

Computer Aided Planning for Optimization of Project Cost

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التخطيط المعان بالحاسوب لأمثل كلفة للمشروع

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الخلاصة:

أن الغرض من هذا البحث هو دراسة استراتيجية طريقة المسار الحرج CPM في عمليات التخطيط وبناء مشروع للمياه النقية بمساعدة الحاسوب (PDWP) لأجل الوصول إلى أمثل وقت وبأقل كلفة لأنجاز وتنفيذ المشروع وتصميم وبناء نظام ويساعد مدير المشروع باتخاذ القرارات ودراسة وتحليل فعاليات المشروع خلال جميع مراحل المشروع للحصول على أعلى الأرباح وبأقل التكاليف عن طريق بناء وحدات نمطية تحتوي على الفعاليات و الموارد الحرجة التي تؤثر على إ نجاز المشروع في الوقت الطبيعي أو المعجل باستخدام طريقة مبادلة الوقت بالكلفة

1- Abstract

The purpose of this research is to studying the CPM strategic planning process for development of pure drinking water project (PDWP) in order to get the optimum time at minimum total cost to complete implementation of project and designing and developing computer aided system, which enables the project manager to make the decision , study and analyses the value of project activity during all phases of project so as to reach the maximum benefit and minimum cost planning. This was achieved by developing modules that allow assessing activities and resources that may be critical through drawing project network, and may affect the project career and its finish date at normal and crash time to perform crashing analysis in effective method by using time cost trade off.

Key word: CAP for (PDWP) Project

1- Introduction

To day project engineering management faces many challenges due to the increased complexity and variety of projects. Successful project management demands that the project meets technical objectives and be completed on schedule and within budget. To ensure success, a well-organized project planning system must be designed, developed and implemented to provide management with timely and accurate feed back on actual usage of resource for comparison to target objectives which were established during the planning. The need for continuous control of time, cost and performance of projects to satisfy clients needs, give rise to the search for new concepts in project engineering management. The scheduling problem is essentially one of finding that project duration that minimizes their sum or finding the optimum point in a time cost trade off. The researcher studied Zulal project produced by Al- Mansoor Company, Which is produce pure drinking water at capacity $5\text{m}^3/\text{hr}$.

The unit of pure drinking water consist of the sand fliter, active carbon filter , 1M filter , 0.45 M filter , ultra violet radiation (U/V) system , delay tank, ozone system.

1-2 Literature Review

-*Bernard, CM Fong (2004)*:-The researcher identifies how risks like security,market saturation and system reliability can be minimized by proper planning and how planning implemented in CPM network and also describes how to detect any changes in the market place so that effective measures can be made to avoid dropping out from competition [5].

- *Kala, C. Seal (2004)*:- describes generalized PERT/CPM implementation in a spreadsheet the sheet describes the implementation of traditional PERT/CPM algorithm for finding the critical path in a project network in a spreadsheet [7].

Shenhar, Aaron, J. (2002):- the research summarizes the higher levels of project success and describes the meaning of project success, the nature of fundamentally different types of project, their technological content, nature of project work for best chance of project success by “optimizing success by matching management style to project type” [12].

-*Mohammed, Salem Mohammed (2000)*:- The researcher applies network analysis to perform the main management function in project (planning, scheduling, controlling) and design automated information system that deals with time and real cost and resources used to execute all the activities in the project [18].

- *Abdul Salam, Sarhid (1991)*: - The researcher describes and studies the level of indirect costs in building project. The aim of study is to determine the relationship between direct and indirect cost using static methods [19].

1-3 Research Problem

The importance of the project appears through the fact that it is essential in constructing pure drinking water project in Iraqi is the availability of raw water, rising up of the citizens economic level and more well cultural and health knowledge in the value of the importance of bottled pure drinking water. Moreover the developed system Pure Drinking Water Project managing (*PDWP*) is considered a tool that helps in managing the construction of service projects that provides pure drinking water for people at efficient and easy way to computerize system for project managers to meet project goals and make the good and fast decisions with focus on time, resource and minimum cost fluctuation.

1-4 Aim of the Research

The research aims in developing an automated system for the design of computer aided planning to meet project goals and make the good and fast decisions with focus on time, resource and minimum cost fluctuation. for civil work of pure drinking project development.

1-5 The Metrology of the research to the reach the objectives are:-

1-Studying the CPM strategic planning process for planning and development of pure drinking water project in order to get the optimum time at minimum total cost to complete implementation of project.

2-Designing and developing a system, which enables the project manager to studies and analyses the value of project activity during all phases of project, so as to reach the maximum benefit and minimum cost planning.

2- Theoretical Concept:-

2 -1 Time Cost Trade off / Minimum Project Cost Scheduling:

Time-cost trade off an approach to project scheduling that enables the project manager to add resources of selected activities in order to reduce activity times , since adding recess, such as more workers , overtimes must take into account these added costs[1]. The impetus to shorten project may reflect efforts to avoid late penalties, to take advantage of monetary incentives for timely or early completion of project or to free resources for use on other projects.

Each activity of project consumes some resources and hence has cost associated with it. In some cases cost of an activity will vary to some extent with the amount of time consumed by activity [2].

The cost of total project, which is the aggregate of activity cost ,well also depend up on project duration time. Thus by increasing the cost, the project duration can be cut down to some extent this is called time cost trade off Figure (1)[3].

The planner aim is always to strike a balance between the costs and time, to obtain an optimum project schedule. An optimum project schedule implies lowest possible cost and minimum possible time for the project as shown in Figure (2). The total cost of any project consists of the direct and indirect costs involved in its execution [4].

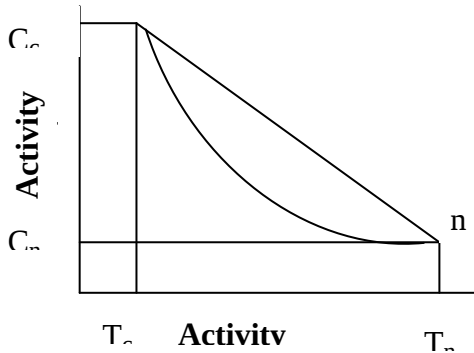
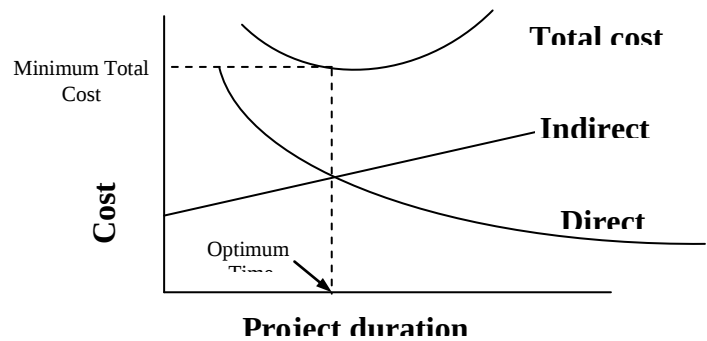


Figure (1) Activity time cost relation



Figure(2) Project time-cost relation

The sum of the direct and indirect costs gives the total project cost. As the direct cost decreases with time and indirect cost increases with time, the total project cost curve will have a point where the total cost will be minimum Figure (2)[5]. The time corresponding to this point is called optimum duration time and cost. The duration of a project can sometimes be reduced by shifting the resource (people, equipment, or money) from activities that have excess free float to critical activities that constrain the project's completion[7] [6].

For most projects there are calendar dates for beginning and ending the project. These milestones become goalposts for measuring the success of the project. It is the responsibility of the project management is to find the necessary unlimited resource and utilize them to achieve the goals of the project, including this schedule dates[8] .

By using the logic and duration developed in the initial development of the schedule, it is possible to identify the resource that will be used in each activity and to develop an assessment of the total resource on a daily basis, that will be required based on the activities beginning in their early start dates and late start dates. This process is known as, resource loading [9] [10].

The scheduler can use this data to determine the day-by-day requirements for particular types of resources on activities and provide a format that will identify the plan to be in progress on a particular days [11] [12].

3- Design and Development and Practical Application of Computer Aided System for Project Planning of Pure Drinking water (PDW)

3-1 System Development

The researcher begins developing (PDWP) system program by designing all its graphical elements including screen, sheets, menus, message boxes and table...etc. The system consists of the following modules as shown in Figure (3)

3-1-1 Activities Critical Analysis Module:

The detail of this module is shown in Figure (4).

The input database as the activity code, activity description, activity precedence, activity duration, activity cost at normal and crash time as shown in Figure (5)

This module of the system is executed through the following steps:-

-Calculate Earliest Start time EST, Earliest Finish time EFT by using, Latest start time LST, Latest Finish Time LFT, Total float (TF), Free Float (FF) by using following formula [1] as shown in Figure (6)

$$ES_1 = ES_0 + D_{01} \text{-----}(1)$$

$$ES_j = \max(ES_i + D_{ij}) \text{-----}(2)$$

$$EF_i = ES_i + D_{ij} \text{-----}(3)$$

$$LS_i = \min(LF_j - D_{ij}) \text{-----}(4)$$

$$TF_i = LS_j - ES_i \text{-----}(5)$$

$$FF_i = ES_j - EF_i \text{-----}(6)$$

An activity (i , j) lies on the critical path if it is satisfies the following three condition.

$$ES_i = LS_i , \quad ES_j = LS_j \text{-----}(7)$$

-Calculate total direct cost of project, total project completion time and draw the network and Cantt chart at normal as shown in Figure (7) and Figure (8).

3-1-2 Activity Crash Analysis /Time- Cost Trade off Module:-

This module is executed by crashing each critical activity until the compression limit and performs crashing analysis of project by the input data activities code, activities description, normal time (T_n), crash time (T_c), normal cost (C_n), crash cost (C_c), normal resource rate (R_n), crash resource rate (R_c) as shown in Figure (8).

The output execution steps of this module are as follows:-

- Specify critical path and critical activity.
- Calculate cost slop of critical activity (m) by applying the following formula [3].

$$m = \text{slop} = \left(\frac{C_c - C_n}{T_n - T_c} \right) \text{-----(9)}$$

- Crash each critical activity one time unit step until the compression limit.
- Updating the network and show all the alteration in time of critical path, calculate the new direct cost by applying the following formula.

The new direct cost = $C_i - (C_{pi} - C_{pj})m$ ------(10)[11]

C_i = Direct old cost of the project.

C_{pi} = Old critical path, C_{pj} = new critical path, m = Cost Slop.

The detail of execution these steps are shown in Figure (9)

- The system display optimistic time at minimum cost value as shown in Figure (10).
- Draw optimistic time curve as shown in Figure (11).
- The detail of implementation the project steps are shown in Figure (12)

4- Result and Discussion

1- The system calculates the number of critical path equal to (5) as a result of the input data as shown in Figure (8).

1- The system calculate the project completion time (102) days at total cost (34644.127) ID with direct cost equal to (310409) ID and total indirect cost as shown in Figure (7).

2- The system calculate the normal and crash resources rate at each activity duration of project and total normal resource equal (147) workers and total crash labor resource (168) workers as shown in Figure (5).

3- The system calculate The optimum time is equal to (102) days at (34644.127) ID minimum total cost for civil engineering works of pure drinking water project as shown in Figure (9),(10),(11).

5- Conclusions and Recommendation

5-1 Conclusion

1-The absence of applying integrated systematic and scientific approach to plan and execute projects leads to time delay, rise in project cost and resource fluctuation.

2-The study shows that the network analysis technique is an appropriate technique to be applied in planning, scheduling and controlling engineering project.

3- The (PDWP) computer aided system enables the project manager to make the cost and crash the activity time to reach the optimum time at minimum cost to implementation the project.

4- The display the Gant Chart and network shows the numbers of critical path as a result of the input data as shown in Figure (8).

5- The system (PDWP) display the critical activity as shown in Figure (10).

5- The system (PDWP) calculate Earliest Start Time EST, Earliest Finish Time EFT by using , Latest Start Times LST, Latest Finish Time LFT , Total float (TF) , Free Float (FF) as appears Call activity analysis module in estimation of time at minimum cost of project as shown in Figure (6),(7),(11).

5-2 Recommendations and Suggestions for Future Works:

Based on the work in this thesis, the following recommendation is put forward:-

1-Designing management information system for resource leveling for project single resources and multi resources by using *Minimum Moment Resource Smoothing* and comparing between the traditional and modified of minimum moment approach with accuracy result.

2-Using concurrent engineering in project planning and development for both design and operational aspects of project.

3-Using E-business project management in managing the planning process.

4- Extending the module of (PDWP) system to release expert system concept.

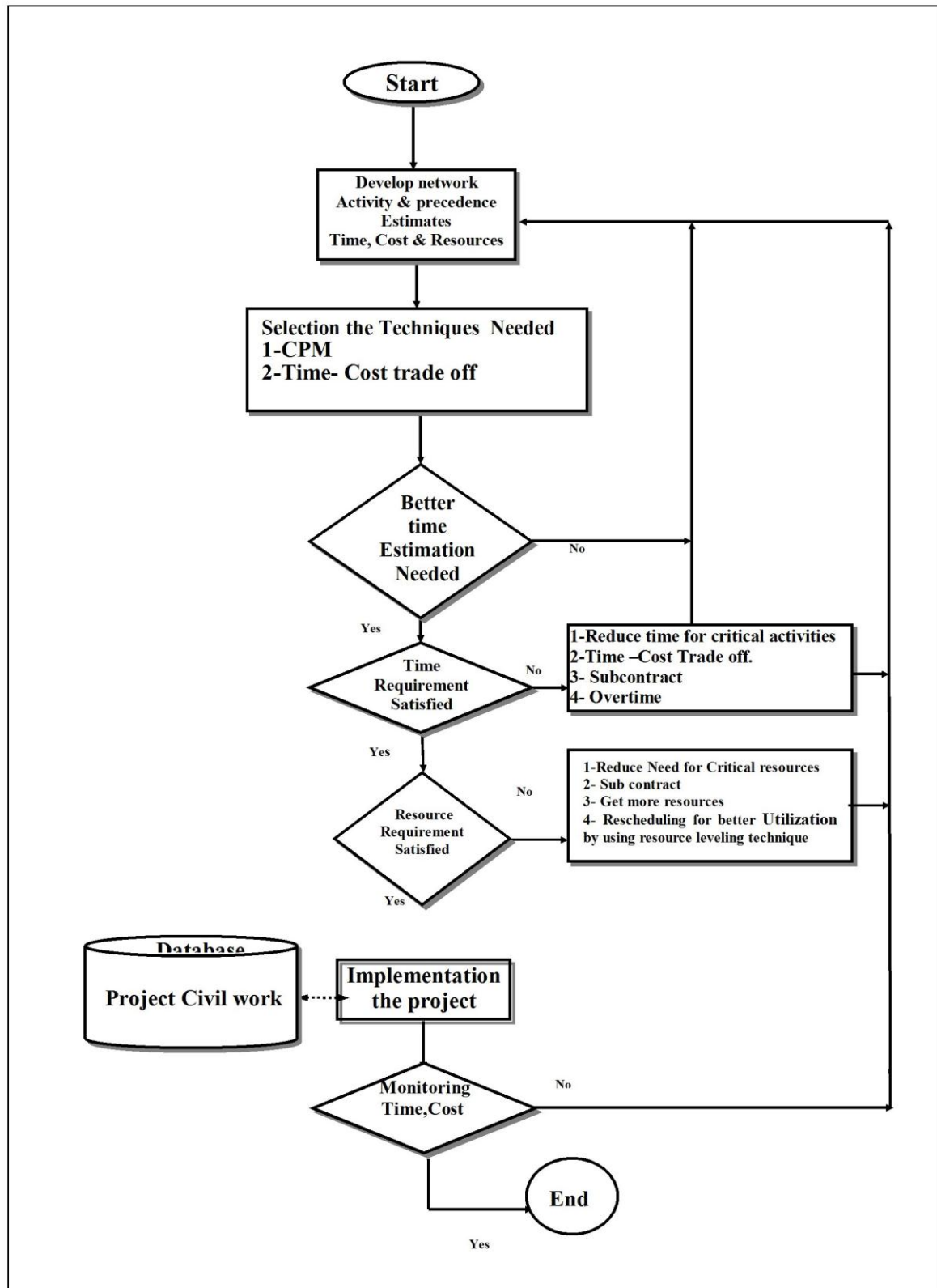


Figure (3) Flowchart of (PDWP) System Architecture

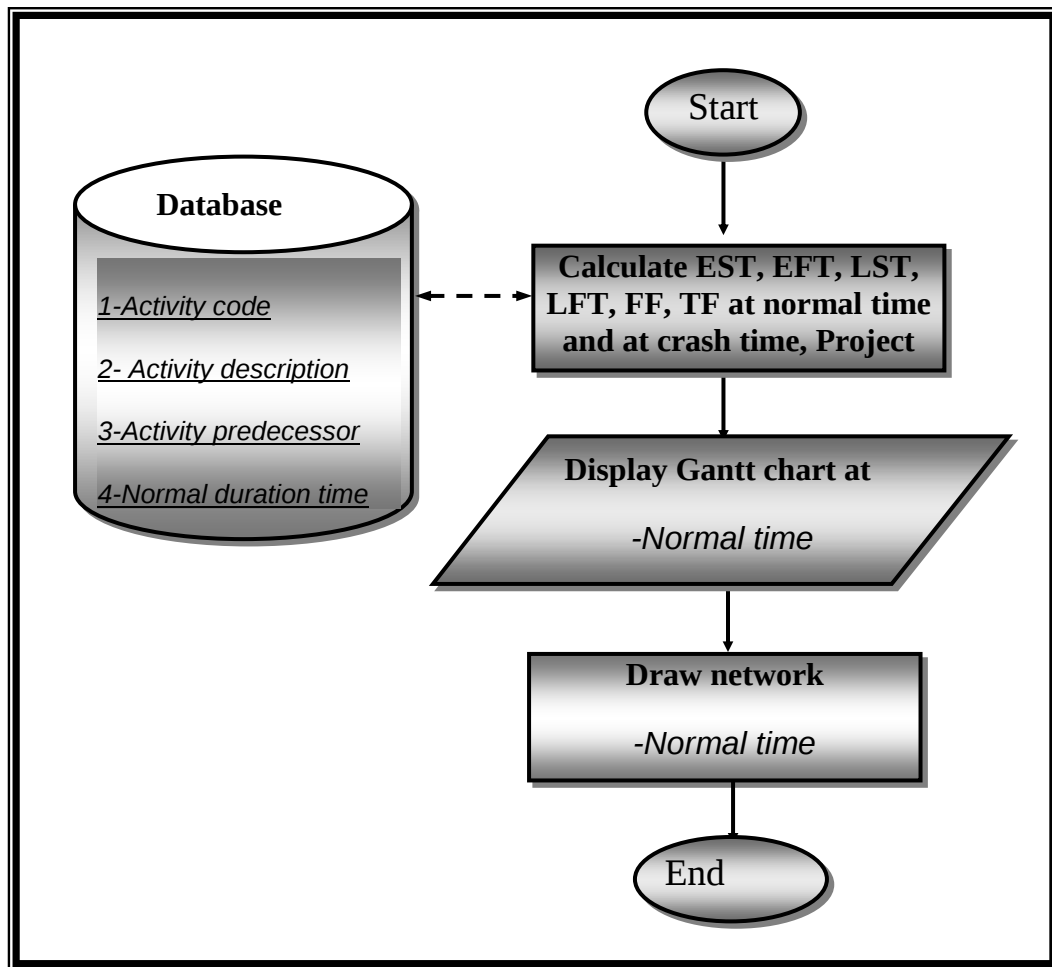


Figure (4) Activity Critical Analysis Module

MAIN SHEET FOR PROJECT PLANNING WINDOW

File Edit View Calculate Window Help

Project Planning Elements

☒ Input Project Planning Elements. Project Name: **Pure Drinking Water (PDW) Project**

☐ Calculate Project Constraints. Project Date/Time: **14/02/2006** **01:59:25**

Start Activity Code Activity Description Pred. Activity Normal Time Crash Time Normal Cost Crash Cost Actual Cost Normal Res. Enter

No.	Activity Code	Activity Description	Pred. Activity	Normal Time	Crash Time	Normal Cost	Crash Cost	Actual Cost	Normal Resource	Crash Resource	Remark
1	A	Cleaning & leveling site	-	10	5	100	150	150	5	10.00	
2	B	Casting concrete to perform	A	20	15	5000	7000	7500	20	26.67	
3	C	Casting concrete for flash n	A	12	10	1424	1890	1890	14	16.80	
4	D	Establishing building struct	B	7	7	1020	1020	1020	6	6.00	
5	E	Casting machinery footing c	B	15	15	1031	1031	1031	12	12.00	
6	F	Executing reinforced conce	D,E	15	15	3000	3000	3000	6	6.00	
7	G	Executing brick walls of 4 m	F	10	10	1400	1400	1400	9	9.00	
8	H	Casting ceiling including fr	D	10	10	405	405	405	10	10.00	
9	I	Executing ceramic tile & ca	F,G	12	10	2295	2678	2678	16	19.20	
10	J	Executing work of coarse c	I	6	6	7043	7043	7044	6	6.00	
11	K	Executing & work painting s	I	12	12	1360	1360	1360	6	6.00	
12	L	Work & covering wall with c	J	8	8	7225	7225	7230	9	9.00	
13	M	Executing false ceiling	I	7	7	3670	3670	3670	4	4.00	
14	N	Fixing & Work of Aluminum c	L	2	2	1906	1906	1906	4	4.00	
15	O	Work fixed of slides steel	B	15	15	900	900	900	10	10.00	
16	P	Building washing room & me	M,N	4	3	30	40	40	10	13.33	

Calculate Project Constraints **Reset** **Edit Activity** **Total Project Direct Normal Cost** **37709.00** **Total Normal Resource Rate** **147.00**

Next >>> **<<< Back** **Help** **End** **Total Project Direct Crash Cost** **40618.00** **Total Crash Resource Rate** **168.00**

Status **16/01/1427** **02:12**

Figure (5) Input Project Planning Parameter Window

ACTIVITY ANALYSIS WINDOW

File Edit View Window Help

☒ Solve Critical Path Using Normal Time..... **Pure Drinking Water Project (PDWP) System**

☐ Solve Critical Path Using Crash Time

Activity Analysis **Activities Path** **Network Display** **Gantt Chart Display**

No.	Activity Code	On Critical Path	Activity Time	Earliest Start	Earliest Finish	Latest Start	Latest Finish	Total Float	Free Float	Remark
1	A	Yes	10	0	10	0	10	0	0	
2	B	Yes	20	10	30	10	30	0	0	
3	C	No	12	10	22	90	102	80	80	
4	D	No	7	30	37	38	45	8	0	
5	E	No	15	30	45	30	45	0	0	
6	F	No	15	45	60	45	60	0	0	
7	G	No	10	60	70	60	70	0	0	
8	H	No	10	37	47	92	102	55	55	
9	I	No	12	70	82	70	82	0	0	
10	J	No	6	82	88	82	88	0	0	
11	K	No	12	82	94	90	102	8	8	
12	L	No	8	88	96	88	96	0	0	
13	M	No	7	82	89	91	98	9	9	
14	N	No	2	96	98	96	98	0	0	
15	O	Yes	15	30	45	87	102	57	0	
16	P	No	4	98	102	98	102	0	0	

Activities Analysis **Output Results**

Project Completion Time **102** **Number of Critical Path(s)** **5**

Total Direct Cost **31409** **Critical Path(s)** **1- A,B,D,F,G,I,J,L,N,P**

Total Indirect Cost **3235.127** **2- A,C**

Total Cost **34644.127** **3- A,B,E,F,G,I,J,L,N,P**

4- A,B,E,F,G,I,J,L,N,P

Next >>>> **<<<< Back** **Help** **End**

Status **16/01/1427** **02:34**

Figure (6) Activity Critical Analysis for Civil Works Window

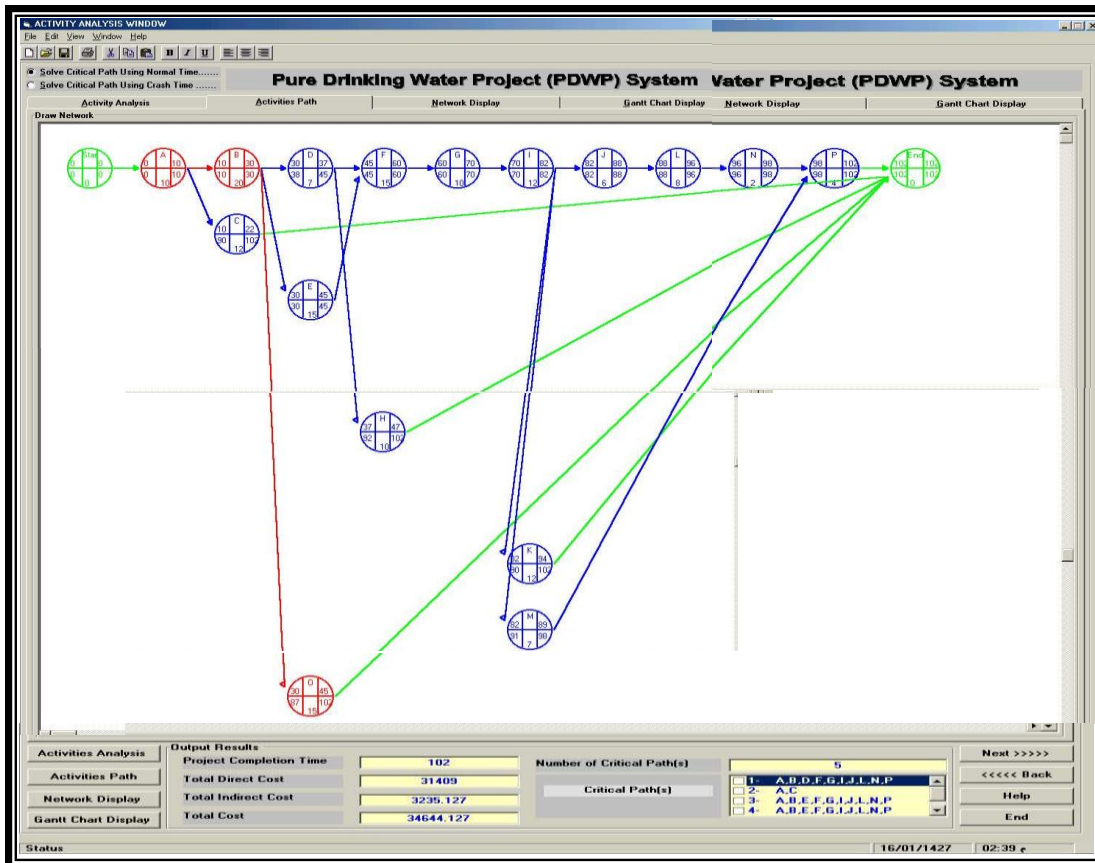


Figure (7) Deterministic Network for Civil Works of Project Window

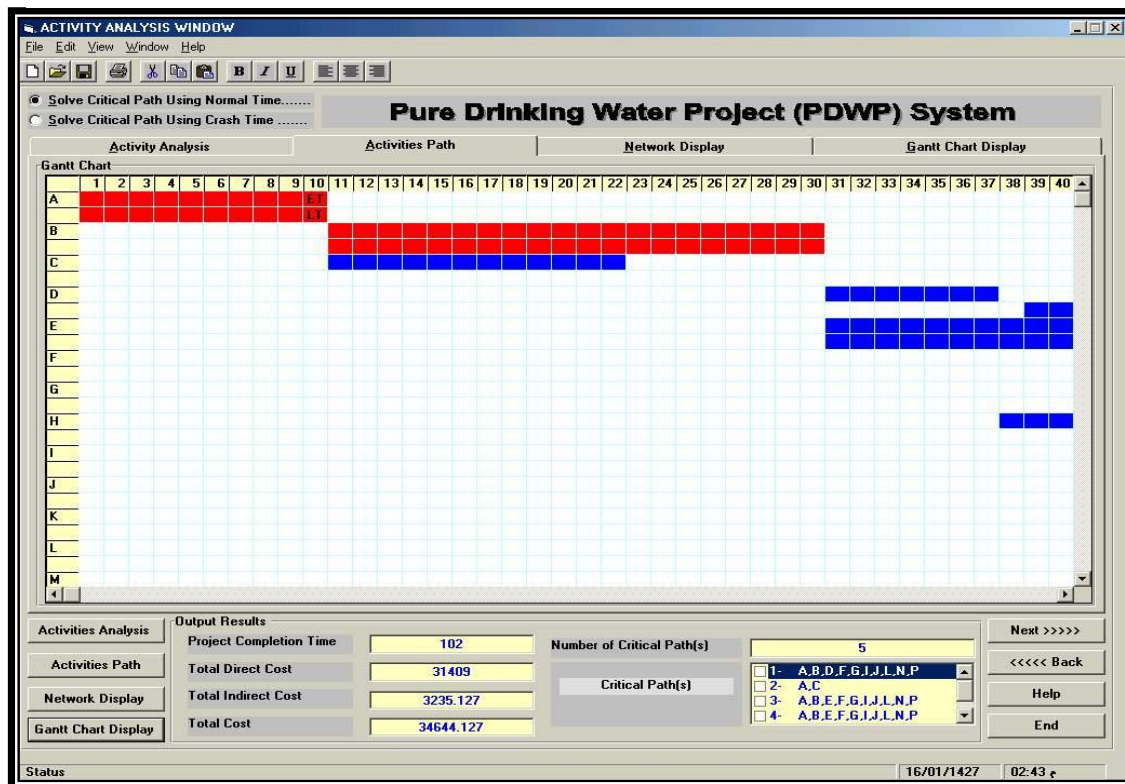


Figure (8) Gantt Chart Of Activity Analysis for Civil Works Window

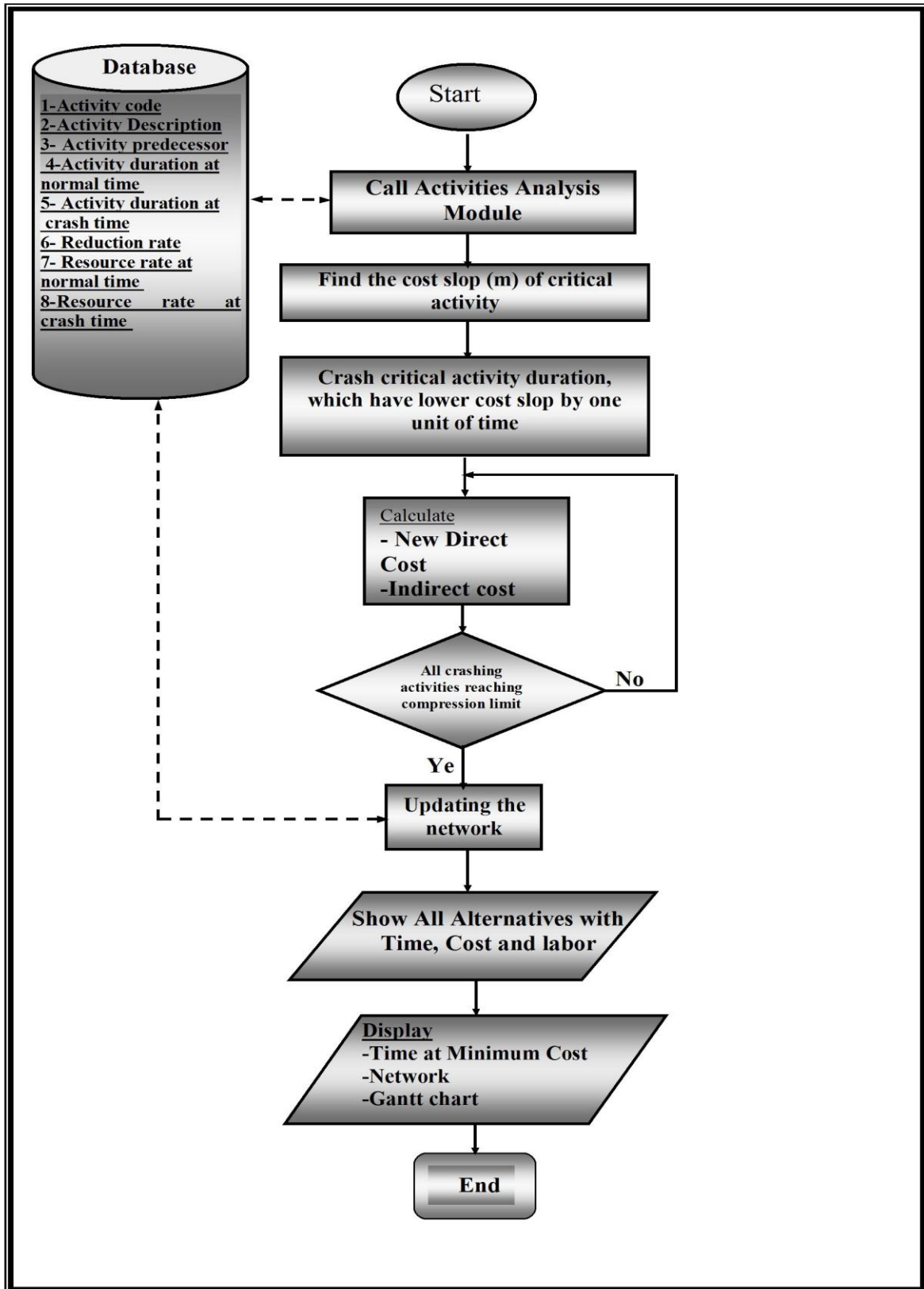


Figure (9) Activity Crash Analysis/ Time Cost Trade off Module

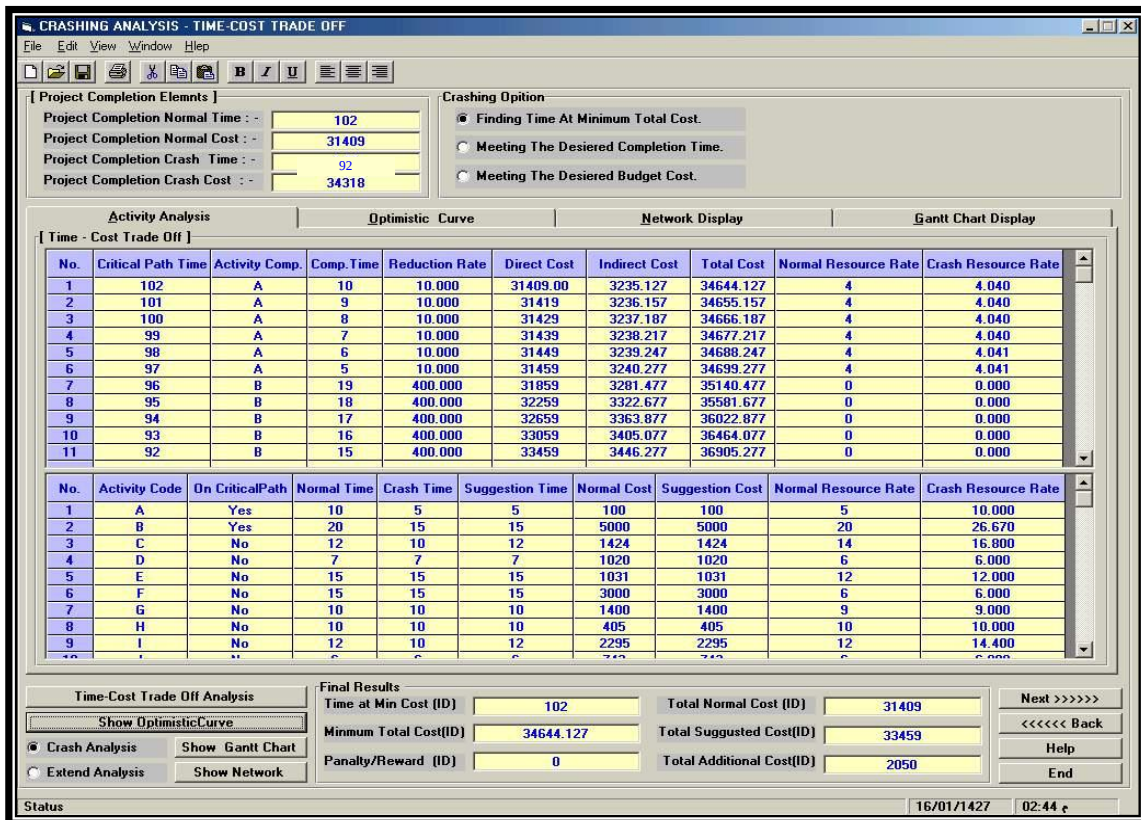


Figure (10) Perform Crash Analysis by Time Cost Trade off

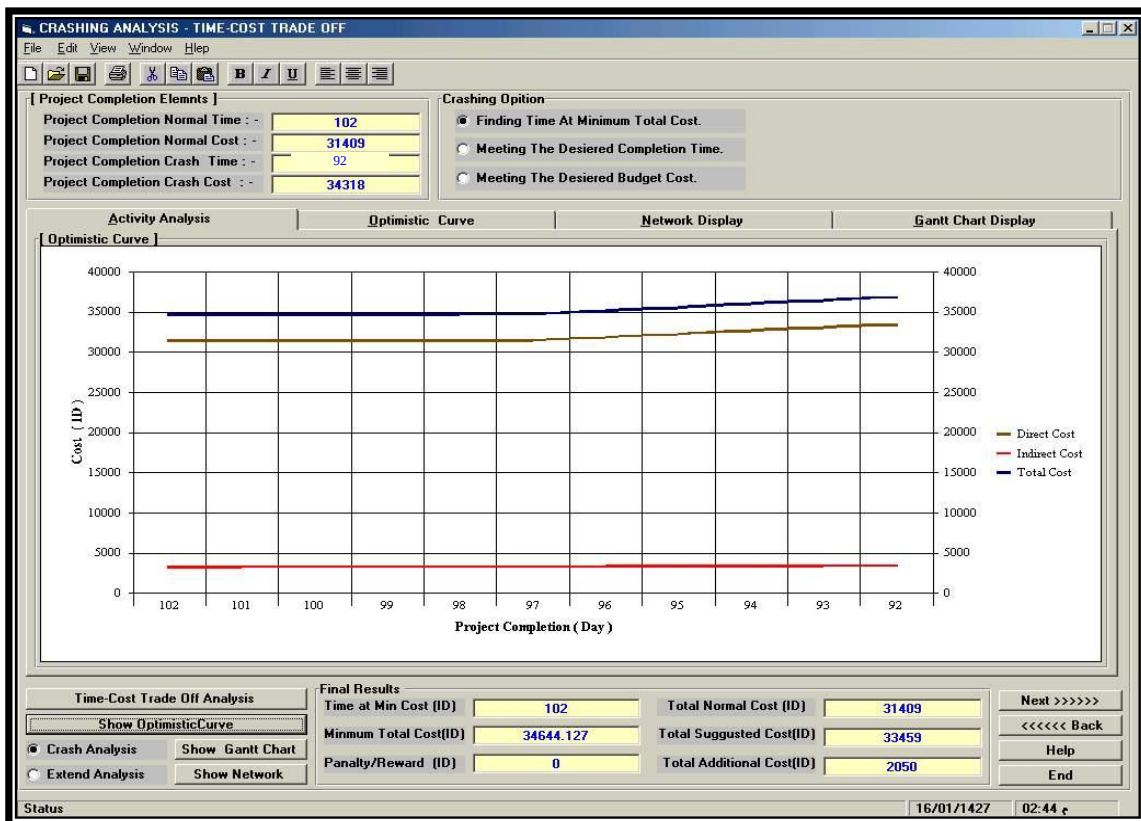


Figure (11) Optimum Time at Minimum Cost for Civil Works Window

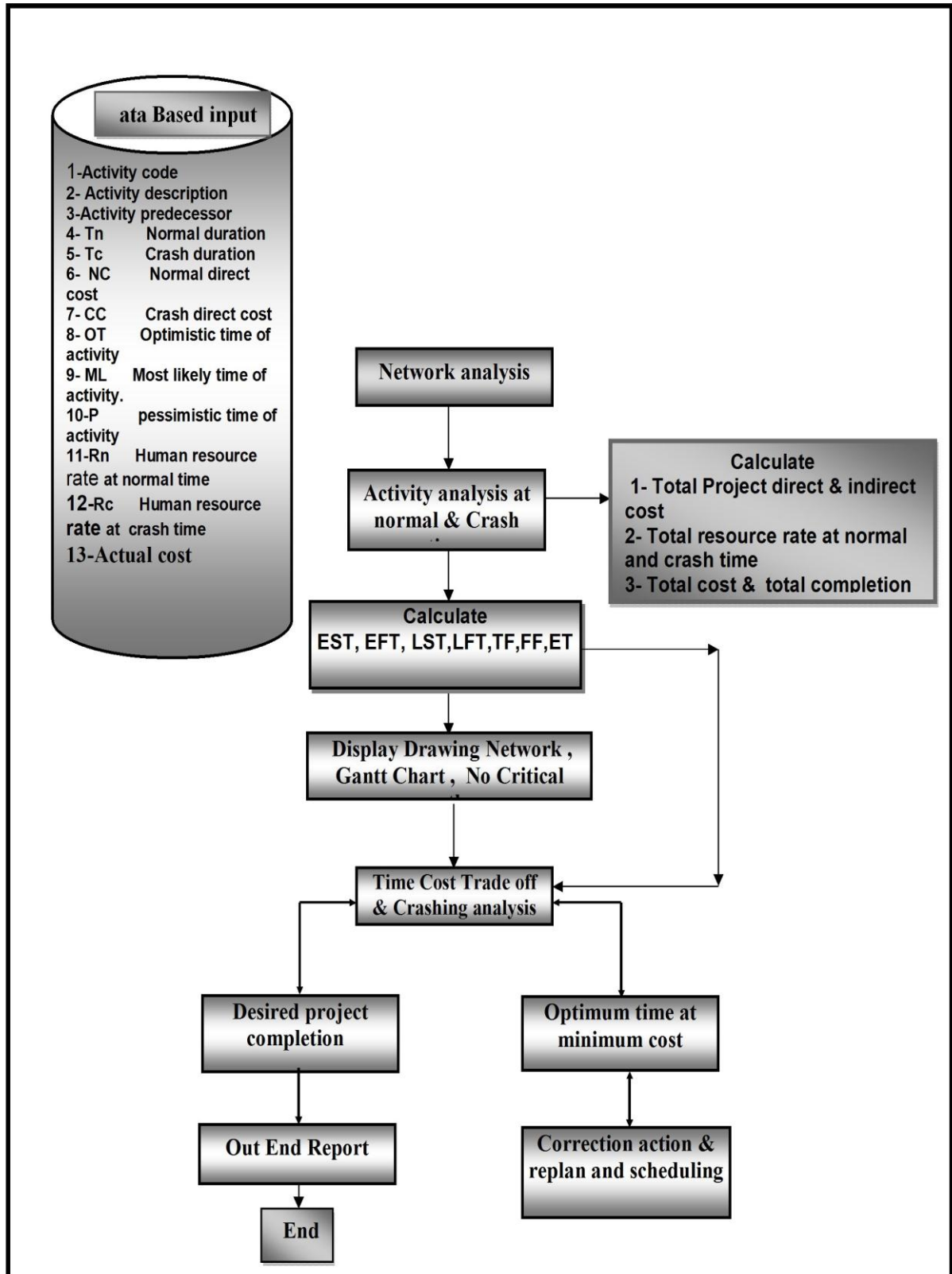


Figure (12) Flow Chart of implementation (PDWP) System

6 – References

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