CPM) in the presence of non-traditional relationships between some project activities due to the presence of progress and delay (lag & lead) between them, and the front and back calculations were used to clarify how to find the critical path, He used calculations of flexibility times (Float Times), which determines critical activities whose value is equal to zero and activities with a positive value that have flexibility, and these methods and programs help engineers and workers in charge of implementation. Establishment of Karbala Metal Silo Project and other projects related to Karbala Governorate to put solid scientific foundations in its calculations for the future benefit, and the research also aimed to show the financial abundance to manage the costs of project activities by the executing entity using the cost scheduling of activities and according to the time of early start ES and late start LS, for the cost of project activities per day, and some ready-made computer programs were used such as (MS_ Project) to find the time and cost of completing the project in the natural and accelerated period.

2.Material and methods:

The research deals with a detailed presentation of the research limits, the research community, the research sample, the measurement tool, and the topics of the theoretical side of the research, as follows:

2.1. Research limits:

2.1.1. Spatial limits: The project for the construction of the Karbala Mineral Silo in the Holy Province of Karbala was selected under the Ministry of Commerce / General Company for Grain Trading as the researcher is one of the engineers in the company and the ministry.

2.1.2. Time limits: The field inspection of the project and the application of the CPM critical path method started in October 2022 until the end of the research, as the project is under completion during the research period

2.2. Research community and sample:

The research community represents all silos of the State Company for Grain Trading, which is one of the companies of the Iraqi Ministry of Trade, which consists of (45) silos in Iraq from north to south. The research sample is represented in the completion of the Karbala mineral silo with a capacity of 30 thousand tons, which is one of the sites for receiving, storing and processing grain (wheat) in the holy province of Karbala and affiliated to the State Company for Grain Trade.

2.3. Research methods and tools used to obtain results:

2.3.1. The researcher relied on the critical path method (CPM) to find time and cost in the normal state of the project, as well as the Trade – off Between Time and Cost in controlling the implementation of the project.

2.3.2. The researcher relied on the calculations of early start and late start in the start of the costs of project activities for one day and the same period of completion of the project.

2.3.3. The researcher used software, which are:

A. MS Project, one of the famous programs in project scheduling management.

2.4. Concept and definition of the project:

The term project is a novelty in French culture, whose terminological meaning was formed only in the middle of the last century through the linguistic derivation of this word in the Latin language, which denotes the implementation of something or a subject. (Hassan, 2019). Each project has a start date, and is determined at some time, and this is done with the implementation of the project activities, in addition to that there is an accurate end date for the project, so a work

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plan must be developed for the project with appropriate work in order to complete the project to meet the requirements and specifications of the project (Kazem and Jawad, 2020). Heizer et al., (2017) developed the definition of a project as "a series of relevant tasks geared towards key outputs and the project is developed and organized in most organizations for the purpose of smoothly continuing existing programs on a daily basis while new projects are successfully completed."

2.5. Project Management Concept:

In general, various methods are used in the implementation of projects, resulting in the diversity of work plans and their differences from one project to another, as these plans need ways to deal with the technical information of the end beneficiary, with means of cost savings, tight deadlines, different complexities and many data (Kerzner, 2017). Project management is the provision of structure that helps define the goal of each project. Means of achieving these goals through performance monitoring (Salah and Khalaf, 2023). Many researchers defined project management as the application of knowledge, skills, tools and technical methods to project activities to achieve project requirements (Al-Hasnawi and Al-Samarrai, 2016).

2.6. Project Scheduling Concept:

In general, a variety of methods are used in the implementation of projects, and this results in the diversity of work plans and their differences from one project to another, as these plans need ways to deal with the technical information of the end user., with means of presenting costs, tight deadlines, different complexities and many data (Kerzner, 2017). Typically, each project has a planned finish date and to help ensure that the project's finish date coincides with the actual completion of the project, there should be a detailed timeline. This timeline includes a list of the main phases, tasks and activities of project completion, and should also include a list of those responsible for performing these tasks and showing the relationships of sequencing, interdependence and precedence between tasks and activities (Al-Mawashi and Dawood, 2016). Heizer et al. (2017) defined project scheduling as "the process of sequencing activities that represent project tasks and allocating the time and resources required to accomplish each activity in the project defined by the project manager."

2.7. Project scheduling methods:

There are two main ways in scheduling projects:

2.7.1. Gantt Chart: Named after the American engineer Henry Gantt, in 1917 he used the bar chart or Gantt chart for business and project planning (Susmanschi and Ruse, 2018).

2.7.2. Network Programming: The network programming method is one of the fairly modern methods in scheduling projects, and the network programming method appeared due to the needs that the previous methods could not meet any Gantt mapping method of business networking methods, the most important of which are the critical path method (CPM) and the Program Evaluation and Review Technique method (PERT), (Azayza, 2019).

2.8. The importance of scheduling:

Scheduling is one of the tools that provide basic and important data for both owners and the public in general, suppliers, contractors, engineers and subcontractors, and it is limited to answering the main question about who and when, and determining the timing and sequence of construction activities, in addition to the schedule, scheduling offers many important benefits, including Al-Ali (2014):

1. Estimate or anticipate the timing of project completion.
2. It is an effective means of monitoring and controlling the project.
3. Avoid lump sum damages.
4. Manage funds by anticipating nutrition flows.
5. Set time intervals for an operation.
6. Organizing the necessary data for the facility.
7. Improve resource allocation and forecast resource demand.
8. An effective means of communication for project contributors, Hassan and Abed (2018).

2.9. Critical Path Method (CPM):

The critical path method is a scheduling method based on network analysis and is used in project scheduling, planning and follow-up and in the graphical representation of the existing associations between all project activities (Khader and Khalaf, 2015). One of the advantages of this method is that it is a specific method (Deterministic) used when ascertaining the duration of the project implementation, as it is a path that includes a range of activities and requires more time than the rest of the tracks in the network (Najm, 2012). It also provides a detailed analysis of the entire project, which creates a manageable work plan, and this method allows to accurately estimate the time period for the implementation of the project or any of its activities, as well as it can set the start and end dates of activities in the project, and this entails identifying the activities with the duty of urgency and those that need to be delayed without affecting the implementation period of the project (Khalaf, 2012). The critical path (CPM) has also been defined as the longest path on a network and is responsible for identifying all the critical activities of the network that should not be delayed from their specified dates, and it is also responsible for informing the project manager where to put the best resources and which ones can be afforded as well as resources that cannot be afforded to lose, Kazem and Jawad (2020).

2.10. Critical Path Method (CPM) calculations:

In order to determine the critical path, we must calculate early times and late times through the use of two types of calculations, (Santiago and Magallon,2009; O'Brien and Plotnick,2010):

2.10.1. Forward Computation:

These calculations start from the first event of the first activity in the network chart, and end with the final event of the last activity in the network chart, and at each event we calculate a number (it is placed in a small square), and this number represents the time of occurrence or the time of early start of those activities that begin with the event (i), and this is the earliest expected time in order to accomplish a work, and this is done according to the following mathematical relationships:

A. The first event of any grid chart is zero:

$$ES_1 = LS_1 = 0 \qquad (1)$$

B. If event (j) in the network diagram is related to a single activity, the mathematical equation is:

$$EF_j = ES_i + D_{ij} \qquad (2)$$

c. If event (j) is associated with more than one activity, we take the highest early and the mathematical equation is:

$$EF_j = max\,[\,ES_i + D_{ij}\,] \qquad (3)$$

2.10.2. Backward Computations:

These calculations determine the time of completion of the delayed work, and these calculations begin at the end of the front calculations, in a more precise sense starting from the end to the beginning, that is, from the last event in the network diagram, to return inversely to the first event, according to the following mathematical equations:

A. The last event in the grid chart is equal to:

$$LS_j = EF_j \qquad (4)$$

B. If event (i) in the network diagram is related to one activity, the mathematical equation is:

$$LS_i = LF_j - D_{ij} \qquad (5)$$

c. If event (i) is associated with more than one activity, the mathematical equation is:

$$LS_i = \min[LF_j - D_{ij}] \qquad (6)$$

2.10.3. Float Times:

It is the excess time extended between the period planned for the implementation of the activity and the actual period, and the calculation of this period depends on the method of calculating the actual period, because the planned period may not be taken into account, and floating takes a positive, zero or negative value, and the positive value means that there is the possibility of delaying the implementation of the activity within the limits of that floating, and the zero is the one that cannot bear any delay in implementation or even at the beginning of the implementation of the activity, it is critical activities, The most important types of flexibility are (Taha, 2007):

2.10.4. Total Slack Time:

It is the largest time that can be postponed to start the implementation of the activity without delay on the time of completion of the project, symbolized by (TF), and is calculated as follows:

$$TF = LS_i - ES_i \quad (7)$$

$$TF = LF_j - EF_j \quad (8)$$

$$TF = LF_j - D_{ij} - ES_i \quad (9)$$

2.11. Non-Traditional Relationships Between Activities:

In the project network diagram there are four types of non-traditional relationships between activities (National Project Management Institute, 2006):

2.11.1. Start to Start (SS) Relationship: means that the subsequent activity begins with the beginning of the previous activity and it is not necessary that the two activities end together.

2.11.2. Finish to Finish (FF) Relationship: meaning the previous activity must end in order for the subsequent activity to end.

2.11.3. Start to Finish (SF) Relationship: meaning the subsequent activity ends after the beginning of the previous activity.

2.11.4. Finish to Start (FS) Relationship: The subsequent activity begins with the end of the previous activity.

2.12. Calculations of Leads and Lag periods:

The calculations are done in the case of (Leads), the subsequent activity begins before the finish of the previous activity and is expressed by a sign (-), then the leads time is subtracted from the time of the early end of the previous activity when calculating and from the early start of the subsequent activity and then added with the normal time of the activity to find the early finish time of the subsequent activity in the case of the relationship finish of the start, and in the case of (Lag) the subsequent activity begins after a period of the finish of the previous activity and is expressed by a sign (+) when calculating the early time of the subsequent activity and added to the normal time to find the early finish of the subsequent activity, and the front and back calculations of non-traditional relationships will be clarified by taking into account the periods of leads and lag, (Al-Ali, 2004).

2.12.1. The process of calculating early times according to forward calculations:

Finish to Start (FS) relationship: In the case of an unconventional relationship between the two activities of the type Finis to Start and its association with a logical relationship of leads ((-e)`) and lag (+e) in the case of forward accounts, while the back accounts are vice versa, the signal will be calculated as follows:

$$ES_b = EF_a + e \quad (10) \quad \text{case lag}$$

$$ES_b = EF_a - \acute{e} \quad (11) \quad \text{case lead}$$

$$EF_b = ES_b + D_b = EF_a + e + D_b \quad (12)$$

$$EF_b = EF_a + D_b = EF_a - \acute{e} + D_b \quad (13)$$

When there is more than one previous activity, the values of the early times are calculated according to the relationship of the current activity with each previous activity, and the largest of these values is chosen.

2.12.2. Calculation of delayed times according to backward calculations:

Finish to Start (FS) relationship: In this case, the late start time of the subsequent activity will change by increasing and by (é+) in the case of leads and by decreasing by (e-) in the case of lag, and the late start and finish time of the previous activity becomes as follows:

$LF_a = LS_b - e$ (14) case lag

$LF_a = LS_b + é$ (15) case lead

$LS_a = LS_b + é - D_a$ (16)

$LS_a = LS_b - e - D_a$ (17)

When there is more than one activity subsequent to the current activity, we work by calculating the late times according to the type of relationship between this activity and the subsequent activity and choose the smallest calculated values.

2.13. Trade – off Between Time and Cost:

The time of project implementation is usually estimated at the time of the critical path of the network plan, and the urgent need may often arise to reduce the period of completion of the project for strategic Cost-time Trade – off , which means the possibility of exchanging cost and time for each stage or for the entire project. objectives, whether political or military, or to reduce some interim periods in order to accelerate the pace of production. We must emphasize that the time of normal achievement (Normal - Time) is offset by normal costs (Normal - Cost) as well as that the Crash time is offset by a high cost called Crash cost and the relationship between cost and time can be represented by linear or non-linear relationships as shown in the figure: (1), (Khalaf, 2022).

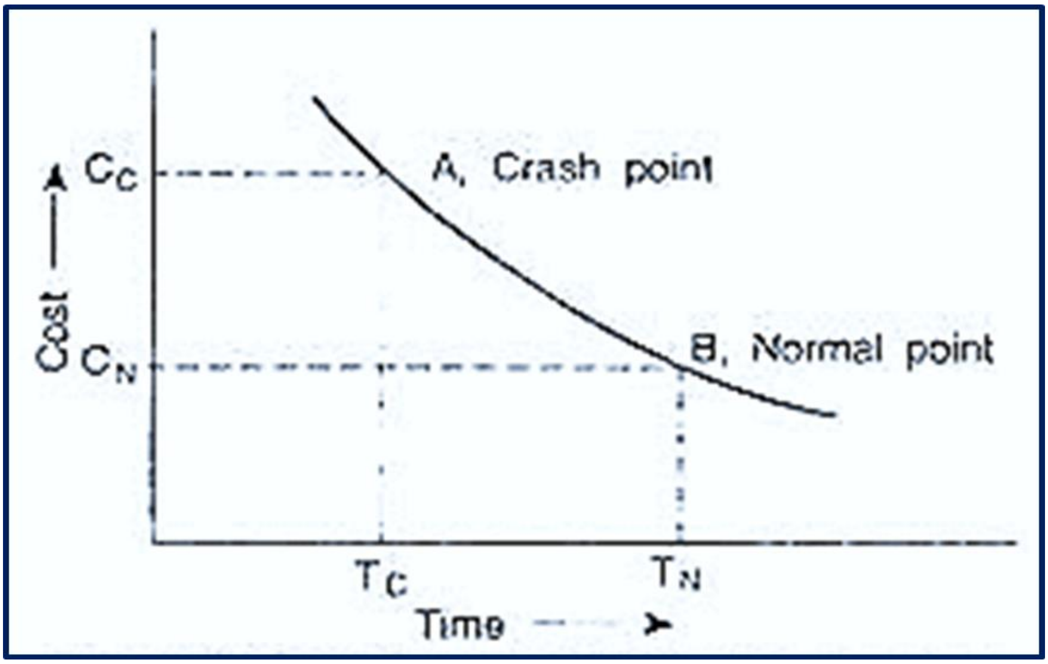

Figure 1: The relationship between cost and time

Using the mathematical formula for slope is:

$$(Slop) = \frac{Cc-Cn}{Tn-Tc} \quad (18)$$

3.Discussion of Results:

3.1. Karbala Metal Silo Project Data:

The State Company for Grain Trading is one of the companies of the Iraqi Ministry of Trade, which was established under Law No. (32) of 1939 and its tasks were a price bulletin and information on grain and under Law No. (199) in 1969 became formations of the General Organization for Grains, where it was previously called the General Authority for Grains and fragmented to become the State Company for Grain Trade and the interest of bakeries and ovens and the tasks of this company were to import grain (wheat) and barley) and grind them and distribute it to bakeries and ovens as well as manufacturing and distributing samoon through a network of agents and kiosks of the company spread throughout Iraq.

3.2. Data description:

The data was obtained through several reviews that started since 5/10/2022 for the General Company for Grain Trading / Karbala Mineral Silo to present their project and discuss the most important problems facing investment projects, especially the completion period of the Karbala Mineral Silo located in Karbala Governorate The problem of studying the case of this project was the delay in delivering the project on time due to their lack of use of modern and advanced methods to schedule the project, Table (1) represents a description of the timetable for the second part of the implementation by the executing authority of the project and according to the schedule of progress of the project The table below shows a summary of the data of the activities, periods and costs of the project, i.e. it begins with civil works and has been symbolized for its activities (A), mechanical works with activities (B), and electrical works with activities (C), for example, the first activity of civil works begins with activity (A1), which represents the preparation of the land for a period of 14 days, and the last activity is symbolized by (D1) for the last stage, which is the total examinations and the period of completion is 45 days.

Table 1: Represents data, past activities, subsequent activities, time and natural costs

No.	Activity Name	Activity Code	Previous Activity	Normal time (day)	Natural cost (Million Dinars)
	Civil Works	A			
1	Preparing the site and the land of the project, which includes planning and settlement with scraping the land, burying it, fixing dimensions and removing rubble	A1	-	14	100,000,000
2	Examinations, evaluation and treatment of test pillars	A2	A1	83	120,000,000
3	Excavation and casting of piles under the benzat	A3	A2	36	1,957,500,000
.					
.					
45	Initial Total Examinations	D1	C4,C5,C9,C13	46	64,000,000
Total					5,012,811,028

To know more periods and costs of activities, go to visit the research portal link listed below.
file:///C:/Users/intel/Downloads/Table1.pdf

3.3. Calculation of the total time to complete the Karbala Mineral Silo using the critical path method:

After determining the type of relationship between all project tasks and activities, the project completion time in the normal case should be calculated in terms of using mathematical equations to calculate the project completion time through forward calculations and backward calculation:

3.3.1. Forward Computation:

In order to find the critical path, the early start and early finish (ES, EF) of the activity must be calculated according to the use of mathematical equations for forward calculations, the relationship from the finish - start (FS) and the logical relationship (-Leads) and (+ lag) between the activities, begin with the first activity (the first point in time) in the network diagram of the project and end with the last activity or event (the last point in time) and the end of the time of the previous activity is the beginning of the time of the subsequent activity and when calculating the early finish of the subsequent activity, the activity time is added to the early start, taking into account the leads and lag in the calculations of the activities, and there are cases in which the event is associated with more than one activity When calculating them, we take the highest value, Table 2 is as follows:

Table 2: Forward calculations represent the existence of unconventional relationships between activities with the calculation of periods (leads and Lag)

No	Activity	Previous Activity	Activity Completion Time (Day)	Leads and Lag	Early Start (ES)	Early Finish (EF)
1	A1	A1	14	0	A1= 0	A1= 0 + 14 = 14
2	A2	A2	83	-5	A2= 14 -5 = 9	A2 =14-5+83 = 92
3	A3		36	-40	A3 =92 – 40 =52	A3 = 92 – 40 + 36 = 88
.	A4	A3, A4	46	0	A4 = 0	A4 = 0 + 46 = 46
.	A5	A5	10	-26	$A5 = \max_{A3,A4}\begin{cases}88-26=62\\46-26=20\end{cases}$	$A5 = MAX_{A3}\ 88-26+10 = 72$
45	D1	C4,C5,C9,C13	45	0	$D1 = Max_{c4,c5,c9,c13}\begin{cases}346\\264\\317\\351\end{cases}$	$D1 = \max_{C13} 351+45 = 396$

To learn more steps for forward calculations for periods of project activities, go to the Research Gate link listed below.
file:///C:/Users/intel/Downloads/ForwardTable2%20(1).pdf

3.3.2. Backward Computations:

These calculations calculate the late start (LS) and late Finish (LF) of project activities, these calculations determine the time of completion of the late activity That is, it starts at the end of the forward accounts of the project activities, meaning that it starts from the last event of the project network diagram and ends with the first event regressively. according to mathematical equations, we will show the calculations in the form of a table and start from the back, that is, activity D1 and with a relation (FS), the table below includes background calculations and there are cases where the event is related to more than one activity When calculating it we take the lowest value and according to the formula to calculate the next late Finish $LF_j = Min\{ES_i + D_{ij}$ as shown in the table above, the rendering and delay calculations were performed by reverse operation, i.e. taking a sign (+) for the rendering state and a sign (-) for the delay state as shown in the following table 3:

Table 3: Backward calculations in the presence of unconventional relationships between activities (lead and lag)

No	Activity	Previous Activity	Leads and Lag	Completion period of activity (day)	Late Finish (LF)	Late Start (LS)
45	D1		0	45	D1 = 396	D1 = 396 – 45 = 351
44	C13	D1	+15	5	C13 = 351	C13=351 -15-5=331
43	C12	C13	-25	10	C12=331	C12= 331 + 25 -10 =346
.						
.						
1	A1	A2	0	14	A1=14	A1=14-14=0

For more steps on backward calculations for activity periods, visit the Research Gate link listed below.
file:///C:/Users/intel/Downloads/BackwardTable3.pdf

3.3.3. Project Float Times Calculations:

When calculating early time and late times for project completion, float time and infloat times for project activities are now calculated by applying $(TF = LS_i - ES_i)$ or $(TF = LF_j - EF_j)$ In the completion of the Karbala Metal Silo Project, as in Table 4.

Table 4: the float times and infloat times for the activities of the Karbala Metal Silo Project

Activity	Previous Activity	Leads (-) and Lag (+)	Time required to complete the activity	ES	EF	LS	LF	Slack TF	CPM 1
A1		0	14	0	14	0	14	0	A1
A2	A1	-5	83	14	92	14	92	0	A2
A3	A2	-40	36	92	88	92	88	0	A3
.									
.									-
D1	C4,C5,C9,C13	0	45	351	396	351	396	0	D1

To learn more float time calculations for all project activities in Table 4, go to visit the Research Gate link listed below. file:///C:/Users/intel/Downloads/Table4floattimes%20(1).pdf

Table 5: shows the following activities whose float times are equal to zero, which are considered critical activities, and therefore these activities are the critical path for the completion of the project and their activities do not bear any delay in the implementation and according to the network plan of the project and calculations of float times, and the critical path consists of 14 activities represented as follows:

$CPM = A1, A2, A3, A9, A10, A11, A13, A14, B3, B4, B8, C10, C13, D1 = 396\ Days$

Table 5: represents the activities of the critical path for the completion of the Karbala Metal Silo Project

Activity	Previous Activity	Leads (-) and Lag (+)	Time required to complete the activity	ES	EF	LS	LF	Slack TF	CPM 1
A1		0	14	0	14	0	14	0	A1
A2	A1	-5	83	14	92	14	92	0	A2
A3	A2	-40	36	92	88	92	88	0	A3
A9	A3,A4	+7	10	88	105	88	105	0	A9
A10	A9	-7	35	105	133	105	133	0	A10
A11	A10	0	30	133	163	133	163	0	A11
A13	A11	-9	80	163	234	163	234	0	A13
A14	A13	-66	30	234	198	234	198	0	A14
B3	A14	-135	180	198	243	198	243	0	B3
B4	B3	-49	60	243	254	243	254	0	B4
B8	B4	+17	91	254	362	254	362	0	B8
C10	B7,B8	-46	15	362	331	362	331	0	C10
C13	C10,C11, C12	+15	5	331	351	331	351	0	C13
D1	C4,C5,C9 ,C13	0	45	351	396	351	396	0	D1

3.3.4. Project network draw:

The network diagram drawn by the researcher shows in the business network the completion of the Karbala metal silo in its natural time with the identification of critical path (CPM) and non-critical activities according to the above activities and relationships and as shown in Figure (2) of the network diagram.

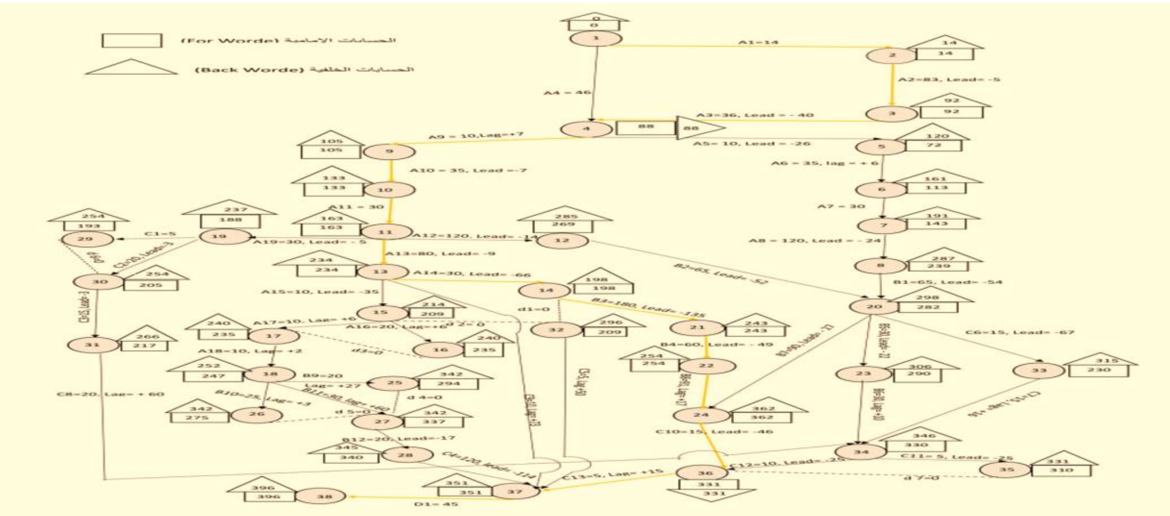

Figure 2: the network plan for the completion of Silo Karbala metal project for natural periods

3.3.5. Discussion of the results of front and back accounts:

By completing the front and back calculations, as well as calculating the surplus time for all project activities, the researcher found the following points:

First: Through the front and back calculations of the second phase of the implementation of the project, the researcher created the time required to complete the project by determining the critical path is 396 days.

Second: The researcher found some non-critical activities in the sense that they have great flexibility and have importance that gives the project management permission to direct financial and technical resources to the implementation plan of other activities.
Third: The researcher found that the importance of float for some non-critical activities gives the project management tolerance towards the financial resources allocated for their implementation by directing their use in the implementation of other more important activities.
Fourth: During the front and back calculations of the project, the researcher found one path for critical activities, including the following:
$CPM = A1, A2, A3, A9, A10, A11, A13, A14, B3, B4, B8, C10, C13, D1 = 396\ Days$
Fifth: The researcher found through the results that there are joint activities located on the critical path due to the nature of the sequential project activities.

3.4. The trade-off between time and cost and the possibility of reducing the completion period of the Karbala metal silo project.

The process of trade-off between time and cost to reduce the completion period of the project results in two cases, either reducing the time and cost of the project or reducing the time with the high cost of the project, Where the period of (396) days, which was determined from the critical path of the network plan in its normal state, was determined by the completion period of (396) days at a cost of (5,012,811,028) five billion twelve million eight hundred and eleven thousand and twenty-eight Iraqi dinars, to the researcher reduced the completion time of the project (307) days also determined by this period the implementation of the project is the critical path of the accelerated network plan and the cost of acceleration is estimated (5,043,894,328) Iraqi dinars, this is the process of switching between time and cost depends on a normal time corresponding to a normal cost as well as crash time offset by the crash cost, the critical path (CPM) was extracted for a period of (307) days at a total cost of (5,043,894,328) dinars, that is, when the normal period was (396) days, the cost was (5,012,811,028) dinars, the critical path of the project was extracted within a period of (307) days. Table (6) also shows the normal and crash times and normal and crash costs of the critical track activities for the implementation of the project.

Table 6: Represents critical path activities in normal times, accelerated times, natural costs, and accelerated costs for the implementation and completion of the project.

NO.	Critical Path Activities	Normal time (day) (NT)	Crash Time (in day) (CT)	Pressure duration (in day) (ΔT)	Normal Cost (Iraqi Dinar) (NC)	Crash Cost (Iraqi Dinar) (CC)	Pressure cost (IQD)	slop(IQD) (σ)
1	A1	14 days	10 days	4 days	100,000,000	102,000,000	2,000,000	500,000
2	A2	83 days	75days	8 days	120,000,000	122,000,000	2,000,000	250,000
3	A3	36 days	36 days	0	1,975,500,000	1,975,500,000	0	0
4	A9	10 days	7 days	3 days	143,875,000	144,875,000	1,000,000	333,333
5	A10	35 days	20 days	15 days	163,500,000	165,500,00	2,000,000	133,333
6	A11	30 days	25 days	5 days	105,000,000	106,000,000	1,000,000	200,000
7	A13	80 days	60 days	20 days	50,000,000	54,000,000	4,000,000	200,000
8	A14	30 days	20 days	10 days	140,400,000	143,400,000	3,000,000	300,000
9	B3	180 days	140 days	40 days	50,000,000	55,000,000	5,000,000	125,000
10	B4	60 days	50 days	10 days	62,000,000	65,000,000	3,000,000	300,000
11	B8	91 days	65 days	26 days	29,000,000	32,000,000	3,000,000	115,384
12	C10	15 days	10 days	5 days	90,000,000	92,000,000	2,000,000	400,000
13	C13	5 days	1 days	4 days	1,000,000	1,500,000	500,000	125,000
14	D1	45 days	30 days	15 days	64,000,000	64,000,000	0	0

$CPM = A_1, A_2, A_3, A_9, A_{10}, A_{11}, A_{13}, A_{14}, B_3, B_4, C_8, C_{10}, C_{13}, D_1 = 307 Days$

3.5. Calculation of project completion time using MS-Project:

The program was used to find the time and cost of completing the Karbala Metal Silo project (Silo) in normal conditions first, and the duration of the completion of the project axis reached (396) working days and a cost of (5,012,811,028) dinars but in crash conditions, the project completion period reached (307) days, That is, reducing the normal time to complete the project is 89 days, which is the last time in which the project can be completed, as the project cannot be compressed less than this time Where the cost of compressing the time of activities amounting to 31,083,300 million dinars will be added to the total normal cost of completing the project in 396 days, amounting to 5,012,811,028 billion dinars, bringing the total cost of the project after compressing some critical activities to 5,043,894,328 billion dinars. or more and after conducting mathematical calculations to exchange the project time for the costs given to the researcher by the beneficiary department of the project, to learn more about the project grid in the MS-Project software, go to the Research Portal link listed below.
file:///C:/Users/intel/Downloads/NetworkchartinMSProject.pdf

3.6. Project cost scheduling by early start time (ES) and late start time (LS):

The researcher considered that the process of scheduling costs according to the method of early times (ES) and late times (LS), in order to help decision makers in the project to find optimal formulas so that the available material resources are distributed, and expressed in monetary units. According to the data given to the researcher. Table 7: shows the cost of activities per day and according to the duration of each activity, for example, starting from activity A1, whose total completion cost is (100,000,000) for a period of (14) days, and its daily cost is (7,142,857) Iraqi dinars, and ends with the last activity, which is D1, and the total cost of its completion is (64,000,000) for a period of (45) days, and the cost of one day is (1,422,22) dinars.

Table 7: The represents division of costs and activities according to the number of time units for the completion of the Karbala metal silo project

No.	Activity Name	Activity Code	Previous Activity	Normal time (day)	Natural cost (Million Dinars)	Cost per day (million)
1	Preparing the site and the land of the project, which includes planning and settlement with scraping the land, burying it, fixing dimensions and removing rubble	A1	-	14	100,000,000	7,142,857
2	Examinations, evaluation and treatment of test pillars	A2	A1	83	120,000,000	1,445,783
3	Excavation and casting of piles under the benzat	A3	A2	36	1,957,500,000	54,375,000
.						.
45	Initial Total Examinations	D1	C4,C5,C9 ,C13	45	64,000,000	1,422,222
Total					5,012,811,028	

To find out more about the costs of project activities per day, go to the Research Gate link listed below.
file:///C:/Users/intel/Downloads/Table7.pdf

3.6.1. Cost distribution detection counter according to early start time (ES):

A table is prepared that includes all the necessary data for the preparation and organization of the cost distribution statement of activities according to the early times (ES) that have been calculated as shown in Table 8. The researcher shows the distribution of costs within the time of early start with the calculation of the relationship of submission and delay of activities and taking into account the time limit of 396 days.

Table 8: The represents distribution of costs by early start time (ES) for the completion of the Karbala Metal Silo Project

no	Activity Name	Activity Code	Normal time (day)	Natural cost (Million Dinars)	Cost per day (million)	Early Times (ES)
1.	Preparing the site and the land of the project, which includes planning and settlement with scraping the land, burying it, fixing dimensions and removing rubble	A1	14	100,000,000	7,142,857	0
2.	Examinations, evaluation and treatment of test pillars	A2	83	120,000,000	1,445,783	9
3.	Excavation and casting of piles under the benzat	A3	36	1,957,500,000	54,375,000	52
4.	Silo schemes and approval	A4	46	150,000,000	3,260,869	0
5.	Earthworks with burial under the foundations of benzan and pouring the blinding layer Benzat group with moisture blocker coating (A)	A5	10	143,875,000	14,387,500	62
6.	Concrete racking casting for benzat(A)	A6	35	163,500,000	4,671,428	78
7.	Pouring concrete columns(A)	A7	30	105,000,000	3,500,000	113
8.	Concrete Hopper Casting (A)	A8	120	216,000,000	1,800,000	143
9.	Earthworks with burial under the foundations of the benzan and pouring the blinding layer Benzat group with moisture blocker coating (B)	A9	10	28,875,000	2,887,000	95
10.	Concrete racking casting for benzat(B)	A10	35	163,500,000	4,671,428	98
11.	Pouring concrete columns(B)	A11	30	105,000,000	3,500,000	133
12	Concrete Hopper Casting (B)	A12	120	216,000,000	1,800,000	149
13.	Excavation, burial and withdrawal of groundwater	A13	80	50,000,000	625.000	154
14.	Concrete pouring works for the operating room and tunnels	A14	30	140,400,000	4,680,000	168
15.	Casting works of the upper transverse conveyor tunnel, depth of 12 m	A15	10	48,600,000	4,860,000	199
16.	Concrete works for train and truck receiving slots	A16	20	26,000,000	1,300,000	215
17.	Pouring concrete foundations silo loading	A17	10	8,000,000	800,000	215
18.	Concrete works for pouring the yards surrounding the operating rooms	A18	10	86,400,000	8,640,000	237
19.	implementation of the electricity building	A19	30	20,000,000	666,666	158
20.	Erection and tightening of metal benzat for line A	B1	65	40,000,000	615,384	185
21.	Erection and tightening of metal benzat for line B	B2	65	40,000,000	615,384	217

22.	Manufacture and installation of the steel structure of the operating room	B3	180	50,000,000	277,777	63
23.	Processing and installation of grain cranes	B4	60	62,000,000	1,033,333	194
24.	Installation and inspection of screening machines	B5	30	10,000,000	333,333	260
25.	Tightening, erecting and checking the dust system	B6	30	20,000,000	666,666	300
26.	Tightening and erecting the upper vector group	B7	90	40,000,000	444,444	255
27.	Tightening and erecting the lower vector group	B8	91	29,000,000	318,681	271
28.	Processing and tightening the metal shed over the receiving holes	B9	20	20,000,000	1,000,000	274
29.	Hydraulic tipper installation and inspection	B10	25	95,000,000	3,800,000	250
30.	Installation of loading silos with telescope hose	B11	30	24,000,000	800,000	307
31.	Packaging of the operating building with the blond Wig Panel	B12	20	30,720,000	1,536,000	320
32.	Laying of high and low voltage power line and control lines	C1	5	30,000,000	6,000,000	188
33.	Equipping, erecting and checking lighting poles	C2	20	12,000,000	600,000	185
34.	Equipping, installing and inspecting generators	C3	15	280,000,000	18,666,666	202
35.	installation and inspection of the control room and connecting of processing and control cables	C4	120	30,000,000	250,000	226
36.	Equipping, erecting and inspection of submersibles	C5	5	6,000,000	1,200,000	259
37.	Tightening and Temperature Monitoring System for Benz	C6	15	10,000,000	666,666	215
38.	Tightening and erecting the air system	C7	15	18,000,000	1,200,000	246
39.	Works and installation of electronic scale calibration	C8	20	30,000,000	1,500,000	277
40.	Works of lightning and ground arrester system	C9	10	5,250,000	525,000	307
41.	Installation, tightening and inspection of an electric elevator for people	C10	15	90,000,000	6,000,000	316
42.	erected switchboard communications cameras	C11	5	6,000,000	1,200,000	305
43.	Internal and external lighting installation works	C12	10	6,191,028	619,102	305
44.	Installation of a grain sterilizer	C13	5	1,000,000	200,000	346
45.	Initial Total Examinations	D1	45	64,000,000	1,422,222	351
Total				5,012,811,028		

A statement of costs is prepared according to the early start of each project activity, represented by the table listed in the Research Gate link, taking into account the activity period according to the (ES) method listed, in order to calculate the cumulative costs for each day of the project activities period, and to know the disclosure data, visit the cumulative costs link in the (ES) method.
https://www.researchgate.net/publication/373361800_hsabat_alklf_btryqt_ES

3.6.2 Preparation of a statement for calculating costs according to the late start time (LS):

The cost of the activities is calculated according to the adjusted late start time (LS)¯) and is obtained through the following mathematical relationship:

$TF = LF - D - ES$

$\overline{LS} = ES + TF$

Table 9: shows all the data required to calculate the cost allocation process by late start time (LS) and based on the critical path time limit of 396 days.

Table 9: shows all the data required to calculate the cost distribution process according to the late start time (LS**)**

no	Activity Name	Activity Code	Normal time (day)	Natural cost (Million Dinars)	Cost per day (million)	Early Times (ES)	TF	Late Start Time(LS)
1.	Preparing the site and the land of the project, which includes planning and settlement with scraping the land, burying it, fixing dimensions and removing rubble	A1	14	100,000,000	7,142,857	0	0	0
2.	Examinations, evaluation and treatment of test pillars	A2	83	120,000,000	1,445,783	9	0	9
3.	Excavation and casting of piles under the benzat	A3	36	1,957,500,000	54,375,000	52	0	52
4.	Silo schemes and approval	A4	46	150,000,000	3,260,869	0	42	42
5.	Earthworks with burial under the foundations of benzan and pouring the blinding layer Benzat group with moisture blocker coating (A)	A5	10	143,875,000	14,387,500	62	48	110
6.	Concrete racking casting for benzat(A)	A6	35	163,500,000	4,671,428	78	48	126
7.	Pouring concrete columns(A)	A7	30	105,000,000	3,500,000	113	48	161
8.	Concrete Hopper Casting (A)	A8	120	216,000,000	1,800,000	143	24	167
9.	Earthworks with burial under the foundations of the benzan and pouring the blinding layer Benzat group with moisture blocker coating (B)	A9	10	28,875,000	2,887,000	95	0	95
10.	Concrete racking casting for benzat(B)	A10	35	163,500,000	4,671,428	98	0	98
11.	Pouring concrete columns(B)	A11	30	105,000,000	3,500,000	133	0	133
12	Concrete Hopper Casting (B)	A12	120	216,000,000	1,800,000	149	16	165
13.	Excavation, burial and withdrawal of groundwater	A13	80	50,000,000	625.000	154	0	154
14.	Concrete pouring works for the operating room and tunnels	A14	30	140,400,000	4,680,000	168	0	168
15.	Casting works of the upper transverse conveyor tunnel, depth of 12 m	A15	10	48,600,000	4,860,000	199	5	204
16.	Concrete works for train and truck receiving slots	A16	20	26,000,000	1,300,000	215	5	220
17.	Pouring concrete foundations silo loading	A17	10	8,000,000	800,000	215	15	230
18.	Concrete works for pouring the yards surrounding the operating rooms	A18	10	86,400,000	8,640,000	237	5	242
19.	implementation of the electricity building	A19	30	20,000,000	666,666	158	49	207

20.	Erection and tightening of metal benzat for line A	B1	65	40,000,000	615,384	185	48	233
21.	Erection and tightening of metal benzat for line B	B2	65	40,000,000	615,384	217	16	233
22.	Manufacture and installation of the steel structure of the operating room	B3	180	50,000,000	277,777	63	0	63
23.	Processing and installation of grain cranes	B4	60	62,000,000	1,033,333	194	0	194
24.	Installation and inspection of screening machines	B5	30	10,000,000	333,333	260	16	276
25.	Tightening, erecting and checking the dust system	B6	30	20,000,000	666,666	300	16	316
26.	Tightening and erecting the upper vector group	B7	90	40,000,000	444,444	255	17	272
27.	Tightening and erecting the lower vector group	B8	91	29,000,000	318,681	271	0	271
28.	Processing and tightening the metal shed over the receiving holes	B9	20	20,000,000	1,000,000	274	48	322
29.	Hydraulic tipper installation and inspection	B10	25	95,000,000	3,800,000	250	67	317
30.	Installation of loading silos with telescope hose	B11	30	24,000,000	800,000	307	5	312
31.	Packaging of the operating building with the blond Wig Panel	B12	20	30,720,000	1,536,000	320	5	325
32.	Laying of high and low voltage power line and control lines	C1	5	30,000,000	6,000,000	188	61	249
33.	Equipping, erecting and checking lighting poles	C2	20	12,000,000	600,000	185	49	234
34.	Equipping, installing and inspecting generators	C3	15	280,000,000	18,666,666	202	49	251
35.	installation and inspection of the control room and connecting of processing and control cables	C4	120	30,000,000	250,000	226	5	231
36.	Equipping, erecting and inspection of submersibles	C5	5	6,000,000	1,200,000	259	87	346
37.	Tightening and Temperature Monitoring System for Benz	C6	15	10,000,000	666,666	215	85	300
38.	Tightening and erecting the air system	C7	15	18,000,000	1,200,000	246	85	331
39.	Works and installation of electronic scale calibration	C8	20	30,000,000	1,500,000	277	49	326
40.	Works of lightning and ground arrester system	C9	10	5,250,000	525,000	307	34	341
41.	Installation, tightening and inspection of an electric elevator for people	C10	15	90,000,000	6,000,000	316	0	316
42.	erected switchboard communications cameras	C11	5	6,000,000	1,200,000	305	21	326
43.	Internal and external lighting installation works	C12	10	6,191,028	619,102	305	16	321
44.	Installation of a grain sterilizer	C13	5	1,000,000	200,000	346	0	346
45.	Initial Total Examinations	D1	45	64,000,000	1,422,222	351	0	351
Total				5,012,811,028				

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A statement of costs is prepared according to the late start of each project activity, represented by the table listed in the Research Gate link, taking into account the period of activity according to the method of (LS) listed, and then the accumulated costs for each activity were calculated. For more information, please visit the link below.
https://www.researchgate.net/publication/373361806_hsabat_alklf_btryqt_LS

3.6.3. Distribution of cumulative costs graphically by early and late start time:

Figure (3) shows the distribution of cumulative costs graphically and on the method of calculating early and late start times, taking into account the identification of the area of financial differences or (financial savings), which are the gaps between the accumulation of costs by the method of (ES) and (LS) that exceed the limits of maneuver or financial movement of the contractor, and that the area located in the middle of the curve represents the amount of financial differences that can be obtained using the method of distributing costs or financial expenses has extracted three gaps, the first gap from day (10) to day (50), the second gap from day (90) to day (200) and the third gap from day (200) to day (340) and these are the financial savings that the contractor can maneuver in terms of costs.

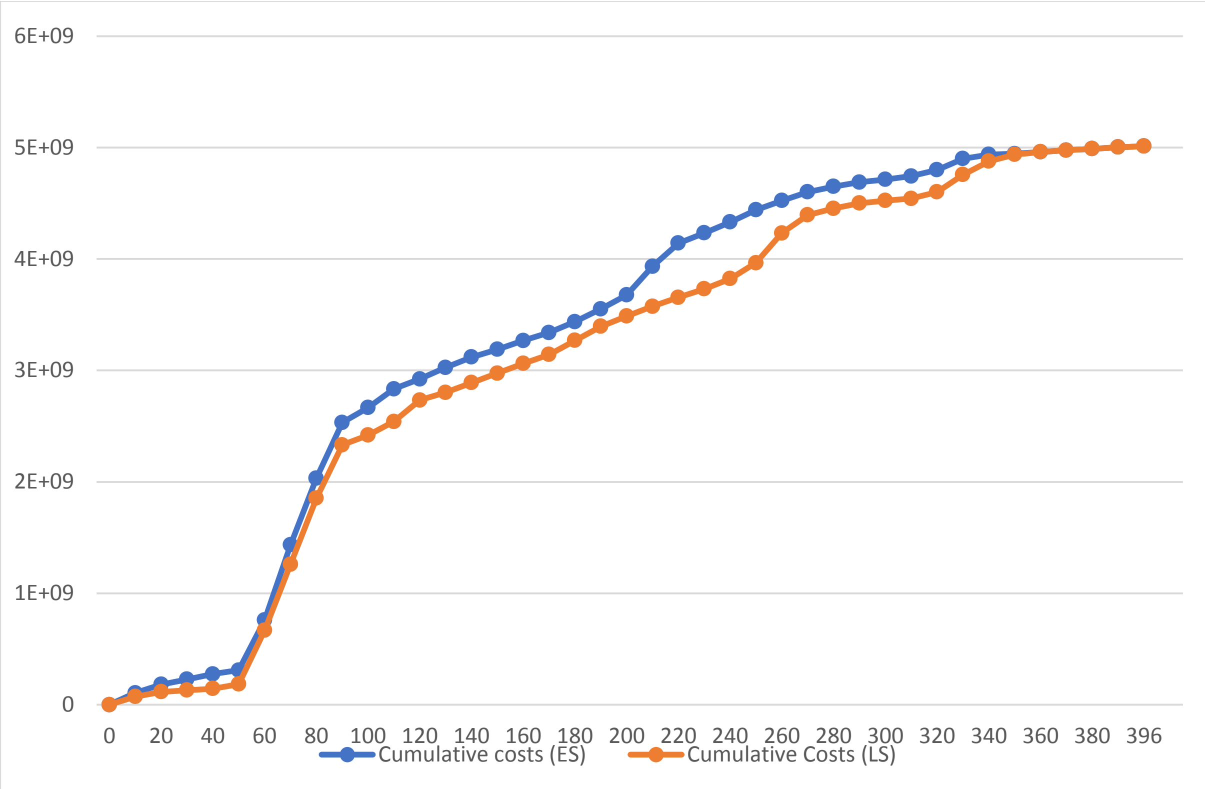

Figure 3: shows the distribution of cumulative costs graphically and on the method of calculating early and late start times

3.6.4. Finding the difference between the cumulative costs (financial savings) of the costs of the project activity:

By determining the financial savings from Figure (3), Table 10: is prepared for the difference between the cumulative costs according to the distribution at the time of early start (ES) and the distribution according to the time of late start (LS), which represents these financial savings similar to the free loans that benefit the company executing the project at the beginning of the implementation of the project, when cash is needed. It is clear from Table 10 above that the last field from the left shows the financial differences through which the contractor obtains if they are adopted according to the late start method, and there are days when high and low financial savings appeared, from the first day to the day 206 and then from the day 207, the abundance began to increase and be at a value of (308,375,718) dinars until the day 258 and a value of (322,182,114) and then began to decrease until 396 and here the table of the amount of financial savings with the addition of the previous tables represents the basic base on which the contractor or decision-maker relies in order to rationalize the use of financial resources available to him, as it leads to achieving the best results in scheduling the project costs.

Table 10: The calculation of amount of financial savings

Time (day)	Cumulative costs by distribution under early start time (ES)	Cumulative costs by distribution under Early Start Time (LS)	Difference (financial savings)
1.	10,412,726	7,142,857	3,269,869
2.	20,816,452	14,285,714	6,530,738
3.	31,220,178	21,428,571	9,791,607
.			
.			
396	5,012,819,552	5,012,815,592	3960

To find out more from Table 10 go visit the Research Gate link listed below.
file:///C:/Users/intel/Downloads/Table10AmountofFinancialSavings.pdf

3.6.5. Discussion of the results of the calculations Cost distribution for early start time (ES) and late start time:

The researcher found several points through the completion and completion of the calculations of the distribution of costs of activities in the manner of (ES, LS) for all project activities and the calculation of financial abundance for each day between the two methods as follows:

First: the researcher found the cumulative costs per day for each activity for the distribution of costs by the early start time (ES) method and the late start method (LS) and the basis of the time limit for the completion of the project, which amounted to 396 days, and this facilitates the process of calculating financial savings between project activities.

Second: the researcher found that during the financial differences (financial savings), the contractor can maneuver financially during the work between the project activities in the accounts by the delayed start method (LS), for example, on day 242, the value of the abundance is (520,838,516).

Third: the researcher found that during the calculations of the front and rear costs of the project, it is a basic rule for decision-making that the contractor relies on in order to rationalize the use of financial resources between the available project activities to achieve the best results.

4. Conclusions:

The most important conclusions reached by the Karbala Metal Project, which were reached are as follows:

1.The importance of using modern methods such as the critical path method (CPM) in reducing the completion time of the Karbala Metal Silo project, where the project completion period was reduced using the critical path method and reduced from (396) days, which is the actual time of the project to (307) days.

2.The researcher found some non-critical activities that have great flexibility and are important that give the project management permission to direct financial and technical resources to plan the implementation of other activities. Project management also directs funds allocated for its implementation in the direction of their use in the implementation of other, more important activities.

3.The researcher concluded that the cumulative daily costs of each activity to distribute the costs at the time of early start (ES) and the method of late start (LS), and the basis of the time limit for the completion of the project is 396 days.

4.The calculations theoretically coincide with the "equations with the exact results of the program" where the duration of the completion of the project in the normal state is (396) days.
5.The researcher concluded that the cumulative daily costs for each activity to distribute the costs by the early start time (ES) and the late start method (LS), and the basis of the time limit for the completion of the project is 396 days.
6.The researcher concluded when accelerating project activities that there is an inverse relationship between time and cost, that is, the shorter the duration of the project, the higher the total cost, and this is the process of exchanging time for cost.

Authors Declaration:
Conflicts of Interest: None
-We Hereby Confirm That All The Figures and Tables In The Manuscript Are Mine and Ours. Besides, The Figures and Images, Which are Not Mine, Have Been Permitted Republication and Attached to The Manuscript.
- Ethical Clearance: The Research Was Approved By The Local Ethical Committee in The University.

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CPM لجدولة المشروع: دراسة حالة في صومعة كربلاء المعدنية

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مستخلص البحث:
يتطلب تطبيق مفهوم جدولة المشاريع في مشاريع الشركة العامة لتجارة الحبوب بصورة عامة الى مجموعة اجراءات ومتطلبات، وهي فهم ومعرفة الادوات والتقنيات والتي تسمى اساليب جدولة المشاريع، وتأخر مشروع انجاز صومعة كربلاء المعدني في محافظة كربلاء المقدسة هي عدم استخدام الأساليب والتقنيات الحديثة في التنفيذ، لذا سعى البحث الى تقديم استخدام جدولة المشاريع باستعمال أحد الاساليب العلمية المتطورة التي اثبتت مدى قدرتها على جدولة اي مشروع وامكانيتها في مبادلة بين الوقت والكلفة لانجاز المشروع. والهدف من البحث هو إيجاد وقت وكلفة اكمال مشروع الصومعة في الوقت الطبيعية والتعجيلية باستخدام المسار الحرج (CPM) والذي سيعمل على سهولة تسويق الحنطة المحلية من الفلاح وتصديرها الى المطاحن، حيث تم استخدام برنامج لتخطيط المشاريع (MS-Project) لأيجاد المسار الحرج، أيضا تم استعمال أسلوب توزيع الكلف وفق طريقة وقت الابتداء المبكر (ES) والمتأخر (LS) لحساب عملية توزيع كلف أنشطة المشروع وتحديد منطقة الوفورات المالية عند تنفيذ أنشطة المشروع. بينت النتائج المستحصلة أهمية (CPM) وكفاءته في جدولة المشروع حيث تم اكمال المشروع في الظروف الطبيعية ب 396 يوم وكلفة كلية 5,012,811,028 دينار عراقي، اما عند تعجيل الأنشطة فان وقت اكمال المشروع كان في 307 يوم وبكلفة كلية هي 5,043,894,328 دينار، وأثبتت النتائج أيضا ان استعمال أسلوب توزيع الكلف وفق طريقة الابتداء المتأخر(LS) ساعد متخذ القرار على تحديد منطقة الوفرة المالية وحدود المناورة المالية التي يستطيع القيام بها اثناء اكمال أنشطة المشروع

المصطلحات الرئيسة للبحث: (جدولة المشروع، طريقة المسار الحرج، المفاضلة بين الوقت والتكلفة، جدولة الكلف)

***البحث مستل من رسالة ماجستير**