Project Management With CPM

by

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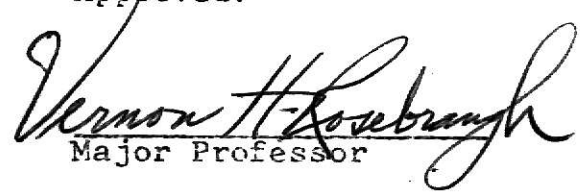

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NOMENCLATURE

CPM	Critical Path Method
EST	Earliest Start Time
EFT	Earliest Finish Time
LST	Latest Start Time
LFT	Latest Finish Time
FF	Free Float
TF	Total Float
DUR	Duration
EPO	Earliest Possible Occurrence
LPO	Latest Possible Occurrence
RSM	Resource Scheduling Method
PERT	Program Evaluation and Review Technique
CONC.	Concrete
RESER.	Reservoir
FDNS.	Foundations
UNGR.	Underground
REINF.	Reinforcement
EXC.	Excavation
BOUND.	Boundary
WTR.	Water
PL.	Place
PACKG.	Packing
WIND.	Windows
DR.	Doors
FR.	Frames
MTL.	Metal
ANC.	Anchors
PARTWAL	Partition Wall
MASON	Masonry
WK.	Work
PK.	Parking

Project Management With CPM

by

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SYNOPSIS

This report basically reviews the methods and techniques of Critical Path Methods and their application to a construction project. It is divided into two parts, the first one deals with the theory of the critical path methods and the second the illustration of these CPM techniques when applied to a construction project which was actually carried out in Pakistan. Results obtained from the numerical example are compared with the ones originally available. Three computer programs have been used for calculation purposes. Hand calculations for finding the critical path are performed so as to check with results obtained by computer.

PURPOSE AND SCOPE OF STUDY

This report, "Project Management With CPM", is basically a review of the methods and techniques of the CPM. A construction project which had been executed in Pakistan about four years ago has been selected to illustrate the incorporation of some of the basic principles of the Critical Path Methods. The results obtained from this study provide a basis for comparison with the ones originally available.

The purpose of this report is to describe the CPM managements methods in an orderly manner and to describe their advantages when this approach is applied to construction projects. These methods emphasize that with the use of CPM the project is executed in an orderly and efficient manner thus resulting in savings of moderate funds and time. From the study it is inferred that CPM cannot be applied successfully until the persons responsible for its application have a sound, practical experience and a good construction judgment, but still, if applied with competency it provides a better picture of the job, pinpoints the problem areas before their occurrences and levels out the available resources thereby resulting in cost control. In a nutshell, the use of CPM results in efficiency, economy and saving of time.

The reason for selecting a particular project for the numerical example for the illustration of CPM techniques is because of the fact that the author had the opportunity of personally viewing the execution of most of the operations, thus enabling him to have the necessary practical experience

required for the determination of the network logic. Without having this practical experience and the necessary insight into the project it becomes quite difficult for the planner to sequence the operations as is described in the preceding paragraph. Computer programs furnished by Prof. Rosebraugh, Prof. Bissey and Prof. Goddard are used for performing the CPM calculations in this numerical example.

INTRODUCTION

CPM (Critical Path Method) is only an information generating process which can yield results that can aid the contractor in the planning, scheduling and controlling the construction of a project with his forces and their experience. In other words, it is a technique which aids construction management in planning, scheduling and controlling the building of any type of project. This report describes the use and application of Critical Path Method in scheduling and planning and its use as a management tool in the construction industry. It focuses on actual construction process showing CPM in action from start to finish on a project. The scope of construction includes not only the building phase, but all of the activities which interrelate to result in decision to proceed with a facility, its design, review, contractual arrangements and finally, actual construction. Many innovations which further enhance the value of critical path usage for job planning and control for simple and complicated projects are being developed with the passage of time. CPM as a tool is not limited to specific projects but can be utilized throughout for plant maintenance, refinery operations, highway planning, and construction and many other areas. Thus, CPM is a disciplined concept representing the sequence of a project logically.

At first, CPM was used primarily in the construction industry. In fact, construction is still one of the areas of most frequent applications of CPM. Although the first

users of CPM did little more than construct arrow diagrams and plan and schedule their projects accordingly, they immediately realized the benefits of this new approach. Project managers found, for example, that they had a clear picture of the project, readily communicable to everyone including new personnel, and they could receive timely and accurate data as the basis of sensible decisions.

With the usage of CPM it became apparent that the principles of network analysis were applicable to projects in industries other than construction. Soon, projects of varying types were being partially planned and controlled by this unconventional method. CPM was accepted as a new way of thinking. Management began to work with precise increment of time on projects and to develop alternative plans in which time was considered by itself, than with respect to other resources. These other resources include men, equipment, materials, working area and money.

Possibly the most important advantage resulting from usage of CPM is that management has clearly defined for itself the genuinely separate functions of planning and scheduling. Management has also realized that CPM is an effective means of control. Thus, CPM has been accepted for a wide variety of projects.

DISCUSSION

The overall purpose is to suggest that the use of CPM will provide maximum advantage for top management, project management, job superintendents and the working foreman. The CPM is a relatively new tool that is gaining wide acceptance. Due to its increased use, additional techniques and modifications are continually improving the overall aspect while making apparent the full potential of CPM as a planning tool. The advantage of this new system is the effectiveness in controlling, staffing, manpower, procurement, cost control, etc. Once the basic benefits are understood the money invested in the use of this tool can be justified. A thorough knowledge of the project is acquired when the participants prepare a CPM arrow network. A typical network requires separating the job into understandable components and establishing their logical sequence and interrelationships. Preparation of CPM necessitates acquiring and understanding the information for a full range of operation which involves design, procurement, shipping, construction and testing. This in itself has considerable value for the project engineer giving him broader view of the situation that can arise, as well as those which will control the total job duration.

After the engineer completes his network and establishes the critical path including float times for various operations, he then gains the additional knowledge which enables him to predict accurately the items that will require very close scrutiny and control for maintaining the established

job completion date. The engineer must also understand and recognize the implications of float times and their importance within the network.

There are many means of presentation that could be utilized. Some of these methods have an advantage for the management while others apply to the job foreman. To the top management or the foreman, an arrow diagram means very little. However, to an engineer who has prepared the schedule it denotes the obvious logical sequence of operations and indicates their interrelationships.

In the past, critical path scheduling and planning have been termed as tremendous by one set of users and impossible, impracticable and unusable by others. Attempting to look at the reasoning behind this wide variety acceptance, we can only come to the conclusion that it is highly dependent on the use and application. One major factor is that CPM is a guide and all users must therefore faithfully follow what has been established. Should deviations occur in items that are critical, it will extend the total job duration. During early use of critical path scheduling, the prepared schedule was normally ignored and the work proceeded at its leisure. This created problems since no attempt was made to apply the knowledge of critical item control.

HISTORY OF CPM

CPM development was initiated in two parallel efforts. They were different in origin and were designed as the probabilistic approach and the deterministic approach. The probabilistic appeared in the form of PERT (Program Evaluation Review Technique). PERT was developed for the U.S. Navy and provided a tool to control the planning and construction of the fleet ballistic missiles program. The system's major variable was estimated completion time. The U.S. Air Force adopted essentially the same procedure with modification and called it PEP (Program Evaluation Procedure). Since then many modifications and revisions have been made with the large companies preparing their own forms and introducing new techniques.

The deterministic case was much more suitable for construction application since it considered both cost and time as controlling variables. The initial effort for this case was accomplished by E. I. DuPont in 1956, along with Univac Division of Sperry Rand Corporation. They developed a project planning and scheduling technique based on network analysis and applied it to a refinery renovation project. This technique was called Critical Path Planning and Scheduling (CPS). Later on, big concerns applied the newly developed technique to their huge projects and realized the potential in the new concept.

WHAT IS CPM?

CPM is a system for planning, scheduling and controlling a project. In CPM the steps or operations necessary to complete the project are shown in a graph called NETWORK. The network also shows the order in which the operations must be completed, which activities can be done together, and which activities must follow the other activities.

When the network is complete, the planner estimates how long it will take to do each operation. Obviously, the time for completing the entire project is not the sum of individual operation times, since some operations can be done at the same time. Actually, a small number of operations control the project completion time. These operations are called the critical operations as they form a chain through the network called the CRITICAL PATH. This is the origin of the term 'Critical Path Method'. The critical path determines the time necessary to complete the project.

By the use of Critical Path Method we get meaningful answers to such questions as:

1. How long will the project take? Can we meet our contract completion date?

2. If there is delay in one activity will the entire project be delayed? If so, by how much?

3. What is the most economical way to speed up the project?

4. How can we tell whether we are on schedule? If not, is there still time to take corrective action?

5. How can we schedule our manpower to avoid excessive ups and downs without delaying the project completion?

6. How can we schedule material deliveries so as to have things on the job when needed, but avoid costly storage for long periods?

WHEN CAN CPM BE USED?

To be able to use CPM, the project must have a definite beginning and a definite ending. It must also be made up of a series of smaller jobs or operations that must be done in an orderly sequence to complete the project. A good example is building a house; the foundations precede the walls, the shingle must follow the roof boards, etc. Construction projects of all types lend themselves to CPM scheduling and the construction industry was among the first to make widespread use of the method. CPM is equally suitable for planning any of the following projects for example:

1. Introducing a new product.
2. Research and development projects.
3. Assembling a large piece of machinery or aircraft.

However, size and approach of CPM analysis is limited only by ingenuity of the user. The dollar size of the project is also a guide in determining which projects should be diagrammed. The primary considerations are the complexity of the project and the degree of coordination required in implementing it.

NETWORK CONSTRUCTION

NETWORK

The arrows are arranged to show the plan or logical sequence in which the activities of the project are to be accomplished. In other words, one has to decide what activities precede a particular activity, what operations are concurrent and what operations must follow other operations. The resulting logical flow chart is a network of arrows usually referred to as the arrow diagram or network. The heart of CPM is the network diagram. This is a graphical picture of the project showing each step or operations and the relationship between the steps. CPM can be a powerful management tool or a total waste of time, depending upon the care with which the network is prepared. To draw a correct network the requirement is familarity with the project, patience and knowledge of a few simple rules.

Drawing the arrow diagram completes the first phase of CPM. Preparation of arrow diagram forces one to think through the project completely and determine just what the sequence of operation would be. It provides a readily understood picture of the project which is useful in briefing the people directly responsible for job execution.

An important aspect of the network is to decide just how detailed the network should be. Several factors are involved. The first consideration is the purpose of the network. If it is to be used for preliminary planning it

usually contains fewer items. On the other hand, it if is to be used for day to day control of the project it involves considerable detail. In general, for reporting to higher management the diagram should be simpler and less detailed as compared for use at field level.

The network of this report is simple in approach so as to help the reader in understanding the fundamentals and their applications.

TIME ESTIMATION

The dimension used for CPM analysis is project completion time. Any convenient unit can be used but it must be consistent throughout the network. The unit is usually in days which is adopted in this report. Full time units are generally used in CPM.

Once the project has been divided into its elements, the next step is to estimate the time, or duration of each operation. To estimate the time duration for an activity the estimator assumes a normal work crew. This normal crew may be the optimum, but it could be larger or smaller. A normal crew size has been the consideration in estimating the event time in this report. Time estimates depend on a variety of factors such as:

1. Type of Work
2. Quantity
3. Working Conditions
4. Location
5. Climate
6. Tools and Equipment
7. Level of Worker's Skill
8. Degree of Supervision

Above all the experience and the breakdown of the project into simpler components makes it relatively easy to estimate the durations.

CPM COMPUTATIONS

The following parameters are calculated as described below in order to determine the completion time of the project and the critical path or chain of critical operations.

EPO - The Earliest Possible Occurrence of a node is the earliest possible time for starting all operations that originate at that node. To find EPO of all of the nodes on an arrow diagram, we first assign an EPO = 0 to the first node on the diagram (Node numbered 1). The EPO for each of the remaining nodes is the maximum of the EFT's of all the operations that terminate at that node.

EFT - The Earliest Finish Time of an operation is the sum of the EPO of the node at the start of the operation plus the duration of the operation.

LPO - The Latest Possible Occurrence of a node is the latest possible time that all of the operations that terminate at that event can finish without causing the project duration to exceed the value originally calculated with the EPO's. This fixes the value of LPO of the last node. LPO of the last node is equal to the EPO of the last node since this is the completion time of the project.

LST - The Latest Start Time of an operation is the LPO of the node at which it terminates minus its duration. In general, the LPO of a node is the minimum of all of the LST's of the operations that originate at the node in question.

EST - The Earliest Start Time is the EPO of the beginning node of an operation.

LFT - The Latest Finish Time is the LPO of the ending node of an operation.

FF - Free Float of an operation is the amount of time that the operation can be delayed or lengthened without affecting the EPO of any node on the arrow diagram. Free Float is calculated as the difference between EFT of an operation and the EPO of the node at which it terminates.

TF - The Total Float of an operation is numerically equal to the LST of an operation minus the EST of the same operation. Total Float is the length of time that an operation can be delayed or expanded without affecting the completion of the project.

CRITICAL PATH

The Critical Path is the chain of operations whose duration determines the overall project time. Any operation not on the critical path has a slack or float time. To find the critical path by using an arrow diagram, duration is added to the earliest start time to find the earliest finish time, and the latest of the earliest finish times becomes the earliest start time of the following operations. In working backwards through the network we subtract durations from the latest finish times to find the latest start times and choose the earliest of latest start times as the earliest finish of the preceding operations. EFT, LST, EST, LFT, FF, and TF are calculated as per their definitions described earlier.

From the results of above computations it is observed that critical operations are those that have Free Floats of zero, however all the operations with zero Free Float do not control the project duration. The operations that do control are the ones that have zero Free Float and form a continuous chain or path, starting at the first node and ending with the last node. Another condition for the operation to be on the critical path is that Total Float of that operation should be zero.

RESOURCE SCHEDULING

Resource Scheduling method determines the levels of resources which must be scheduled in order to implement the plan and also alters the CPM plan in an efficient way in order to convert it to a usable CPM plan. This solution re-sequences the operations such that preset level of each resource is not violated and such that this re-sequencing increases the project time of unacceptable CPM plan in a minimal way.

The following data are required:

1. The amount of each resource required to complete the operation in the specified duration.

2. Maximum level of each resource.

CALENDAR DAY CONVERSION

The schedule may be converted to calendar dates by relating time zero to node 1. By knowing the starting date and relating it to node 1 and assuming work week of 5 ≈ 6 ≈ 7 days the dates pertaining to EST, EFT, LST, and LFT can be calculated. This helps in correlating time with the weather conditions prevalent at specific times.

UPDATING

This aid consists of planning and scheduling what remains of a project by placing the latest information concerning the project onto the original arrow network. The reason why updating is done is because of the fact that some operations may have completed on schedule, some may have taken a shorter time and some may have taken a longer time to complete, so to check the progress at a certain time and reschedule the remaining operations this calculation is performed.

Calculations are done in the following manner:

1. The durations of the operations which have been completed at the time of the update are set as zero.

2. The EST of the completed operations are set as the time of update.

3. Estimated durations of the operations which are in progress are calculated.

4. For the operations which have not yet started, the durations remain unchanged. If the planner wants to re-schedule, they could be done at this stage.

5. With the help of the above information project completion time is calculated. If it is not in accordance with the schedule, critical operations are compressed and more resources are aimed at these operations so as to enable the project to finish on time.

CPM AND COST CONTROL

All the CPM techniques discussed in the preceding pages were based on time dimension alone. However, money which is vitally important has to be tied to the CPM to make its application more fruitful. CPM does not offer any replacement for cost estimation and hence, the traditional methods of estimation are employed. Costs are assigned to each activity which helps a great deal in progress payments as it places progress evaluation on a well defined basis--activity completion rather than the traditional percentage estimates. Project costs are set up on the basis of CPM activities and the actual costs of work to date are compared with the cost estimates which are used in monitoring the project moneywise. CPM cost techniques also help in cost forecasting, i.e., time and cost dimensions are combined to forecast the rate of spending on a project. Cost expediting is another feature of CPM, i.e., in order to keep a project on schedule certain critical activities have to be shortened in duration but in such a manner that the increments in costs are in a minimal way.

STEPS INVOLVED IN AN ANALYSIS OF A PROJECT WITH THE USE OF CPM

Following are the steps involved in the analysis of a project:

1. The project is analyzed, that is, broken down into activities or operations according to the required level of approach, e.g., for field level or management level.

2. The network is constructed showing the logical sequence of operations and their relationships.

3. Computations are performed to locate the Critical Path (the chain of interdependent operations that determine the duration of the entire project).

4. Analysis and evaluation of results obtained from Step 3 are performed which helps as a check and also discloses possible ways of improving the proposed project plan and schedule, i.e.,

   a. analysis via operation breakdown.

   b. analysis via resource allocation.

   c. analysis via completion time.

   d. analysis via calendar day conversion.

5. Schedule which is determined is used to control and monitor the job progress.

6. Revision and updating of schedule is done periodically on account of unforeseeable factors which affect the progress.

7. Resources Scheduling is applied to determine the best possible schedule, keeping in view the limited resources available.

8. Cost controls and cost expediting methods are used to keep the project execution cost as economical as possible.

ADVANTAGES OF CPM

1. A Disciplined Approach to Planning:

The network diagram shows the relationship between various jobs that constitute the project. It shows the dependency of one activity on another. This provides a much better picture of the job than was possible by a bar chart or other scheduling device.

2. More Effective Planning:

The use of CPM gives a better definition of the scope of work. It forces the Project Manager to think through the job thoroughly to completion. It demands careful detailed planning. This fact alone justifies the time spent on this system.

3. Separation of Planning and Scheduling:

In CPM, planning is separate from scheduling. This is a key feature of the method. Planning is the process of analyzing the project, breaking it down into the steps or operations necessary for its completion and finding the order in which these steps must be done. The results of planning appear on the diagram itself. The network also functions as an aid to the planning process since it forces the planner to clearly define each operation and its proper relationship to all the others.

Scheduling introduces the element of time. First, the time necessary to accomplish each operation is estimated. With this information the critical path is located and then a schedule is established for the

remaining activities. The result is a complete schedule for the entire project.

4. Identification of Critical Work:

If properly applied it pinpoints the potential problem areas and bottle necks before they occur.

5. Improvement in Communications:

As soon as personnel are trained in its use, CPM provides an easily understood graphical model of the job which can be constructively reviewed. It also provides a ready frame of reference for discussion between the parties concerned, such as the owner, contractor, engineer, architect and material suppliers. This proves to be an effective, timely liaison for job progress and control.

6. Resource Allocation:

Through CPM the planner is able to determine the most effective use of personnel, equipment and other resources. Overtime can be reduced or confined to the jobs when it will do the most good. Undesirable peaks and valleys in manpower requirements can be leveled out thereby resulting in cost control.

7. Study of Alternate Courses of Action:

A powerful use of the method is in providing management with means of studying different courses of action. For example, contracting out certain work as compared to doing the work with forces. This type of study is known as Simulation. It gives the management the basis for making an intelligent choice between alternatives.

8. Management by Exception:

By identifying the critical operations, CPM focuses attention on those jobs that control overall completion time. Further, CPM defines just how far each of the other jobs can slip behind schedule without affecting overall progress. This permits true "Management by Exception", since management can concentrate on key jobs. At the same time, limits are set up for the remaining jobs that must be met if the project is to be completed on schedule. Any slippage beyond these limits immediately signals the need for management attention.

9. Tool in Decision Making:

Another application of CPM is the simulation of an alternate course of action. Various methods may be under consideration for accomplishing same phase of the project. CPM provides a MODEL of the project that is useful in comparing these alternatives. For example:

1. Evaluation of proposals with different delivery dates.
2. Evaluation of proposals of subcontracting or executing the contract themselves.
3. Evaluation of proposals of hiring additional personnel, overtime, etc.

In design, various materials present differing problems of delivery, fabrication or erection times. Time is an important factor in the choice between materials or types of design. CPM provides an effective and realistic tool to aid in a decision of this type.

LIMITATIONS OF CPM

The listing of all the advantages possible from the use of CPM should not blind us to its limitations. CPM is not a substitute for thinking or planning. On the contrary, to be successful it requires the most careful, precise planning and demands that every step of the project be thought out more fully than ever before.

CPM requires the wholehearted support of management and active participation by the people who will direct the work. A common mistake is to turn over the scheduling to a 'Staff Expert' or an outside consultant and hope that something worthwhile would result. The project manager and his staff must be a part of the planning process.

To obtain maximum effectiveness, CPM should not be confined to the preliminary planning stages of the project. It should be used throughout the job to monitor and control the work until completion. However, CPM itself furnishes only information. It needs prompt, effective action by people to keep the project on schedule and compensate for changes and delays.

DEVELOPMENT AND USES OF CPM

This report is primarily concerned with the theory and a few applications of CPM for a construction project, but there are new techniques and modifications that have been incorporated into programs enhancing and increasing the value as described in the introduction and the discussion. Recent

introduction is the computer approach for the solution of projects. With present day organizations there are computer service departments which prepare all forms of computer applications for engineering. One of the functions of one such department has been to prepare a critical path program from other programs already available to achieve the latest in programming techniques.

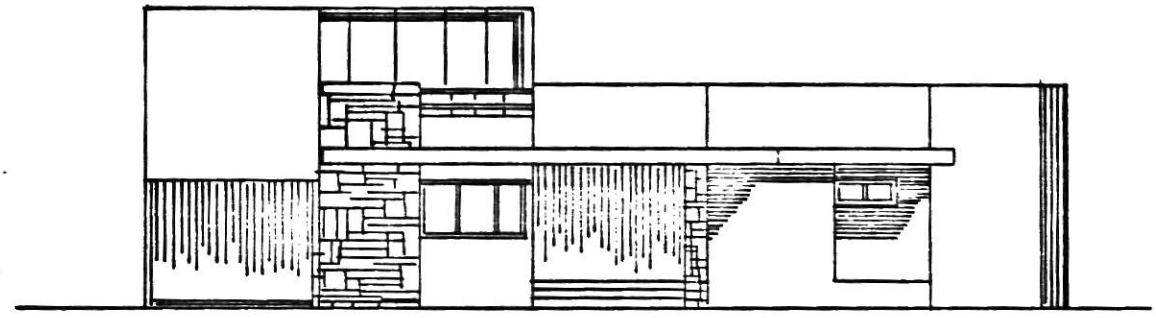
Programs are available for:

1. Dated Bar Chart
2. Man Scheduling
3. Critical Path Method
4. Dating a Critical Path Network
5. Special Updating Features
6. Resource Scheduling
7. Least Cost Estimating and Scheduling

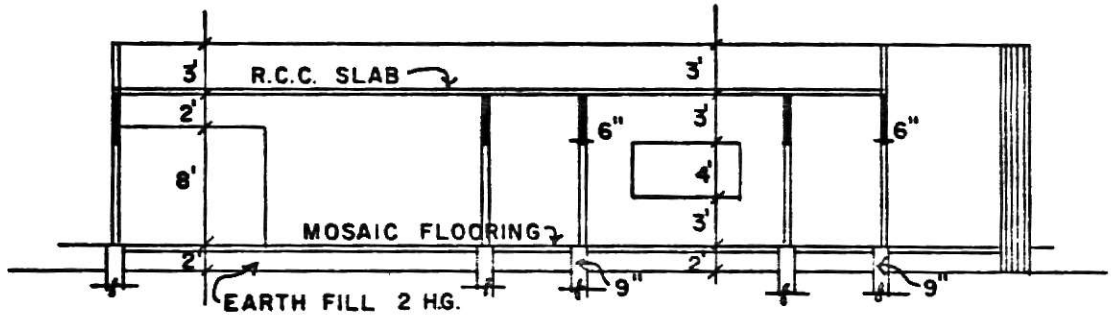
NUMERICAL EXAMPLE

DESCRIPTION OF THE PROJECT

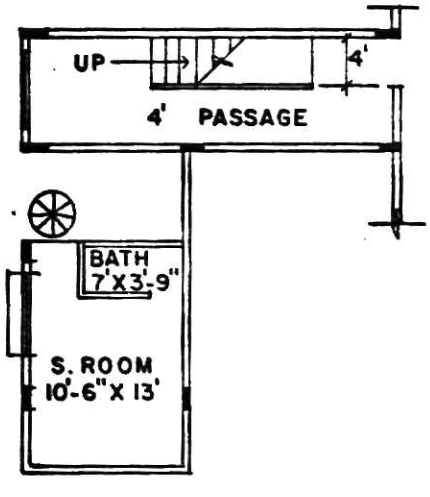
The project 'Construction of a Bungalow' was carried out in Pakistan in 1970-1971. The bungalow is located in Defense Housing Society and is built on a plot of 1,000 sq. yards. The covered area is 336.11 sq. yards. It is a single story house with four bedrooms with attached baths, one living room, dining room and a kitchen. The other construction items include a garage, boundary wall, an underground water reservoir and an overhead water reservoir. The frame of the house is of reinforced cement concrete, while the walls, etc., are of block masonry. It is founded on isolated footings. A grade beam connects all the footings. The respective sizes and dimensions of all the items are shown in the following drawings (Fig. 1 to Fig. 4).



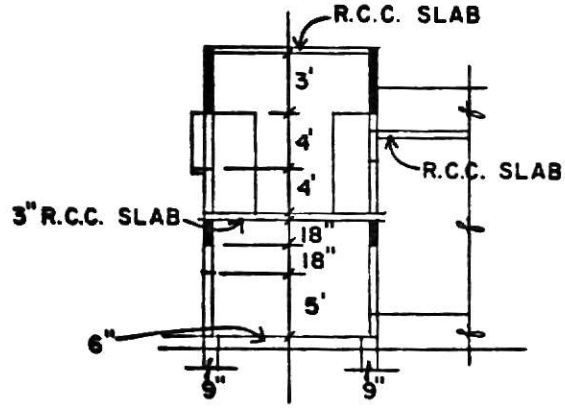
ELEVATION



SECTION A-A

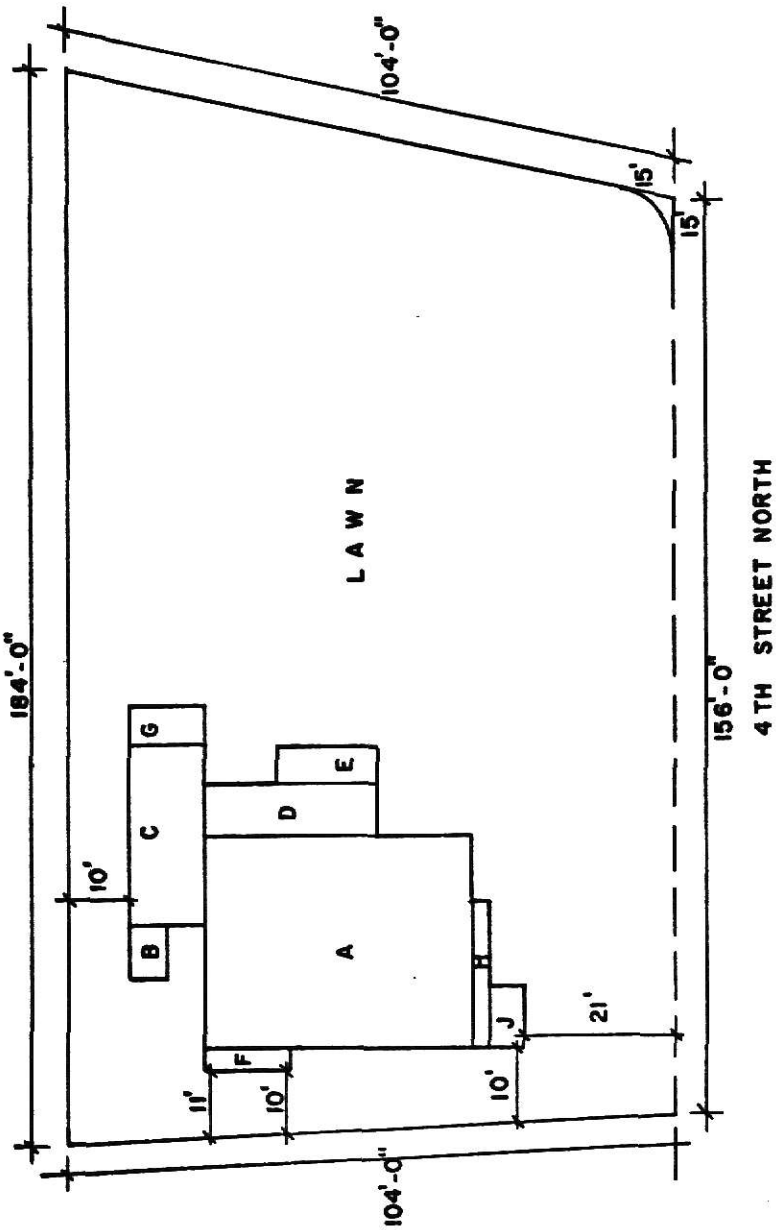


FIRST FLOOR PLAN



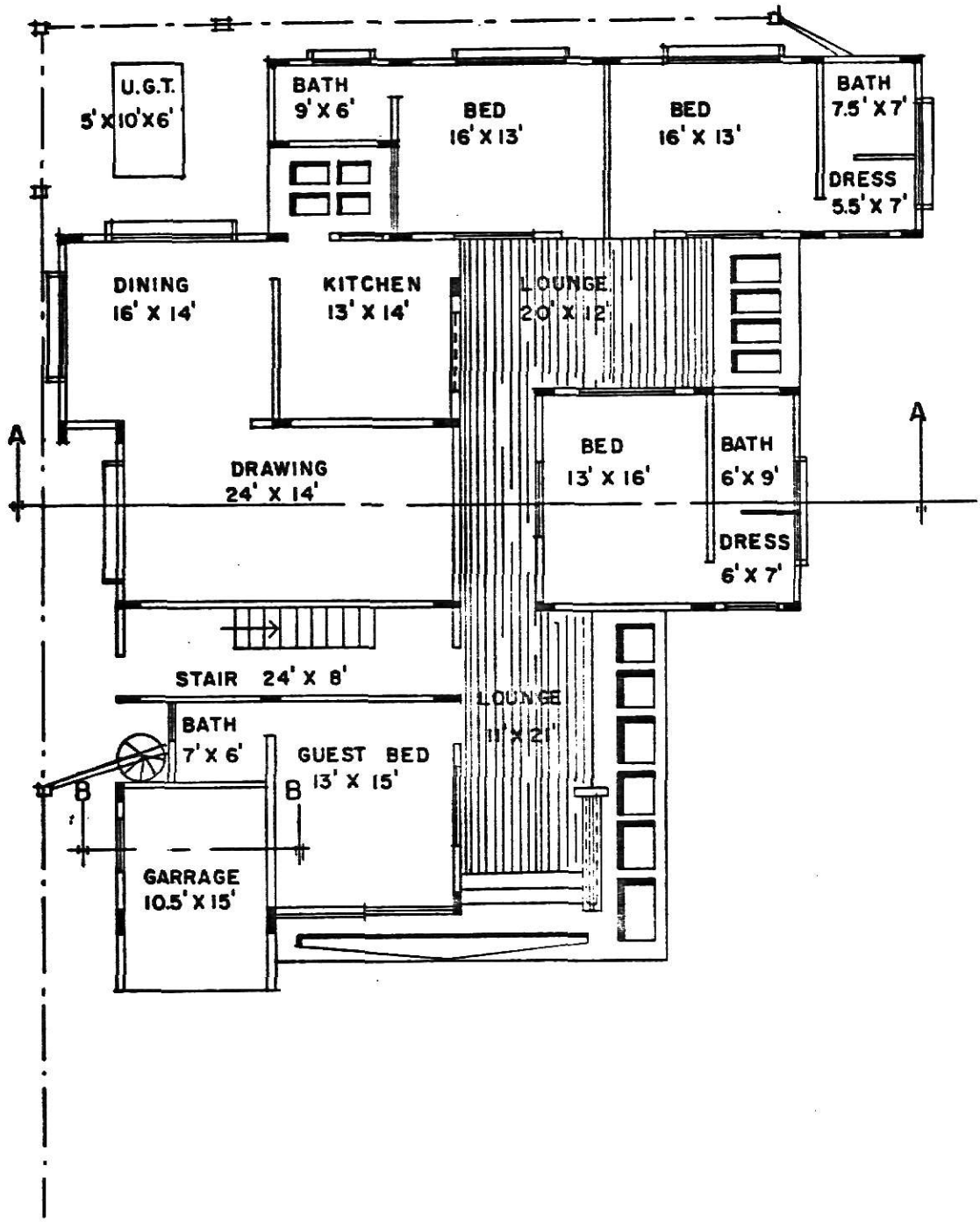
SECTION B-B

FIG. 1



SITE PLAN

FIG. 2



GROUND FLOOR PLAN

FIG. 3

SCHEDULE OF R.C.C.

R.C.C. SLAB

R.C.C. SLAB 6" THICK 0.5" DIA. BARS 6" C/C.

R.C.C. BEAMS

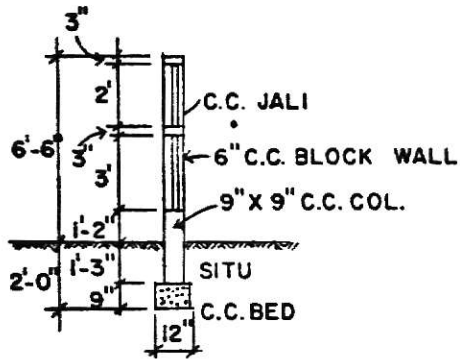
B1. R.C.C. BEAM. 42" X 6" 8 BARS 5/8" DIA.
B2. " " 42" X 6" 6 BARS 5/8" DIA.
B3. " " 42" X 6" 4 BARS 1/2" DIA.

R.C.C. COLUMNS

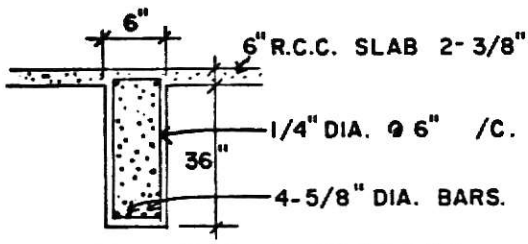
R.C.C. COL. 6" X 18" 4 BARS 1/2" DIA.

SCHEDULE OF AREA

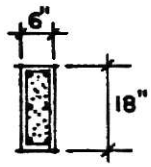
TOTAL AREA OF PLOT.	1942.00	SYD.
ALLOWABLE BUILD-UP AREA.	647.33	"
PROPOSED COVERED AREA.	336.11	"
A. 36'-0" X 50'-6" =	1818.00	SFT.
B. 9'-6" X 7'-0" =	66.50	"
C. 33'-0" X 13'-6" =	445.50	"
D. 9'-0" X 29'-0" =	261.00	"
E. 6'-6" X 17'-0" =	110.50	"
F. 15'-0" X 4'-6" =	67.50	"
G. 8'-0" X 14'-0" =	112.00	"
H. 25'-0" X 3'-0" =	75.00	"
J. 11'-6" X 6'-0" =	69.00	"
TOTAL COVERED AREA	3025.00	SFT.
OR	336.11	SYD.



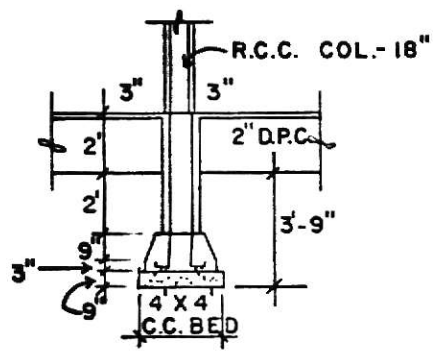
SEC. OF WALL & PARTITION WALL



SECTION R.C.C. BEAMS

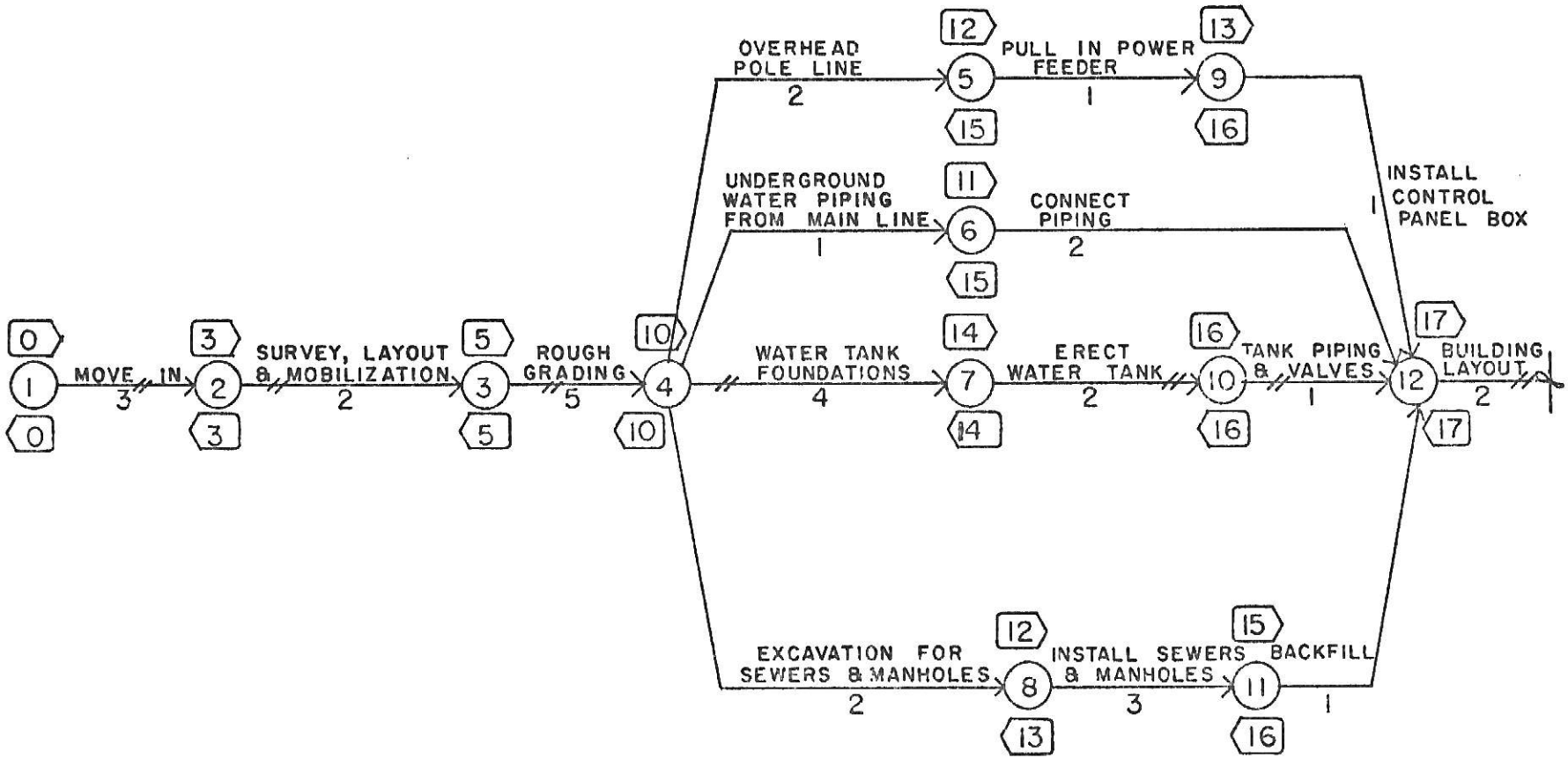


SEC. R.C.C. COL.



DETAIL R.C.C. COL.

FIG. 4



NUMERICAL EXAMPLE FLOW CHART

FIG. 5a

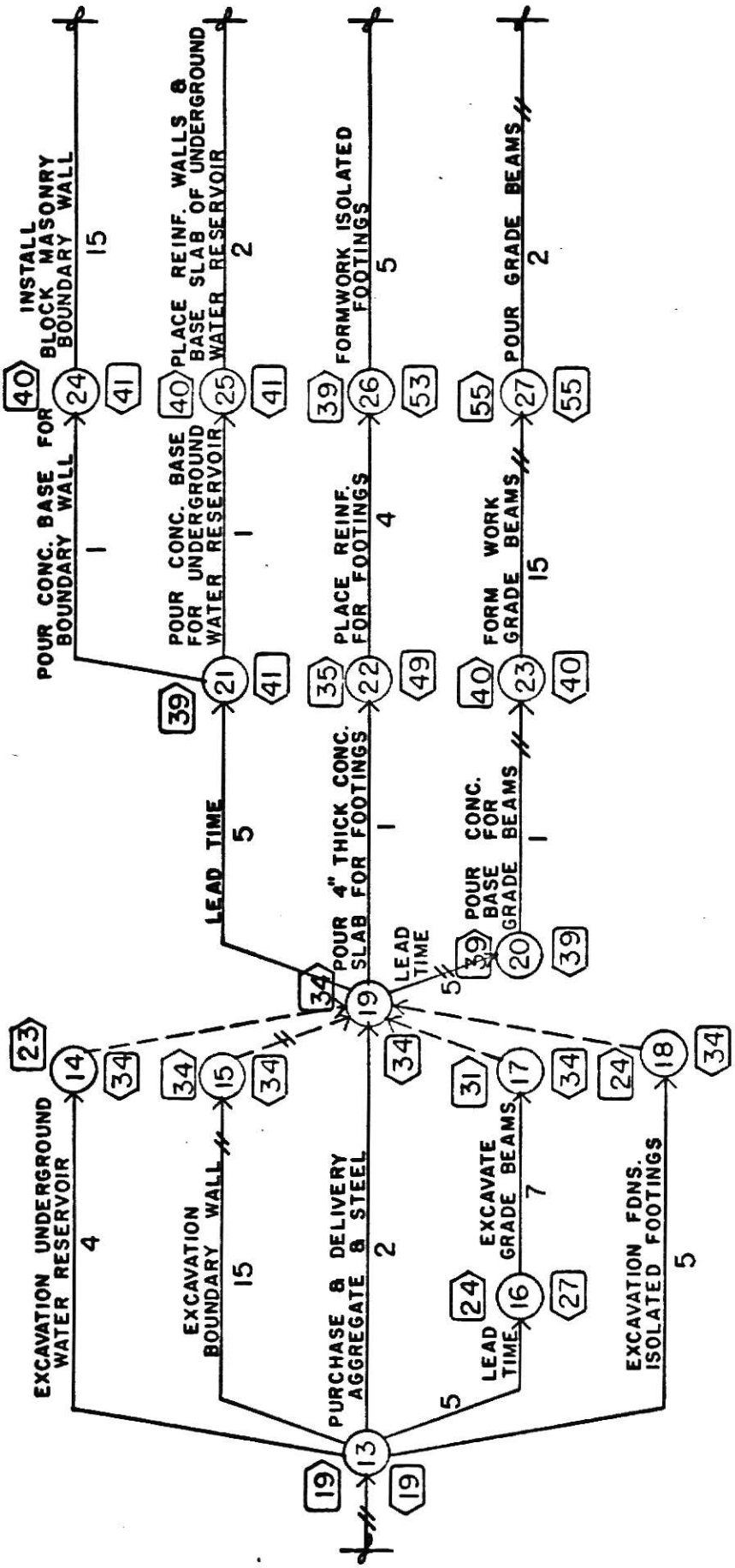

EXCAVATION UNDERGROUND WATER RESERVOIR
4
EXCAVATION BOUNDARY WALL
15
PURCHASE & DELIVERY AGGREGATE & STEEL
2
LEAD TIME
5
EXCAVATE GRADE BEAMS
7
EXCAVATION FDNS. ISOLATED FOOTINGS
5
POUR CONC. BASE FOR BOUNDARY WALL
1
POUR CONC. BASE FOR UNDERGROUND WATER RESERVOIR
1
POUR 4" THICK CONC. SLAB FOR FOOTINGS
1
PLACE REINF. FOR FOOTINGS
4
POUR CONC. BASE FOR GRADE BEAMS
1
FORM WORK GRADE BEAMS
15
INSTALL BLOCK MASONRY BOUNDARY WALL
15
PLACE REINF. WALLS & BASE SLAB OF UNDERGROUND WATER RESERVOIR
2
FORMWORK ISOLATED FOOTINGS
5
POUR GRADE BEAMS
2
LEAD TIME
5
LEAD TIME
5
LEAD TIME
24
LEAD TIME
5
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27

FIG. 5b

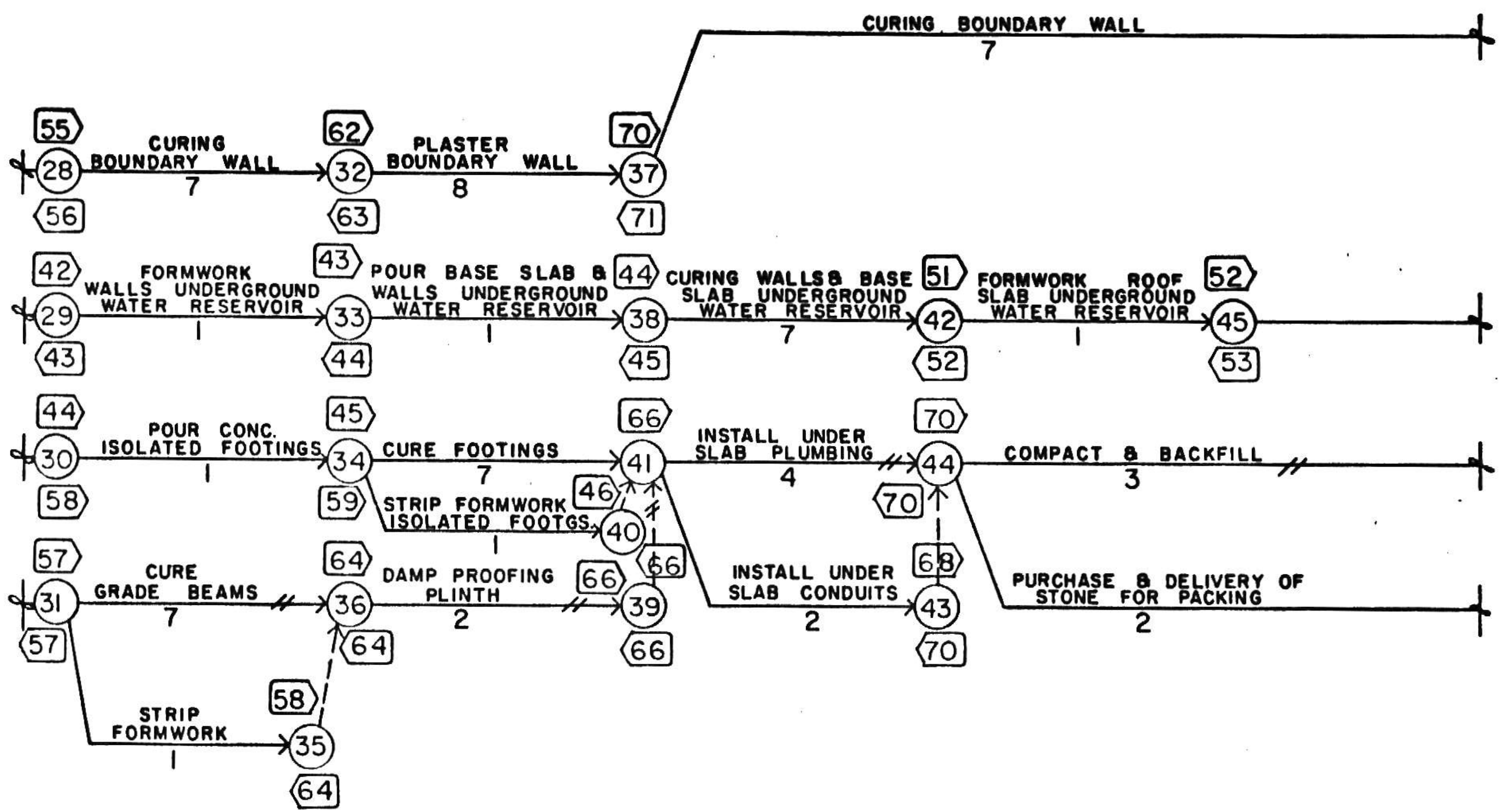

CURING BOUNDARY WALL
7
CURING BOUNDARY WALL
7
PLASTER BOUNDARY WALL
8
FORMWORK WALLS UNDERGROUND WATER RESERVOIR
1
POUR BASE SLAB & WALLS UNDERGROUND WATER RESERVOIR
1
CURING WALLS & BASE SLAB UNDERGROUND WATER RESERVOIR
7
FORMWORK ROOF SLAB UNDERGROUND WATER RESERVOIR
1
POUR CONC. ISOLATED FOOTINGS
1
CURE FOOTINGS
7
STRIP FORMWORK ISOLATED FOOTGS.
1
INSTALL UNDER SLAB PLUMBING
4
COMPACT & BACKFILL
3
CURE GRADE BEAMS
7
DAMP PROOFING PLINTH
2
INSTALL UNDER SLAB CONDUITS
2
PURCHASE & DELIVERY OF STONE FOR PACKING
2
STRIP FORMWORK
1

FIG. 5c

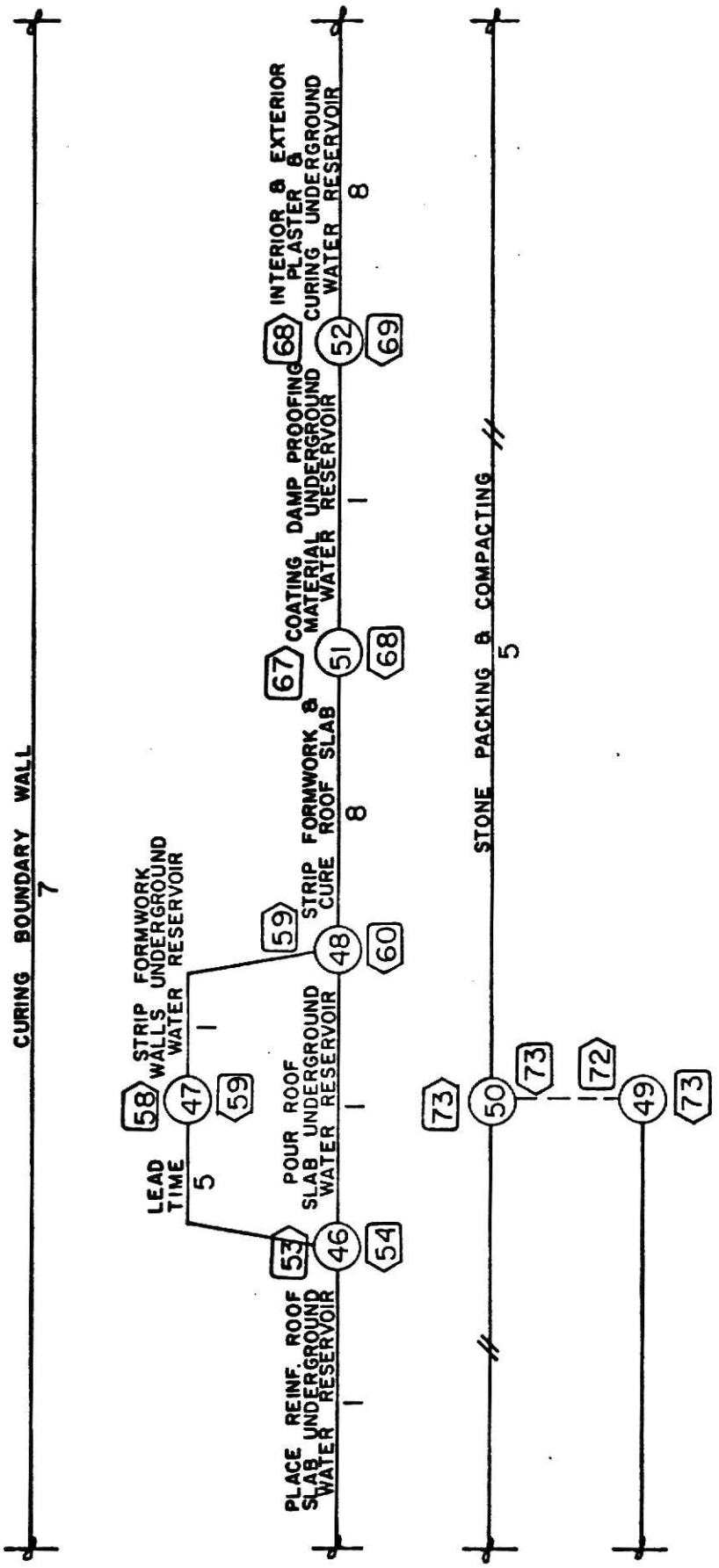

CURING BOUNDARY WALL
7
PLACE REINF. ROOF SLAB UNDERGROUND WATER RESERVOIR
1
53
46
54
LEAD TIME
5
POUR ROOF SLAB UNDERGROUND WATER RESERVOIR
1
58
STRIP FORMWORK WALLS UNDERGROUND WATER RESERVOIR
47
59
1
59
STRIP FORMWORK & ROOF SLAB CURE
8
48
60
67
COATING DAMP PROOFING MATERIAL UNDERGROUND WATER RESERVOIR
1
51
68
68
INTERIOR & EXTERIOR PLASTER & CURING UNDERGROUND WATER RESERVOIR
8
52
69
73
STONE PACKING & COMPACTING
5
50
73
73
72
49
73

FIG. 5d

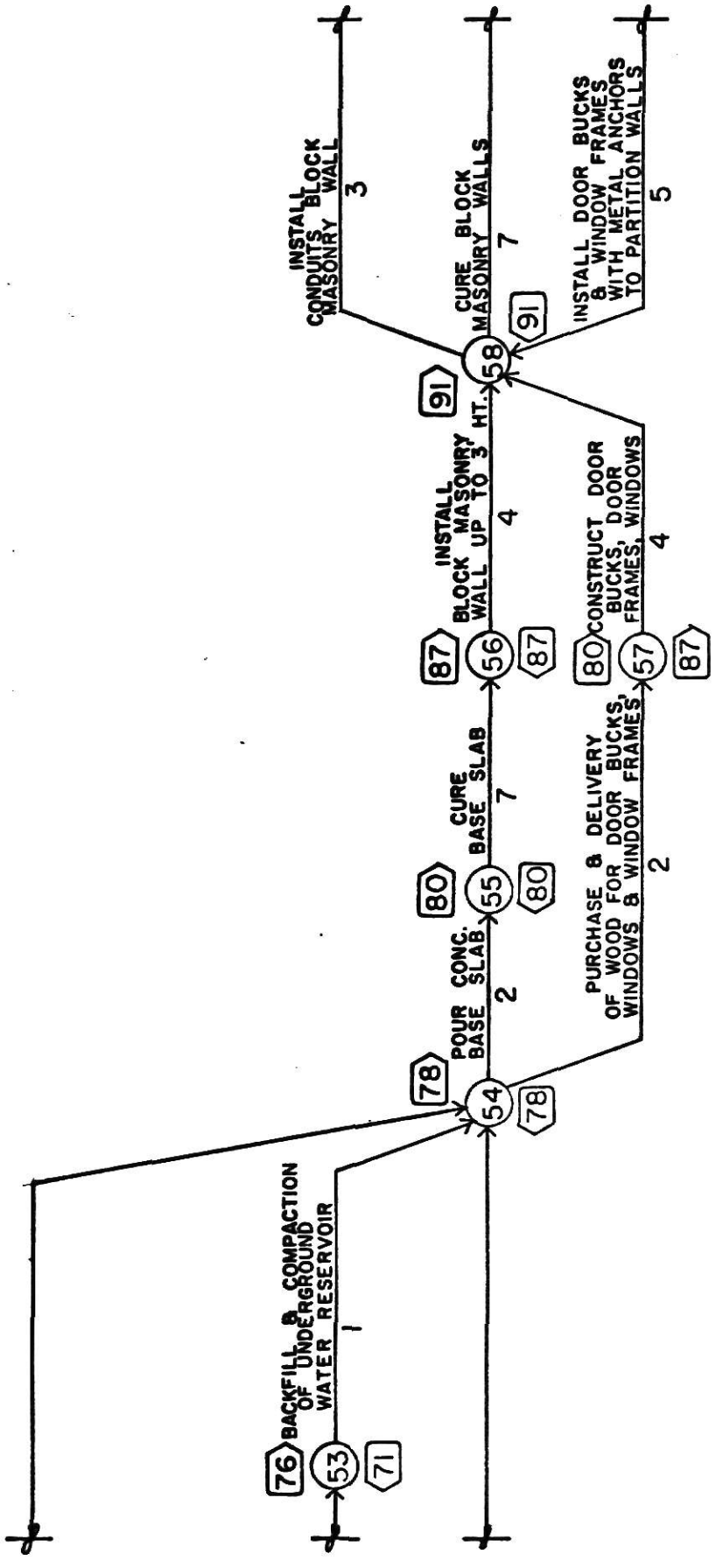

BACKFILL & COMPACTION OF UNDERGROUND WATER RESERVOIR
1
POUR CONC. BASE SLAB
2
CURE BASE SLAB
7
INSTALL BLOCK MASONRY WALL UP TO 3' HT.
4
INSTALL CONDUITS BLOCK MASONRY WALL
3
CURE BLOCK MASONRY WALLS
7
INSTALL DOOR BUCKS & WINDOW FRAMES WITH METAL ANCHORS TO PARTITION WALLS
5
PURCHASE & DELIVERY OF WOOD FOR DOOR BUCKS, WINDOWS & WINDOW FRAMES
2
CONSTRUCT DOOR BUCKS, DOOR FRAMES, WINDOWS
4
53
54
55
56
57
58
71
78
80
87
91

FIG. 5e

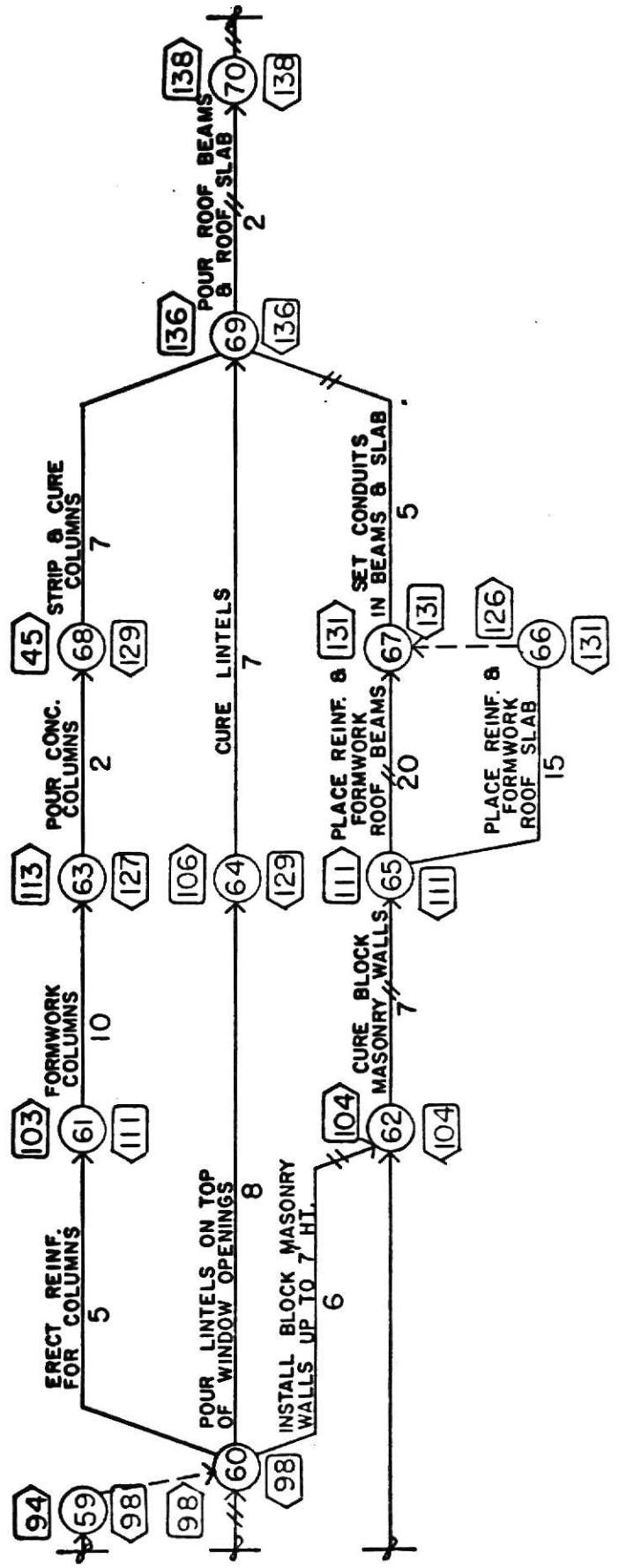

94
59
98
98
60
98
ERECT REINF. FOR COLUMNS
5
103
61
111
FORMWORK COLUMNS
10
113
63
127
POUR CONC. COLUMNS
2
45
68
129
STRIP & CURE COLUMNS
7
136
69
136
POUR ROOF BEAMS & ROOF SLAB
2
138
70
138
POUR LINTELS ON TOP OF WINDOW OPENINGS
8
106
64
129
CURE LINTELS
7
INSTALL BLOCK MASONRY WALLS UP TO 7' HT.
6
104
62
104
CURE BLOCK MASONRY WALLS
7
111
65
111
PLACE REINF. & FORMWORK ROOF BEAMS
20
131
67
131
SET CONDUITS IN BEAMS & SLAB
5
PLACE REINF. & FORMWORK ROOF SLAB
15
126
66
131

FIG. 5f

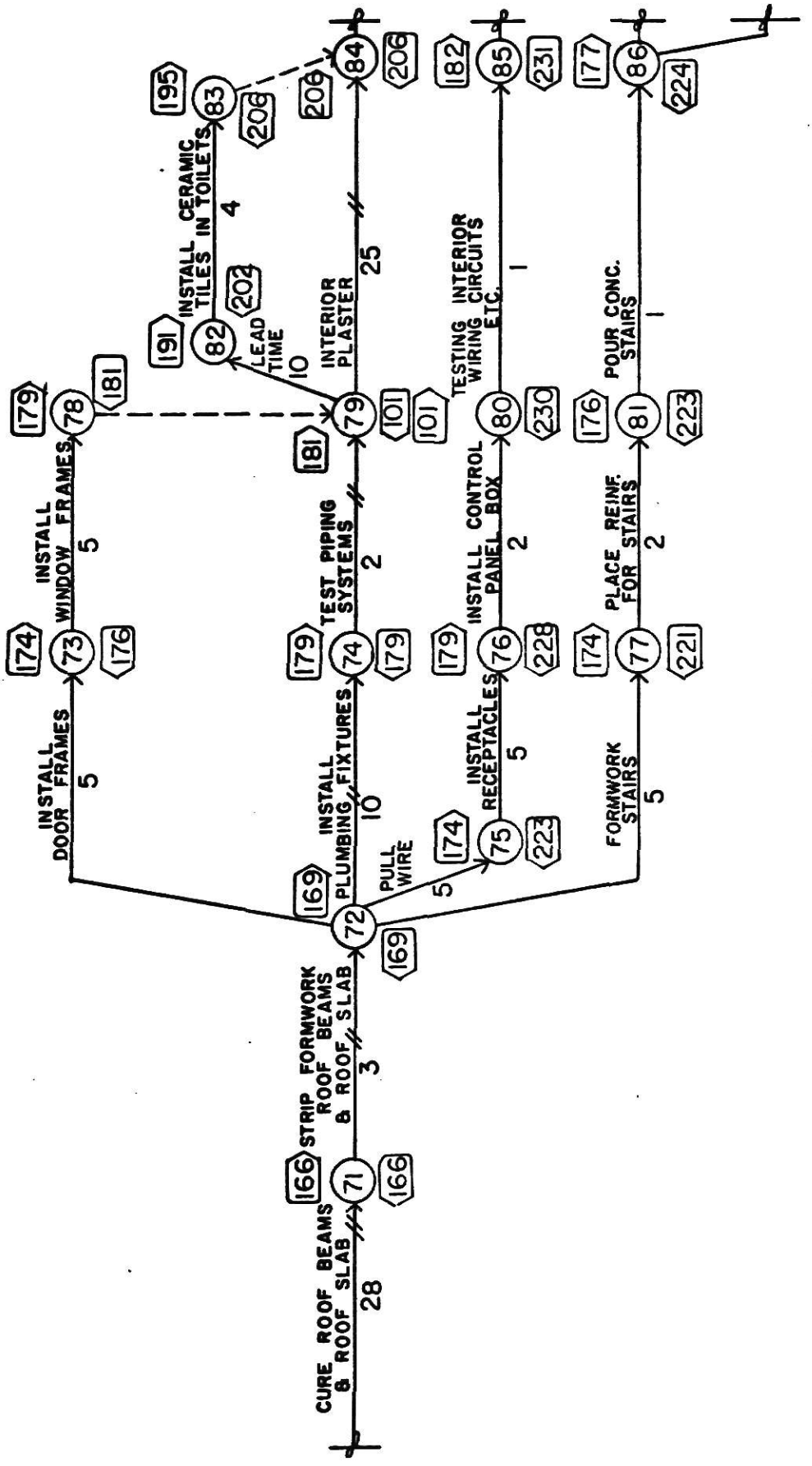

CURE ROOF BEAMS & ROOF SLAB
28
71
166
166
STRIP FORMWORK ROOF BEAMS & ROOF SLAB
3
72
169
169
PULL WIRE
5
75
174
223
INSTALL RECEPTACLES
5
76
179
228
INSTALL PLUMBING FIXTURES
10
74
179
179
TEST PIPING SYSTEMS
2
79
181
101
101
INTERIOR PLASTER
25
84
206
206
INSTALL CERAMIC TILES IN TOILETS
4
83
195
206
LEAD TIME
10
82
191
202
INSTALL DOOR FRAMES
5
73
174
176
INSTALL WINDOW FRAMES
5
78
179
181
FORMWORK STAIRS
5
77
174
221
PLACE REINF. FOR STAIRS
2
81
176
223
INSTALL CONTROL PANEL BOX
2
80
179
230
TESTING INTERIOR WIRING CIRCUITS ETC.
1
85
182
231
POUR CONC. STAIRS
1
86
177
224

FIG. 5g

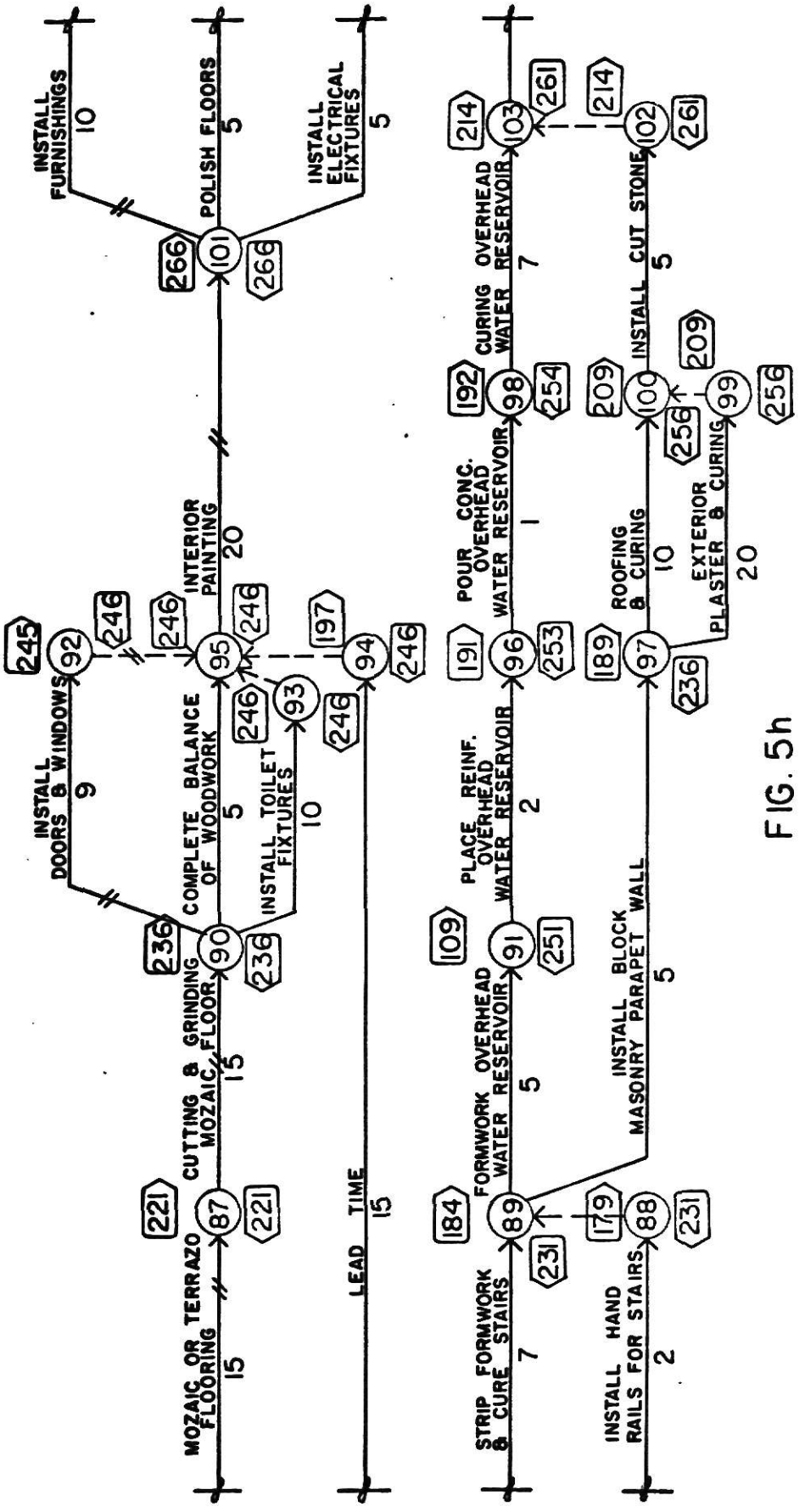

MOZAIC OR TERRAZO FLOORING
15
CUTTING & GRINDING MOZAIC FLOOR
15
COMPLETE BALANCE OF WOODWORK
5
INSTALL DOORS & WINDOWS
9
INSTALL TOILET FIXTURES
10
INTERIOR PAINTING
20
POLISH FLOORS
5
INSTALL FURNISHINGS
10
INSTALL ELECTRICAL FIXTURES
5
LEAD TIME
15
STRIP FORMWORK & CURE STAIRS
7
FORMWORK OVERHEAD WATER RESERVOIR
5
PLACE REINF. OVERHEAD WATER RESERVOIR
2
POUR CONC. OVERHEAD WATER RESERVOIR
1
CURING OVERHEAD WATER RESERVOIR
7
INSTALL HAND RAILS FOR STAIRS
2
INSTALL BLOCK MASONRY PARAPET WALL
5
ROOFING & CURING
10
EXTERIOR PLASTER & CURING
20
INSTALL CUT STONE
5
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
184
221
231
236
245
246
197
191
253
189
179
109
251
192
254
209
256
214
261
266

FIG. 5h

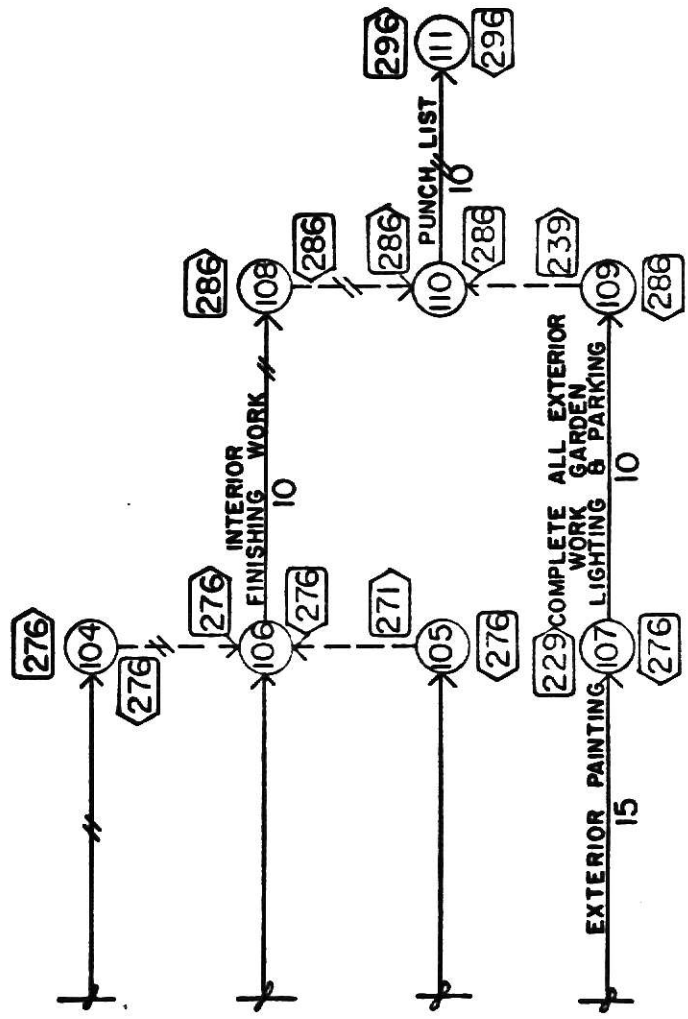

276
104
276
276
106
276
INTERIOR FINISHING WORK
10
271
105
276
286
108
286
286
110
286
296
111
296
PUNCH LIST
10
239
109
286
229
COMPLETE WORK LIGHTING
107
276
ALL EXTERIOR GARDEN & PARKING
10
EXTERIOR PAINTING
15

FIG. 5i

FINDING THE CRITICAL PATH AND COMPUTATIONS OF EARLY START, LATE START, EARLY FINISH AND LATE FINISH TIMES

Once the arrow network has been constructed as shown in Fig. 5a to Fig. 5i and the durations specified, the critical path, early start, late start, early finish, total float and free float are determined with the help of a computer program. The results are tabulated under Table 2. Another program is used to sort out the activities in a sequential order with respect to time, i.e., according to early start times, late start times and late finish times and the output is listed in Tables 3a to 3f. Calculations are also performed by hand in order to check with the results obtained by computer and they are listed under Table 1.

DATA ACTIVITY LIST

	DESCRIPTION	NODE NO.	DURATIONS
1.	Move In	1,2	3
2.	Survey, Layout and Mobilization	2,3	2
3.	Rough Grading	3,4	5
4.	Overhead Pole Line	4,5	2
5.	Underground Piping from Main Line	4,6	1
6.	Water Tank Foundations	4,7	4
7.	Excavations for Sewers and Manholes	4,8	2
8.	Pull In Power Feeder	5,9	1
9.	Connect Piping	6,12	2
10.	Erect Water Tank	7,10	2
11.	Install Sewers and Manholes	8,11	3
12.	Install Control Panel Box	9,12	1
13.	Tank Piping and Walls	10,12	1
14.	Backfill	11,12	1
15.	Building Layout	12,13	2
16.	Excavation Ungr. Water Reser.	13,14	4
17.	Excavation Boundary Wall	13,15	15
18.	Purchase & Delivery of Aggregate & Steel	13,19	2
19.	Lead Time	13,16	5
20.	Excavation Foundations Isolated Footings	13,18	5
21.	Dummy	14,19	0
22.	Dummy	15,19	0
23.	Excavation Grade Beams	16,17	7
24.	Dummy	17,19	0
25.	Dummy	18,19	0
26.	Lead Time	19,20	5
27.	Lead Time	19,21	5
28.	Pour 4" Thick Conc. Slab for Footings	19,22	1
29.	Pour Grade Beams Base Layer	20,23	1
30.	Pour Conc. Base for Boundary Wall	21,24	1
31.	Pour Conc. Base for Ungr. Water Reser.	21,25	1
32.	Place Reinf. for Footings	22,26	4
33.	Formwork Grade Beams	23,27	15
34.	Install Block Masonry Boundary Wall	24,28	15
35.	Place Reinf. for Base Slab & Wall Ungr. Water Reservoir	25,29	2
36.	Formwork Isolated Footings	26,30	5
37.	Pour Grade Beams	27,31	2
38.	Curing Boundary Wall	28,32	7
39.	Formwork Wall Ungr. Water Reservoir	29,33	1
40.	Pour Conc. Isolated Footings	30,34	1
41.	Strip Formwork	31,35	1
42.	Cure Grade Beams	31,36	7
43.	Plaster Boundary Walls	32,37	8
44.	Pour Base Slab & Walls Ungr. Wtr. Reser.	33,38	1
45.	Strip Formwork Isolated Footings	34,40	1
46.	Cure Footings	34,41	7
47.	Dummy	35,36	0
48.	Damp Proofing of Plinth	36,39	2

	DESCRIPTION	NODE NO.	DURATIONS
49.	Curing Boundary Wall	37,54	7
50.	Cure Base Slab & Walls Ungr. Wtr. Reser.	38,42	7
51.	Dummy	39,41	0
52.	Dummy	40,41	0
53.	Install Ungr. Slab Conduits	41,43	2
54.	Install Ungr. Plumbing	41,44	4
55.	Formwork Roof Slab Ungr. Wtr. Reser.	42,45	1
56.	Dummy	43,44	0
57.	Purchase & Delivery of Stone for Packing	44,49	2
58.	Compact and Backfill	44,50	3
59.	Place Reinf. Roof Slab Ungr. Wtr. Reser.	45,46	1
60.	Lead Time	46,47	5
61.	Pour Roof Slab Ungr. Wtr. Reser.	46,48	1
62.	Strip Formwork Walls Ungr. Wtr. Reser.	47,48	1
63.	Strip Formwork and Cure Roof Slab	48,51	8
64.	Dummy	49,50	0
65.	Stone Packing and Compaction	50,54	5
66.	Coating Damp Proofing Material Ungr. Wtr. Reservoir	51,52	1
67.	Interior & Exterior Plaster & Curing Ungr. Wtr. Reservoir	52,53	8
68.	Backfill & Compaction (Ungr. Wtr. Reser.)	53,54	1
69.	Pour Conc. Base Slab	54,55	2
70.	Purchase & Delivery of Wood for Dr. Bucks, Dr. Frames, Windows & Window Frames	54,57	2
71.	Cure Base Slab	55,56	7
72.	Install Block Masonry Walls up to 3' Ht.	56,58	4
73.	Construct Dr. Bucks, Dr. Frames, Windows and Window Frames	57,58	4
74.	Install Conduits in Block Masonry Walls	58,59	3
75.	Cure Block Masonry Walls	58,60	7
76.	Install Dr. Bucks & Window Frames With Metal Anchors to Partition Wall	58,62	5
77.	Dummy	59,60	0
78.	Erect Reinf. for Columns	60,61	5
79.	Install Block Masonry Walls up to 7' Height (Partition Walls)	60,62	6
80.	Pour Lintels on Top of Window Openings	60,64	8
81.	Formwork Columns	61,63	10
82.	Cure Block Masonry Walls	62,65	7
83.	Pour Conc. in Columns	63,68	2
84.	Cure Lintels	64,69	7
85.	Formwork Roof Slab & Placing Reinf.	65,66	15
86.	Formwork Roof Beams & Placing Reinf.	65,67	20
87.	Dummy	66,67	0
88.	Set Conduits in Beam & Slabs	67,69	5
89.	Strip and Cure Columns	68,69	7
90.	Pour Roof Beam and Roof Slab	69,70	2
91.	Cure Roof Slab & Roof Beams	70,71	28
92.	Strip Formwork Roof Slab and Roof Beams	71,72	3
93.	Install Door Frames	72,73	5
94.	Install Plumbing Fixtures	72,74	10
95.	Pull Wire	72,75	5

	DESCRIPTION	NODE NO.	DURATIONS
96.	Formwork Stairs	72,77	5
97.	Install Window Frames	73,78	5
98.	Test Piping Systems	74,79	2
99.	Install Receptacles	75,76	5
100.	Install Control Panel Box	76,80	2
101.	Place Reinf. for Stairs	77,81	2
102.	Dummy	78,79	0
103.	Lead Time	79,82	10
104.	Interior Plaster	79,84	25
105.	Testing Interior Wiring Circuits, etc.	80,85	1
106.	Pour Conc. Stairs	81,86	1
107.	Install Ceramic Tiles in Toilets	82,83	4
108.	Dummy	83,84	0
109.	Mozaic or Terrazo Flooring	84,87	15
110.	Lead Time	85,94	15
111.	Install Hand Rails for Stairs	86,88	2
112.	Strip Formwork and Cure Stairs	86,89	7
113.	Cutting & Grinding Mozaic Floor	87,90	15
114.	Dummy	88,89	0
115.	Formwork Overhead Wtr. Reser.	89,91	5
116.	Install Block Masonry Parapet Wall	89,97	5
117.	Install Doors and Windows	90,92	9
118.	Install Toilet Fixtures	90,93	10
119.	Complete Balance of Woodwork	90,95	5
120.	Place Reinf. for Overhead Wtr. Reser.	91,96	2
121.	Dummy	92,95	0
122.	Dummy	93,95	0
123.	Dummy	94,95	0
124.	Interior Painting	95,101	20
125.	Pour Conc. Overhead Water Reser.	96,98	1
126.	Exterior Plaster & Curing including Overhead Wtr. Reser.	97,99	20
127.	Roofing & Curing	97,100	10
128.	Curing Overhead Wtr. Reservoir	98,103	7
129.	Dummy	99,100	0
130.	Install Cut stone	100,102	5
131.	Install Furnishings	101,104	10
132.	Install Electrical Fixtures	101,105	5
133.	Polish Floors	101,106	5
134.	Dummy	102,103	0
135.	Exterior Painting	103,107	15
136.	Dummy	104,106	0
137.	Dummy	105,106	0
138.	Interior Finishing Work	106,108	10
139.	Complete all Exterior Work (Gate, Garden, Lighting, Parking)	107,109	10
140.	Dummy	108,110	0
141.	Dummy	109,110	0
142.	Punchlist	110,111	10

CRITICAL PATH SCHEDULING

Calculations performed by hand.
Activities on the critical path are indicated by *.

TABLE 1

	NO.	I	J	DUR	EST	LST	EFT	LFT	TF	FF
*	1	1	2	3	0	0	3	3	0	0
*	2	2	3	2	3	3	5	5	0	0
*	3	3	4	5	5	5	10	10	0	0
	4	4	5	2	10	13	12	15	3	0
	5	4	6	1	10	14	11	15	4	0
*	6	4	7	4	10	10	14	14	0	0
	7	4	8	2	10	11	12	13	1	0
	8	5	9	1	12	15	13	16	3	0
	9	6	12	2	11	15	13	17	4	4
*	10	7	10	2	14	14	16	16	0	0
	11	8	11	3	12	13	15	16	1	0
	12	9	12	1	13	16	14	17	3	3
*	13	10	12	1	16	16	17	17	0	0
	14	11	12	1	15	16	16	17	1	1
	15	12	13	2	17	17	19	19	0	0
	16	13	14	4	19	30	23	34	11	0
*	17	13	15	15	19	19	34	34	0	0
	18	13	19	2	19	32	21	34	13	13
	19	13	16	5	19	22	24	27	3	0
	20	13	18	5	19	29	24	34	10	0
	21	14	19	0	23	34	23	34	11	11
*	22	15	19	0	34	34	34	34	0	0
	23	16	17	7	24	27	31	34	3	0
	24	17	19	0	31	34	31	34	3	3
	25	18	19	0	24	34	24	34	10	10
*	26	19	20	5	34	34	39	39	0	0
	27	19	21	5	34	35	39	40	1	0
	28	19	22	1	34	48	35	49	14	0
*	29	20	23	1	39	39	40	40	0	0
	30	21	24	1	39	40	40	41	1	0
	31	21	25	1	39	40	40	41	1	0
	32	22	26	4	35	49	39	53	14	0
*	33	23	27	15	40	40	55	55	0	0
	34	24	28	15	40	41	55	56	1	0
	35	25	29	2	40	41	42	43	1	0
	36	26	30	5	39	53	44	58	14	0
*	37	27	31	2	55	55	57	57	0	0
	38	28	32	7	55	56	62	63	1	0
	39	29	33	1	42	43	43	44	1	0
	40	30	34	1	44	58	45	59	14	0
	41	31	35	1	57	63	58	64	6	0
*	42	31	36	7	57	57	64	64	0	0
	43	32	37	8	62	63	70	71	1	0
	44	33	38	1	43	44	44	45	1	0
	45	34	40	1	45	65	46	66	20	0

	NO.	I	J	DUR	EST	LST	EFT	LFT	TF	FF
	46	34	41	7	45	59	52	66	14	14
	47	35	36	0	58	64	58	64	6	6
*	48	36	39	2	64	64	66	66	0	0
	49	37	54	7	70	71	77	78	1	1
	50	38	42	7	44	45	51	52	1	0
*	51	39	41	0	66	66	66	66	0	0
	52	40	41	0	46	66	46	66	20	20
	53	41	43	2	66	68	68	70	2	0
*	54	41	44	4	66	66	70	70	0	0
	55	42	45	1	51	52	52	53	1	0
	56	43	44	0	68	70	68	70	2	2
	57	44	49	2	70	71	72	73	1	0
*	58	44	50	3	70	70	73	73	0	0
	59	45	46	1	52	53	53	54	1	0
	60	46	47	5	53	54	58	59	1	0
	61	46	48	1	53	59	54	60	6	5
	62	47	48	1	58	59	59	60	1	0
	63	48	51	8	59	60	67	68	1	0
	64	49	50	0	72	73	72	73	1	1
*	65	50	54	5	73	73	78	78	0	0
	66	51	52	1	67	68	68	69	1	0
	67	52	53	8	68	69	76	77	1	0
	68	53	54	1	76	77	77	78	1	1
*	69	54	55	2	78	78	80	80	0	0
	70	54	57	2	78	85	80	87	7	0
*	71	55	56	7	80	80	87	87	0	0
*	72	56	58	4	87	87	91	91	0	0
	73	57	58	4	80	87	84	91	7	7
	74	58	59	3	91	95	94	98	4	0
*	75	58	60	7	91	91	98	98	0	0
	76	58	62	5	91	99	96	104	8	8
	77	59	60	0	94	98	94	98	4	4
	78	60	61	5	98	112	103	117	14	0
*	79	60	62	6	98	98	104	104	0	0
	80	60	64	8	98	121	106	129	23	0
	81	61	63	10	103	117	113	127	14	0
*	82	62	65	7	104	104	111	111	0	0
	83	63	68	2	113	127	115	129	14	0
	84	64	69	7	106	129	113	136	23	23
	85	65	66	15	111	116	126	131	5	0
*	86	65	67	20	111	111	131	131	0	0
	87	66	67	0	126	131	126	131	5	5
*	88	67	69	5	131	131	136	136	0	0
	89	68	69	7	115	129	122	136	14	14
*	90	69	70	2	136	136	138	138	0	0
*	91	70	71	28	138	138	166	166	0	0
*	92	71	72	3	166	166	169	169	0	0
	93	72	73	5	169	171	174	176	2	0
*	94	72	74	10	169	169	179	179	0	0
	95	72	75	5	169	218	174	223	49	0
	96	72	77	5	169	216	174	221	47	0
	97	73	78	5	174	176	179	181	2	0

	NO.	I	J	DUR	EST	LST	EFT	LFT	TF	FF
*	98	74	79	2	179	179	181	181	0	0
	99	75	76	5	174	223	179	228	49	0
	100	76	80	2	179	228	181	230	49	0
	101	77	81	2	174	221	176	223	47	0
	102	78	79	0	179	181	179	181	2	2
	103	79	82	10	181	192	191	202	11	0
*	104	79	84	25	181	181	206	206	0	0
	105	80	85	1	181	230	182	231	49	0
	106	81	86	1	176	223	177	224	47	0
	107	82	83	4	191	202	195	206	11	0
	108	83	84	0	195	206	195	206	11	11
*	109	84	87	15	206	206	221	221	0	0
	110	85	94	15	182	231	197	246	49	0
	111	86	88	2	177	229	179	231	52	0
	112	86	89	7	177	224	184	231	47	0
*	113	87	90	15	221	221	236	236	0	0
	114	88	89	0	179	231	179	231	52	5
	115	89	91	5	184	246	189	251	62	0
	116	89	97	5	184	231	189	236	47	0
	117	90	92	9	236	237	245	246	1	0
*	118	90	93	10	236	236	246	246	0	0
	119	90	95	5	236	241	241	246	5	5
	120	91	96	2	189	251	191	253	62	0
	121	92	95	0	245	246	245	246	1	1
*	122	93	95	0	246	246	246	246	0	0
	123	94	95	0	197	246	197	246	49	49
*	124	95	101	20	246	246	266	266	0	0
	125	96	98	1	191	253	192	254	62	0
	126	97	99	20	189	236	209	256	47	0
	127	97	100	10	189	246	199	256	57	10
	128	98	103	7	192	254	199	261	62	15
	129	99	100	0	209	256	209	256	47	0
	130	100	102	5	209	256	214	261	47	0
*	131	101	104	10	266	266	276	276	0	0
	132	101	105	5	266	271	271	276	5	0
	133	101	106	5	266	271	271	276	5	5
	134	102	103	0	214	261	214	261	47	0
	135	103	107	15	214	261	229	276	47	0
*	136	104	106	0	276	276	276	276	0	0
	137	105	106	0	271	276	271	276	5	5
*	138	106	108	10	276	276	286	286	0	0
	139	107	109	10	229	276	239	286	47	0
*	140	108	110	0	286	286	286	286	0	0
	141	109	110	0	239	286	239	286	47	47
	142	110	111	10	286	286	296	296	0	0

Total Time on Critical Path is 296 days.
Results obtained from hand computations agree with the ones obtained by computer.

TABLE 2

$ENTRY

CRITICAL PATH SCHEDULING

	NO.	I	J	DUR	EST	LST	EFT	LFT	TF	FF
*	1	1	2	3.00	0.00	0.00	3.00	3.00	0.00	0.00
*	2	2	3	2.00	3.00	3.00	5.00	5.00	0.00	0.00
*	3	3	4	5.00	5.00	5.00	10.00	10.00	0.00	0.00
	4	4	5	2.00	10.00	13.00	12.00	15.00	3.00	0.00
	5	4	6	1.00	10.00	14.00	11.00	15.00	4.00	0.00
*	6	4	7	4.00	10.00	10.00	14.00	14.00	0.00	0.00
	7	4	9	2.00	10.00	11.00	12.00	13.00	1.00	0.00
	8	5	9	1.00	12.00	15.00	13.00	16.00	3.00	0.00
	9	6	12	2.00	11.00	15.00	13.00	17.00	4.00	4.00
*	10	7	10	2.00	14.00	14.00	16.00	16.00	0.00	0.00
	11	8	11	3.00	12.00	13.00	15.00	16.00	1.00	0.00
	12	9	12	1.00	13.00	16.00	14.00	17.00	3.00	3.00
*	13	10	12	1.00	16.00	16.00	17.00	17.00	0.00	0.00
	14	11	12	1.00	15.00	16.00	16.00	17.00	1.00	1.00
*	15	12	13	2.00	17.00	17.00	19.00	19.00	0.00	0.00
	16	13	14	4.00	19.00	30.00	23.00	34.00	11.00	0.00
*	17	13	15	15.00	19.00	19.00	34.00	34.00	0.00	0.00
	18	13	19	2.00	19.00	32.00	21.00	34.00	13.00	13.00
	19	13	16	5.00	19.00	22.00	24.00	27.00	3.00	0.00
	20	13	18	5.00	19.00	29.00	24.00	34.00	11.00	0.00
	21	14	19	0.00	23.00	34.00	23.00	34.00	11.00	11.00

•	22	15	19	0.00	34.00	34.00	34.00	34.00	0.00	0.00
	23	16	17	7.00	24.00	27.00	31.00	34.00	3.00	0.00
	24	17	19	0.00	31.00	34.00	31.00	34.00	3.00	3.00
	25	18	19	0.00	24.00	34.00	24.00	34.00	10.00	10.00
•	26	19	20	5.00	34.00	34.00	39.00	39.00	0.00	0.00
	27	19	21	5.00	34.00	35.00	39.00	40.00	1.00	0.00
	28	19	22	1.00	34.00	48.00	35.00	49.00	14.00	0.00
•	29	20	23	1.00	39.00	39.00	40.00	40.00	0.00	0.00
	30	21	24	1.00	39.00	40.00	40.00	41.00	1.00	0.00
	31	21	25	1.00	39.00	40.00	40.00	41.00	1.00	0.00
	32	22	26	4.00	35.00	49.00	39.00	53.00	14.00	0.00
•	33	23	27	15.00	40.00	40.00	55.00	55.00	0.00	0.00
	34	24	28	15.00	40.00	41.00	55.00	56.00	1.00	0.00
	35	25	29	2.00	40.00	41.00	42.00	43.00	1.00	0.00
	36	25	30	5.00	39.00	53.00	44.00	58.00	14.00	0.00
•	37	27	31	2.00	55.00	55.00	57.00	57.00	0.00	0.00
	38	28	32	7.00	55.00	56.00	62.00	63.00	1.00	0.00
	39	29	33	1.00	42.00	43.00	43.00	44.00	1.00	0.00
	40	30	34	1.00	44.00	58.00	45.00	59.00	14.00	0.00
	41	31	35	1.00	57.00	63.00	58.00	64.00	6.00	0.00
•	42	31	36	7.00	57.00	57.00	64.00	64.00	0.00	0.00
	43	32	37	8.00	62.00	63.00	70.00	71.00	1.00	0.00
	44	33	38	1.00	43.00	44.00	44.00	45.00	1.00	0.00
	45	34	40	1.00	45.00	65.00	46.00	66.00	20.00	0.00
	46	34	41	7.00	45.00	59.00	52.00	66.00	14.00	14.00
	47	35	36	0.00	58.00	64.00	58.00	64.00	6.00	6.00
•	48	36	39	2.00	64.00	64.00	66.00	66.00	0.00	0.00
	49	37	54	7.00	70.00	71.00	77.00	78.00	1.00	1.00
	50	38	42	7.00	44.00	45.00	51.00	52.00	1.00	0.00
•	51	39	41	0.00	66.00	66.00	66.00	66.00	0.00	0.00
	52	40	41	0.00	46.00	66.00	46.00	66.00	20.00	20.00
	53	41	43	2.00	66.00	68.00	68.00	70.00	2.00	0.00
•	54	41	44	4.00	66.00	66.00	70.00	70.00	0.00	0.00
	55	42	45	1.00	51.00	52.00	52.00	53.00	1.00	0.00
	56	43	46	0.00	68.00	70.00	68.00	70.00	2.00	2.00
	57	44	49	2.00	70.00	71.00	72.00	73.00	1.00	0.00
•	58	44	50	3.00	70.00	70.00	73.00	73.00	0.00	0.00
	59	45	46	1.00	52.00	53.00	53.00	54.00	1.00	0.00
	60	46	47	5.00	53.00	54.00	58.00	59.00	1.00	0.00
	61	46	48	1.00	53.00	59.00	54.00	60.00	6.00	5.00
	62	47	48	1.00	58.00	59.00	59.00	60.00	1.00	0.00
	63	48	51	8.00	59.00	60.00	67.00	68.00	1.00	0.00
	64	49	50	0.00	72.00	73.00	72.00	73.00	1.00	1.00
•	65	50	54	5.00	73.00	73.00	78.00	78.00	0.00	0.00
	66	51	52	1.00	67.00	68.00	68.00	69.00	1.00	0.00
	67	52	53	8.00	68.00	69.00	76.00	77.00	1.00	0.00
	68	53	54	1.00	76.00	77.00	77.00	78.00	1.00	1.00
•	69	54	55	2.00	78.00	78.00	80.00	80.00	0.00	0.00
	70	54	57	2.00	78.00	85.00	80.00	87.00	7.00	0.00
•	71	55	56	7.00	80.00	80.00	87.00	87.00	0.00	0.00
•	72	56	58	4.00	87.00	87.00	91.00	91.00	0.00	0.00
	73	57	58	4.00	80.00	87.00	84.00	91.00	7.00	7.00
	74	58	59	3.00	91.00	95.00	94.00	98.00	4.00	0.00
•	75	58	60	7.00	91.00	91.00	98.00	98.00	0.00	0.00
	76	58	62	5.00	91.00	99.00	96.00	104.00	8.00	8.00
	77	59	60	0.00	94.00	98.00	94.00	98.00	4.00	4.00
	78	60	61	5.00	98.00	112.00	103.00	117.00	14.00	0.00
•	79	60	62	6.00	98.00	98.00	104.00	104.00	0.00	0.00
	80	60	64	8.00	98.00	121.00	106.00	129.00	23.00	0.00
	81	61	63	10.00	103.00	117.00	113.00	127.00	14.00	0.00

*	82	62	65	7.00	104.00	104.00	111.00	111.00	0.00	0.00
	83	63	68	2.00	113.00	127.00	115.00	129.00	14.00	0.00
	84	64	69	7.00	106.00	129.00	113.00	136.00	23.00	23.00
	85	65	66	15.00	111.00	116.00	126.00	131.00	5.00	0.00
*	86	65	67	20.00	111.00	111.00	131.00	131.00	0.00	0.00
	87	66	67	0.00	126.00	131.00	126.00	131.00	5.00	5.00
*	88	67	69	5.00	131.00	131.00	136.00	136.00	0.00	0.00
	89	68	69	7.00	115.00	129.00	122.00	136.00	14.00	14.00
*	90	69	70	2.00	136.00	136.00	138.00	138.00	0.00	0.00
*	91	70	71	28.00	138.00	138.00	166.00	166.00	0.00	0.00
*	92	71	72	3.00	166.00	166.00	169.00	169.00	0.00	0.00
	93	72	73	5.00	169.00	171.00	174.00	176.00	2.00	0.00
*	94	72	74	10.00	169.00	169.00	179.00	179.00	0.00	0.00
	95	72	75	5.00	169.00	218.00	174.00	223.00	49.00	0.00
	96	72	77	5.00	169.00	216.00	174.00	221.00	47.00	0.00
	97	73	78	5.00	174.00	176.00	179.00	181.00	2.00	0.00
*	98	74	77	2.00	179.00	179.00	181.00	181.00	0.00	0.00
	99	75	76	5.00	174.00	223.00	179.00	228.00	49.00	0.00
	100	76	80	2.00	179.00	228.00	181.00	230.00	49.00	0.00
	101	77	81	2.00	174.00	221.00	176.00	223.00	47.00	0.00
	102	78	79	0.00	179.00	181.00	179.00	181.00	2.00	2.00
	103	79	82	10.00	181.00	192.00	191.00	202.00	11.00	0.00
*	104	79	84	25.00	181.00	181.00	206.00	206.00	0.00	0.00
	105	80	85	1.00	181.00	230.00	182.00	231.00	49.00	0.00
	106	81	86	1.00	176.00	223.00	177.00	224.00	47.00	0.00
	107	82	83	4.00	191.00	202.00	195.00	206.00	11.00	0.00
	108	83	84	0.00	195.00	206.00	195.00	206.00	11.00	11.00
*	109	84	87	15.00	206.00	206.00	221.00	221.00	0.00	0.00
	110	85	84	15.00	182.00	231.00	197.00	246.00	49.00	0.00
	111	86	88	2.00	177.00	229.00	179.00	231.00	52.00	0.00
	112	86	89	7.00	177.00	224.00	184.00	231.00	47.00	0.00
*	113	87	90	15.00	221.00	221.00	236.00	236.00	0.00	0.00
	114	88	89	0.00	179.00	231.00	179.00	231.00	52.00	5.00
	115	89	91	5.00	184.00	246.00	189.00	251.00	62.00	0.00
	116	89	87	5.00	184.00	231.00	189.00	236.00	47.00	0.00
	117	90	92	9.00	236.00	237.00	245.00	246.00	1.00	0.00
*	118	90	93	10.00	236.00	236.00	246.00	246.00	0.00	0.00
	119	90	95	5.00	236.00	241.00	241.00	246.00	5.00	5.00
	120	91	94	2.00	189.00	251.00	191.00	253.00	62.00	0.00
	121	92	95	0.00	245.00	246.00	245.00	246.00	1.00	1.00
*	122	93	95	0.00	246.00	246.00	246.00	246.00	0.00	0.00
	123	94	95	0.00	197.00	246.00	197.00	246.00	49.00	49.00
*	124	95	101	20.00	246.00	246.00	266.00	266.00	0.00	0.00
	125	96	98	1.00	191.00	253.00	192.00	254.00	62.00	0.00
	126	97	99	20.00	189.00	236.00	209.00	256.00	47.00	0.00
	127	97	100	10.00	189.00	246.00	199.00	256.00	57.00	10.00
	128	98	103	7.00	192.00	254.00	199.00	261.00	62.00	15.00
	129	99	100	0.00	209.00	256.00	209.00	256.00	47.00	0.00
	130	100	102	5.00	209.00	256.00	214.00	261.00	47.00	0.00
*	131	101	104	10.00	266.00	266.00	276.00	276.00	0.00	0.00
	132	101	105	5.00	266.00	271.00	271.00	276.00	5.00	0.00
	133	101	106	5.00	266.00	271.00	271.00	276.00	5.00	5.00
	134	102	108	0.00	214.00	261.00	214.00	261.00	47.00	0.00
	135	103	107	15.00	214.00	261.00	229.00	276.00	47.00	0.00
*	136	104	106	0.00	276.00	276.00	276.00	276.00	0.00	0.00
	137	105	106	0.00	271.00	276.00	271.00	276.00	5.00	5.00
*	138	106	108	10.00	276.00	276.00	286.00	286.00	0.00	0.00
	139	107	109	10.00	229.00	276.00	239.00	286.00	47.00	0.00
*	140	108	110	0.00	286.00	286.00	286.00	286.00	0.00	0.00
	141	109	110	0.00	239.00	286.00	239.00	286.00	47.00	47.00

*	142	110	111	10.00	286.00	286.00	296.00	296.00	0.00	0.00

TOTAL TIME ON CRITICAL PATH IS 296.00

ACTIVITIES ON CRITICAL PATH INDICATED BY *

23 JAN 76

TABLE 3a

DEFENCE SOCIETY BUNGALOW — DATA DATED 8 1 74

ACTIVITY DEFINITION	I	J	DUR	E.S.	E.F.	L.S.	L.F.	T.F.	F.F.
MOVE IN	1	2	3.	0.	3.	0.	3.	0.	0.
SURVEY LAYOUT & MOBLIZATION	2	3	2.	3.	5.	3.	5.	0.	0.
ROUGH GRADING	3	4	5.	5.	10.	5.	10.	0.	0.
OVER HEAD POLE LINE	4	5	2.	10.	12.	13.	15.	3.	0.
UNDERGROUND WATER PIPNG FROM MAINLINE	4	6	1.	10.	11.	14.	15.	4.	0.
WATER TANK FDNS	4	7	4.	10.	14.	10.	14.	0.	0.
EXC FOR SEWERS & MANHOLES	4	8	2.	10.	12.	11.	13.	1.	0.
PULL IN POWER FEEDER	5	9	1.	12.	13.	15.	16.	3.	3.
CONNECT PIPING	6	12	2.	11.	13.	15.	17.	4.	4.
ERRECT WATER TANK	7	10	2.	14.	16.	14.	16.	0.	0.
INSTALL SEWERS&MANHOLES	8	11	3.	12.	15.	13.	16.	1.	0.
INSTALL CONTROL PANELBOX	9	12	1.	13.	14.	16.	17.	3.	3.
TANK PIPING AND VALVES	10	12	1.	16.	17.	16.	17.	0.	0.
BACKFILL	11	12	1.	15.	16.	16.	17.	1.	1.
BUILDING LAYOUT	12	13	2.	17.	19.	17.	19.	0.	0.
EXC UNDERGROUND WATER RESERVOIR	13	14	4.	19.	23.	30.	34.	11.	0.
EXC BOUNDARY WALL	13	15	15.	19.	34.	19.	34.	0.	0.
PURCHASE&DELIVERY AGGREGATE & STEEL	13	19	2.	19.	21.	32.	34.	13.	13.
LEAD TIME	13	16	5.	19.	24.	22.	27.	3.	0.
EXC FDNS ISOLATED FOOTINGS	13	18	5.	19.	24.	29.	34.	10.	0.
DUMMY	14	19	0.	23.	23.	34.	34.	11.	11.
DUMMY	15	19	0.	34.	34.	34.	34.	0.	0.
EXC GRADE BEAMS	16	17	7.	24.	31.	27.	34.	3.	0.
DUMMY	17	19	0.	31.	31.	34.	34.	3.	3.
DUMMY	18	19	0.	24.	24.	34.	34.	10.	10.
LEAD TIME	19	20	5.	34.	39.	34.	39.	0.	0.
LEAD TIME	19	21	5.	34.	39.	35.	40.	1.	0.
POUR 4 IN THICK CONC SLAB FOR FOOTINGS	19	22	1.	34.	35.	48.	49.	14.	0.
POUR CONC BASE FOR GRADE BEAMS	20	23	1.	39.	40.	39.	40.	0.	0.
POUR CONC. BASE FOR BOUND. WALL	21	24	1.	39.	40.	40.	41.	1.	0.
POUR CONC BASE FOR UNGR WTR RESER	21	25	1.	39.	40.	40.	41.	1.	0.
PLACE REINF FOR FOOTINGS	22	26	4.	35.	39.	49.	53.	14.	0.
FORM WORK GRADE BEAMS	23	27	15.	40.	55.	40.	55.	0.	0.
INSTALL BLOCK MASONRY BOUND WALL	24	28	15.	40.	55.	41.	56.	1.	0.
PL REINF FOR BASE &WALLS UNGR WTR RESR	25	29	2.	40.	42.	41.	43.	1.	0.
FORMWORK ISOLATED FOOTINGS	26	30	5.	39.	44.	53.	58.	14.	0.
POUR GRADE BEAMS	27	31	2.	55.	57.	55.	57.	0.	0.
CURING BOUNDARY WALL	28	32	7.	55.	62.	56.	63.	1.	0.
FORMWORK WALLS UNGR WTR RESER	29	33	1.	42.	43.	43.	44.	1.	0.
POUR CONC ISOLATED FOOTINGS	30	34	1.	44.	45.	58.	59.	14.	0.
STRIP FORMWORK ISOLATED FOOTINGS	31	35	1.	57.	58.	63.	64.	6.	0.
CURE GRADE BEAMS	31	36	7.	57.	64.	57.	64.	0.	0.
PLASTER BOUNDARY WALL	32	37	8.	62.	70.	63.	71.	1.	0.
POUR BASE SLAB&WALLS UNGR WTR RESER	33	38	1.	43.	44.	44.	45.	1.	0.
STIP FORMWORK ISOLATED FOOTINGS	34	40	1.	45.	46.	65.	66.	20.	0.
CURE FOOTINGS	34	41	7.	45.	52.	59.	66.	14.	14.
DUMMY	35	36	0.	58.	58.	64.	64.	6.	6.
DAMP PROOFING PLINTH	36	39	2.	64.	66.	64.	66.	0.	0.
CURING BOUNDARY WALL	37	54	7.	70.	77.	71.	78.	1.	1.
CURING BASTSLAB & WALLS UNGR WTR RESER	38	42	7.	44.	51.	45.	52.	1.	0.
DUMMY	39	41	0.	66.	66.	66.	66.	0.	0.
DUMMY	40	41	0.	46.	46.	66.	66.	20.	20.
INSTALL UNDERGROUND SLAB CONDUITS	41	43	2.	66.	68.	68.	70.	2.	0.
INSTALL UNDERGROUND PLUMBING	41	44	4.	66.	70.	66.	70.	0.	0.

FORMWORK ROOF SLAB UNGR WTR RESER	42	45	1.	51.	52.	52.	53.	1.	0.
DUMMY	43	44	0.	68.	68.	70.	70.	2.	2.
PURCHASE&DELIVERY OF STONE FOR PACKG	44	49	2.	70.	72.	71.	73.	1.	0.
COMPACT AND BACKFILL	44	50	3.	70.	73.	70.	73.	0.	0.
PLACE REIF ROOF SLAB UNGR WTR RESER	45	46	1.	52.	53.	53.	54.	1.	0.
LEAD TIME	46	47	5.	53.	58.	54.	59.	1.	0.
POUR ROOF SLAB UNGR WTR RESER	46	48	1.	53.	54.	59.	60.	6.	5.
STRIP FORMWORK WALLS UNGR WTR RESER	47	48	1.	58.	59.	59.	60.	1.	0.
STRIP FORMWORK & CURE ROOF SLAB	48	51	8.	59.	67.	60.	68.	1.	0.
DUMMY	49	50	0.	72.	72.	73.	73.	1.	1.
STONE PACKING & COMPACTION	50	54	5.	73.	78.	73.	78.	0.	0.
CUTTING DAMP PROOFING MAT UNGR WTR RESER	51	52	1.	67.	68.	68.	69.	1.	0.
INTERNT PLASTER & CURING UNGR WTR RESER	52	53	8.	68.	76.	69.	77.	1.	0.
BACKFILL AND COMPACT(UNGR WTR RESER)	53	54	1.	76.	77.	77.	78.	1.	1.
POUR CONC BASE SLAB CN PLINTH	54	55	2.	78.	80.	78.	80.	0.	0.
PROPERLY WOOD FOR DR BUCKS,WIND,WIND FR	54	57	2.	78.	80.	85.	87.	7.	0.
CURE BASE SLAB	55	56	7.	80.	87.	80.	87.	0.	0.
INSTALL BLOCK MASONRY WALLS UPTO 3FT HT	56	58	4.	87.	91.	87.	91.	0.	0.
CONSTRUCT DR BUCKS,DR FR,WIND FR,WIND	57	58	4.	80.	84.	87.	91.	7.	7.
INSTALL CONDUITS IN BLOCK MASONRY WALLS	58	59	3.	91.	94.	95.	98.	4.	3.
CURE BLOCK MASONRY WALLS	58	60	7.	91.	98.	91.	98.	0.	0.
INST DR BUCKS&WIND FR WI MTL ANC PARTWAL	58	62	5.	91.	96.	99.	104.	6.	8.
DUMMY	59	60	0.	94.	94.	98.	98.	4.	4.
ERECT REINF FOR COLUMNS	60	61	5.	98.	103.	112.	117.	14.	0.
INST BLOCK MASONRY WALLS UPTO 7 FT HT	60	62	6.	98.	104.	98.	104.	0.	0.
POUR LINTELS CN TOP OF WIND OPENINGS	60	64	8.	98.	106.	121.	129.	23.	0.
FORMWORK COLUMNS	61	63	10.	103.	113.	117.	127.	14.	0.
CURE BLOCK MASONRY WALLS	62	65	7.	104.	111.	104.	111.	0.	0.
POUR CONCRETE COLUMNS	63	68	2.	113.	115.	127.	129.	14.	0.
CURE LINTELS	64	69	7.	106.	113.	129.	136.	23.	23.
FORMWORK ROOF SLAB & PL REINF	65	66	15.	111.	126.	116.	131.	5.	0.
FORMWORK ROOF BEAMS & PL REINF	65	67	20.	111.	131.	111.	131.	0.	0.
DUMMY	66	67	0.	126.	126.	131.	131.	5.	5.
SET CONDUITS IN BEAMS & SLABS	67	69	5.	131.	136.	131.	136.	0.	0.
STRIP AND CURE COLUMNS	68	69	7.	115.	122.	129.	136.	14.	14.
POUR ROOF BEAMS AND ROOF SLAB	69	70	2.	136.	138.	136.	138.	0.	0.
CURE ROOF BEAMS AND ROOF SLAB	70	71	28.	138.	166.	138.	166.	0.	0.
STRIP FORMWORK ROOF BEAMS AND ROOF SLAB	71	72	3.	166.	169.	166.	169.	0.	0.
INSTALL DOOR FRAMES	72	73	5.	169.	174.	171.	176.	2.	0.
INSTALL PLUMBING FIXTURES	72	74	10.	169.	179.	169.	179.	0.	0.
PULL WIRE	72	75	5.	169.	174.	218.	223.	49.	0.
FORMWORK STAIRS	72	77	5.	169.	174.	216.	221.	47.	0.
INSTALL WINDOW FRAMES	73	78	5.	174.	179.	176.	181.	2.	0.
TEST PIPING SYSTEMS	74	79	2.	179.	181.	179.	181.	0.	0.
INSTALL RECEPTACLES	75	76	5.	174.	179.	223.	228.	49.	0.
INSTALL CONTROL PANEL BOX	76	80	2.	179.	181.	228.	230.	49.	0.
PLACE REINF FOR STAIRS	77	81	2.	174.	176.	221.	223.	47.	0.
DUMMY	78	79	0.	179.	179.	181.	181.	2.	2.
LEAD TIME	79	82	10.	181.	191.	192.	202.	11.	0.
INTERIOR PLASTER	79	84	25.	181.	206.	191.	206.	0.	0.
TESTING INTERIOR WIRING CIRCUITS ETC	80	85	1.	181.	182.	230.	231.	49.	0.
POUR CONCRETE STAIRS	81	86	1.	176.	177.	223.	224.	47.	0.
INSTALL CERAMIC TILES IN TOILETS	82	83	4.	191.	195.	202.	206.	11.	0.
DUMMY	83	84	0.	195.	195.	206.	206.	11.	11.
MOZAIC OR TERRAZO FLOORING	84	87	15.	206.	221.	206.	221.	0.	0.
LEAD TIME	85	94	15.	182.	197.	231.	246.	49.	0.
INSTALL HAND RAILS FOR STAIRS	86	88	2.	177.	179.	229.	231.	52.	0.
STRIP FORMWORK AND CURE STAIRS	86	89	7.	177.	184.	224.	231.	47.	0.
CUTTING AND GRINDING MOZAIC FLOOR	87	90	15.	221.	236.	221.	236.	0.	0.
DUMMY	88	89	0.	179.	179.	231.	231.	52.	5.

FORMWORK OVERHEAD WTR RESERVOIR	89	91	5.	184.	189.	246.	251.	62.	0.
INSTALL BLOCK MASON PARAPET WALL	89	97	5.	184.	189.	231.	236.	47.	0.
INSTALL DOORS AND WINDOWS	90	92	9.	236.	245.	237.	246.	1.	0.
INSTALL TOILET FIXTURES	90	93	10.	236.	246.	236.	246.	0.	0.
COMPLETE BALANCE OF WOOD WORK	90	95	5.	236.	241.	241.	246.	5.	5.
PLACE REINF FOR OVERHEAD WTR RESER	91	96	2.	189.	191.	251.	253.	62.	0.
DUMMY	92	95	0.	245.	245.	246.	246.	1.	1.
DUMMY	93	95	0.	246.	246.	246.	246.	0.	0.
DUMMY	94	95	0.	197.	197.	246.	246.	49.	49.
INTERIOR PAINTING	95	101	20.	246.	266.	246.	266.	0.	0.
POUR CONC OVERHEAD WTR RESERVOIR	96	98	1.	191.	192.	253.	254.	62.	0.
EXTERIOR PLASTER AND CURING	97	99	20.	189.	209.	236.	256.	47.	0.
ROOFING AND CURING	97	100	10.	189.	199.	246.	256.	57.	10.
CURING OVERHEAD WTR RESERVOIR	98	103	7.	192.	199.	254.	261.	62.	15.
DUMMY	99	100	0.	209.	209.	256.	256.	47.	0.
INSTALL CUTSTONE	100	102	5.	209.	214.	256.	261.	47.	0.
INSTALL FURNISHINGS	101	104	10.	266.	276.	266.	276.	0.	0.
INSTALL ELECTRICAL FIXTURES	101	105	5.	266.	271.	271.	276.	5.	0.
POLISH FLOORS	101	106	5.	266.	271.	271.	276.	5.	5.
DUMMY	102	103	0.	214.	214.	261.	261.	47.	0.
EXTERIOR PAINTING	103	107	15.	214.	229.	261.	276.	47.	0.
DUMMY	104	106	0.	276.	276.	276.	276.	0.	0.
DUMMY	105	106	0.	271.	271.	276.	276.	5.	5.
INTERIOR FINISHING WORK	106	108	10.	276.	286.	276.	286.	0.	0.
COMP ALL EXT WK(GATE,GARDN,LIGHTING&PK)	107	109	10.	229.	239.	276.	286.	47.	0.
DUMMY	108	110	0.	286.	286.	286.	286.	0.	0.
DUMMY	109	110	0.	239.	239.	286.	286.	47.	47.
PUNCHLIST	110	111	10.	286.	296.	286.	296.	0.	0.

TABLE 3b

CRITICAL PATH

ACTIVITY DEFINITION	I	J	DUR	E.S.	E.F.	L.S.	L.F.	T.F.	F.F.
MOVE IN	1	2	3.	0.	3.	0.	3.	0.	0.
SURVEY LAYOUT & MOBLIZATION	2	3	2.	3.	5.	3.	5.	0.	0.
ROUGH GRADING	3	4	5.	5.	10.	5.	10.	0.	0.
WATER TANK FDNS	4	7	4.	10.	14.	10.	14.	0.	0.
ERECT WATER TANK	7	10	2.	14.	16.	14.	16.	0.	0.
TANK PIPING AND VALVES	10	12	1.	16.	17.	16.	17.	0.	0.
BUILDING LAYOUT	12	13	2.	17.	19.	17.	19.	0.	0.
EXC BOUNDARY WALL	13	15	15.	19.	34.	19.	34.	0.	0.
DUMMY	15	19	0.	34.	34.	34.	34.	0.	0.
LEAD TIME	19	20	5.	34.	39.	34.	39.	0.	0.
POUR CONC BASE FOR GRADE BEAMS	20	23	1.	39.	40.	39.	40.	0.	0.
FORM WORK GRADE BEAMS	23	27	15.	40.	55.	40.	55.	0.	0.
POUR GRADE BEAMS	27	31	2.	55.	57.	55.	57.	0.	0.
CURE GRADE BEAMS	31	36	7.	57.	64.	57.	64.	0.	0.
DAMP PROOFING PLINTH	36	39	2.	64.	66.	64.	66.	0.	0.
DUMMY	39	41	0.	66.	66.	66.	66.	0.	0.
INSTALL UNDERGROUND PLUMBING	41	44	4.	66.	70.	66.	70.	0.	0.
COMPACT AND BACKFILL	44	50	3.	70.	73.	70.	73.	0.	0.
STONE PACKING & COMPACTION	50	54	5.	73.	78.	73.	78.	0.	0.
POUR CONC BASE SLAB CR PLINTH	54	55	2.	78.	80.	78.	80.	0.	0.
CURE BASE SLAB	55	56	7.	80.	87.	80.	87.	0.	0.
INSTALL BLOCK MASONRY WALLS UPTO 3FT HT	56	58	4.	87.	91.	87.	91.	0.	0.
CURE BLOCK MASONRY WALLS	58	60	7.	91.	98.	91.	98.	0.	0.
INST BLOCK MASONRY WALLS UPTO 7 FT HT	60	62	6.	98.	104.	98.	104.	0.	0.
CURE BLOCK MASONRY WALLS	62	65	7.	104.	111.	104.	111.	0.	0.
FORMWORK ROOF BEAMS & PL REINF	65	67	20.	111.	131.	111.	131.	0.	0.
SET CONDUITS IN BEAMS & SLABS	67	69	5.	131.	136.	131.	136.	0.	0.
POUR ROOF BEAMS AND ROOF SLAB	69	70	2.	136.	138.	136.	138.	0.	0.
CURE ROOF BEAMS AND ROOF SLAB	70	71	28.	138.	166.	138.	166.	0.	0.
STRIP FORMWORK ROOF BEAMS AND ROOF SLAB	71	72	3.	166.	169.	166.	169.	0.	0.
INSTALL PLUMBING FIXTURES	72	74	10.	169.	179.	169.	179.	0.	0.
TEST PIPING SYSTEMS	74	79	2.	179.	181.	179.	181.	0.	0.
INTERIOR PLASTER	79	84	25.	181.	206.	181.	206.	0.	0.
MOZAIC OR TERRAZO FLOORING	84	87	15.	206.	221.	206.	221.	0.	0.
CUTTING AND GRINDING MOZAIC FLOOR	87	90	15.	221.	236.	221.	236.	0.	0.
INSTALL TOILET FIXTURES	90	93	10.	236.	246.	236.	246.	0.	0.
DUMMY	93	95	0.	246.	246.	246.	246.	0.	0.
INTERIOR PAINTING	95	101	20.	246.	266.	246.	266.	0.	0.
INSTALL FURNISHINGS	101	104	10.	266.	276.	266.	276.	0.	0.
DUMMY	104	106	0.	276.	276.	276.	276.	0.	0.
INTERIOR FINISHING WORK	106	108	10.	276.	286.	276.	286.	0.	0.
DUMMY	108	110	0.	286.	286.	286.	286.	0.	0.
PUNCHLIST	110	111	10.	286.	296.	286.	296.	0.	0.

TABLE 3c

EARLY START

ACTIVITY DEFINITION	I	J	DUR	E.S.	E.F.	L.S.	L.F.	T.F.	F.F.
MOVE IN	1	2	3.	0.	3.	0.	3.	0.	0.
SURVEY LAYOUT & MOBLIZATION	2	3	2.	3.	5.	3.	5.	0.	0.
ROUGH GRADING	3	4	5.	5.	10.	5.	10.	0.	0.
OVER HEAD POLE LINE	4	5	2.	10.	12.	13.	15.	3.	0.
UNDERGROUND WATER PIPNG FROM MAINLINE	4	6	1.	10.	11.	14.	15.	4.	0.
WATER TANK FDNS	4	7	4.	10.	14.	10.	14.	0.	0.
EXC FOR SEWERS & MANHOLES	4	8	2.	10.	12.	11.	13.	1.	0.
CONNECT PIPING	6	12	2.	11.	13.	15.	17.	4.	4.
POLE IN POWER FEEDER	5	9	1.	12.	13.	15.	16.	3.	0.
INSTALL SEWERS&MANHOLES	8	11	3.	12.	15.	13.	16.	1.	0.
INSTALL CONTROL PANELBOX	9	12	1.	13.	14.	16.	17.	3.	3.
EXPECT WATER TANK	7	10	2.	14.	16.	14.	16.	0.	0.
BACKFILL	11	12	1.	15.	16.	16.	17.	1.	1.
TANK PIPING AND VALVES	10	12	1.	16.	17.	16.	17.	0.	0.
BUILDING LAYOUT	12	13	2.	17.	19.	17.	19.	0.	0.
EXC UNDERGROUND WATER RESERVOIR	13	14	4.	19.	23.	30.	34.	11.	0.
EXC BOUNDARY WALL	13	15	15.	19.	34.	19.	34.	0.	0.
PURCHASE&DELIVERY AGGREGATE & STEEL	13	19	2.	19.	21.	32.	34.	13.	13.
LEAD TIME	13	16	5.	19.	24.	22.	27.	3.	0.
EXC FDNS ISOLATED FOOTINGS	13	18	5.	19.	24.	29.	34.	10.	0.
DUMMY	14	19	0.	23.	23.	34.	34.	11.	11.
EXC GRADE BEAMS	16	17	7.	24.	31.	27.	34.	3.	0.
DUMMY	18	19	0.	24.	24.	34.	34.	10.	10.
DUMMY	17	19	0.	31.	31.	34.	34.	3.	3.
DUMMY	15	19	0.	34.	34.	34.	34.	0.	0.
LEAD TIME	19	20	5.	34.	39.	34.	39.	0.	0.
LEAD TIME	19	21	5.	34.	39.	35.	40.	1.	0.
POUR 4 IN THICK CONC SLAB FOR FOOTINGS	19	22	1.	34.	35.	48.	49.	14.	0.
PLACE REINF FOR FOOTINGS	22	26	4.	35.	39.	49.	53.	14.	0.
POUR CONC BASE FOR GRADE BEAMS	20	23	1.	39.	40.	39.	40.	0.	0.
POUR CONC. BASE FOR BOUND. WALL	21	24	1.	39.	40.	40.	41.	1.	0.
POUR CONC BASE FOR UNGR WTR RESER	21	25	1.	39.	40.	40.	41.	1.	0.
FORMWORK ISOLATED FOOTINGS	26	30	5.	39.	44.	53.	58.	14.	0.
FORM WORK GRADE BEAMS	23	27	15.	40.	55.	40.	55.	0.	0.
INSTALL BRICK MASONRY BOUND WALL	24	28	15.	40.	55.	41.	56.	1.	0.
PL REINF FOR BASE &WALLS UNGR WTR RESR	25	29	2.	40.	42.	41.	43.	1.	0.
FORMWORK WALLS UNGR WTR RESER	29	33	1.	42.	43.	43.	44.	1.	0.
POUR BASE SLAB&WALLS UNGR WTR RESER	33	38	1.	43.	44.	44.	45.	1.	0.
POUR CONC ISOLATED FOOTINGS	30	34	1.	44.	45.	58.	59.	14.	0.
CURING BASESLAB & WALLS UNGR WTR RESER	38	42	7.	44.	51.	45.	52.	1.	0.
STRIP FORMWORK ISOLATED FOOTINGS	34	40	1.	45.	46.	65.	66.	20.	0.
CURE FOOTINGS	34	41	7.	45.	52.	59.	66.	14.	14.
DUMMY	40	41	0.	46.	46.	66.	66.	20.	20.
FORMWORK ROOF SLAB UNGR WTR RESER	42	45	1.	51.	52.	52.	53.	1.	0.
PLACE REIF ROOF SLAB UNGR WTR RESER	45	46	1.	52.	53.	53.	54.	1.	0.
LEAD TIME	46	47	5.	53.	58.	54.	59.	1.	0.
POUR ROOF SLAB UNGR WTR RESER	46	48	1.	53.	54.	59.	60.	6.	5.
POUR GRADE BEAMS	27	31	2.	55.	57.	55.	57.	0.	0.
CURING BOUNDARY WALL	28	32	7.	55.	62.	56.	63.	1.	0.
STRIP FORMWORK ISOLATED FOOTINGS	31	35	1.	57.	58.	63.	64.	6.	0.
CURE GRADE BEAMS	31	36	7.	57.	64.	57.	64.	0.	0.
DUMMY	35	36	0.	58.	58.	64.	64.	6.	6.

STRIP FORWORK WALLS UNGR WTR RESER	47	49	1.	58.	59.	59.	60.	1.	0.
STRIP FORMWORK & CURE ROOF SLAB	48	51	3.	59.	67.	60.	68.	1.	0.
PLASTER BOUNDARY WALL	32	37	8.	62.	70.	63.	71.	1.	0.
DAMP PROOFING PLINTH	36	39	2.	64.	66.	64.	66.	0.	0.
DUMMY	39	41	0.	66.	66.	66.	66.	0.	0.
INSTALL UNDERGROUND SLAB CONDUITS	41	43	2.	66.	68.	66.	71.	2.	3.
INSTALL UNDERGROUND PLUMBING	41	44	4.	66.	70.	66.	70.	0.	0.
COATING DAMP PROOFING MAT UNGR WTR RESER	51	52	1.	67.	68.	68.	69.	1.	0.
DUMMY	43	44	0.	68.	68.	70.	70.	2.	2.
INTERNT PLASTER & CUPING UNGR WTR RESER	52	53	8.	68.	76.	69.	77.	1.	0.
CURING BOUNDARY WALL	27	54	7.	70.	77.	71.	78.	1.	1.
PURCHASE&DELIVERY OF STONE FOR PACKG	44	49	2.	70.	72.	71.	73.	1.	0.
COMPACT AND BACKFILL	44	50	3.	70.	73.	70.	73.	0.	0.
DUMMY	49	50	0.	72.	72.	73.	73.	1.	1.
STONE PACKING & COMPACTION	50	54	5.	73.	78.	73.	79.	0.	0.
BACKFILL AND COMPACT(UNGR WTR RESER)	53	54	1.	76.	77.	77.	78.	1.	1.
POUR CONC BASE SLAB ON PLINTH	54	55	2.	78.	80.	78.	80.	0.	0.
PURCHASE WOOD FOR DR BUCKS,WIND,WIND FR	54	57	2.	78.	80.	85.	87.	7.	0.
CURE BASE SLAB	55	56	7.	80.	87.	80.	87.	0.	0.
CONSTRUCT DR BUCKS,DR FR,WIND FR,WIND	57	58	4.	80.	84.	87.	91.	7.	7.
INSTALL BLOCK MASONRY WALLS UPTO 3FT HT	56	58	4.	87.	91.	87.	91.	0.	0.
INSTALL CONDUITS IN BLOCK MASONRY WALLS	58	59	3.	91.	94.	95.	98.	4.	4.
CURE BLOCK MASONRY WALLS	58	60	7.	91.	98.	91.	98.	0.	0.
INST DR BUCKS&WIND FR WI MTL ANC PARTWAL	58	62	5.	91.	96.	99.	104.	8.	8.
DUMMY	59	60	0.	94.	94.	98.	98.	4.	4.
PROJECT REINF FOR COLUMNS	60	61	5.	98.	103.	112.	117.	14.	0.
INST BLOCK MASONRY WALLS UPTO 7 FT HT	60	62	6.	98.	104.	98.	104.	0.	0.
POUR LINTELS ON TOP OF WIND OPENINGS	60	64	8.	98.	106.	121.	129.	23.	0.
FORMWORK COLUMNS	61	63	10.	103.	113.	117.	127.	14.	0.
CURE BLOCK MASONRY WALLS	62	65	7.	104.	111.	104.	111.	0.	0.
CURE LINTELS	64	69	7.	106.	113.	129.	136.	23.	23.
FORMWORK ROOF SLAB & PL REINF	65	66	15.	111.	126.	116.	131.	5.	5.
FORMWORK ROOF BEAMS & PL REINF	65	67	20.	111.	131.	111.	131.	0.	0.
POUR CONCRETE COLUMNS	63	68	2.	113.	115.	127.	129.	14.	0.
STRIP AND CURE COLUMNS	68	69	7.	115.	122.	129.	136.	14.	14.
DUMMY	66	67	0.	126.	126.	131.	131.	5.	5.
SET CONDUITS IN BEAMS & SLABS	67	69	5.	131.	136.	131.	136.	0.	0.
POUR ROOF BEAMS AND ROOF SLAB	69	70	2.	136.	138.	136.	138.	0.	0.
CURE ROOF BEAMS AND ROOF SLAB	70	71	28.	138.	166.	138.	166.	0.	0.
STRIP FORMWORK ROOF BEAMS AND ROOF SLAB	71	72	3.	166.	169.	166.	169.	0.	0.
INSTALL DOOR FRAMES	72	73	5.	169.	174.	171.	176.	2.	0.
INSTALL PLUMBING FIXTURES	72	74	10.	169.	179.	169.	179.	0.	0.
POUR SILS	72	75	5.	169.	174.	218.	223.	49.	0.
FORMWORK STAIRS	72	77	5.	169.	174.	216.	221.	47.	0.
INSTALL WINDOW FRAMES	73	78	5.	174.	179.	176.	181.	2.	0.
INSTALL RECEPTACLES	75	76	5.	174.	179.	223.	228.	49.	0.
PLACE REINF FOR STAIRS	77	81	2.	174.	176.	221.	223.	47.	0.
POUR CONCRETE STAIRS	81	86	1.	176.	177.	223.	224.	47.	0.
INSTALL HAND RAILS FOR STAIRS	86	88	2.	177.	179.	229.	231.	52.	0.
STRIP FORMWORK AND CURE STAIRS	86	89	7.	177.	184.	224.	231.	47.	0.
TEST PIPING SYSTEMS	74	79	2.	179.	181.	179.	181.	0.	0.
INSTALL CONTROL PANEL BOX	76	80	2.	179.	181.	228.	230.	49.	0.
DUMMY	78	79	0.	179.	179.	181.	181.	2.	2.
DUMMY	88	89	0.	179.	179.	231.	231.	52.	5.
LEAD TIME	79	82	10.	181.	191.	192.	202.	11.	0.
INTERIOR PLASTER	79	84	25.	181.	206.	181.	206.	0.	0.
TESTING INTERIOR WIRING CIRCUITS ETC	80	85	1.	191.	192.	230.	231.	49.	0.
LEAD TIME	85	94	15.	192.	197.	231.	246.	49.	0.
FORMWORK OVERHEAD WTR RESERVOIR	89	91	5.	194.	199.	246.	251.	62.	0.
INSTALL BLOCK MASON PARAPET WALL	89	97	5.	194.	199.	231.	236.	47.	0.

PLACE REINF FOR OVERHEAD WTR RESER	91	96	2.	181.	191.	251.	253.	62.	0.
EXTERIOR PLASTER AND CURING	97	99	20.	189.	209.	236.	256.	47.	0.
ROOFING AND CURING	97	100	10.	189.	199.	246.	256.	57.	10.
INSTALL CERAMIC TILES IN TOILETS	82	83	4.	191.	195.	202.	206.	11.	0.
PLACE CONC OVERHEAD WTR RESERVOIR	96	98	1.	191.	192.	253.	254.	62.	0.
CURING OVERHEAD WTR RESERVOIR	98	103	7.	192.	199.	254.	261.	62.	15.
DUMMY	83	84	0.	195.	195.	206.	206.	11.	11.
DUMMY	94	95	0.	197.	197.	246.	246.	49.	49.
MOZAIC OR TERRAZO FLOORING	84	87	15.	206.	221.	206.	221.	0.	0.
DUMMY	99	100	0.	209.	209.	256.	256.	47.	0.
INSTALL CUISTONE	100	102	5.	209.	214.	256.	261.	47.	0.
DUMMY	102	103	0.	214.	214.	261.	261.	47.	0.
EXTERIOR PAINTING	103	107	15.	214.	229.	261.	276.	47.	0.
CUTTING AND GRINDING MOZAIC FLOOR	87	90	15.	221.	236.	221.	236.	0.	0.
COMP ALL EXT WK(GATE,GARDN,LIGHTING&PK)	107	109	10.	229.	239.	276.	286.	47.	0.
INSTALL DOORS AND WINDOWS	90	92	9.	236.	245.	237.	246.	1.	0.
INSTALL TOILET FIXTURES	90	93	10.	236.	246.	236.	246.	0.	0.
COMPLETE BALANCE OF WOOD WORK	90	95	5.	236.	241.	241.	246.	5.	5.
DUMMY	109	110	0.	239.	239.	286.	286.	47.	47.
DUMMY	92	95	0.	245.	245.	246.	246.	1.	1.
DUMMY	93	95	0.	246.	246.	246.	246.	0.	0.
INTERIOR PAINTING	95	101	20.	246.	266.	246.	266.	0.	0.
INSTALL FURNISHINGS	101	104	10.	266.	276.	266.	276.	0.	0.
INSTALL ELECTRICAL FIXTURES	101	105	5.	266.	271.	271.	276.	5.	0.
POLISH FLOORS	101	106	5.	266.	271.	271.	276.	5.	5.
DUMMY	105	106	0.	271.	271.	276.	276.	5.	5.
DUMMY	104	106	0.	276.	276.	276.	276.	0.	0.
INTERIOR FINISHING WORK	106	108	10.	276.	286.	276.	286.	0.	0.
DUMMY	108	110	0.	286.	286.	286.	286.	0.	0.
PUNCHLIST	110	111	10.	286.	296.	286.	296.	0.	0.

TABLE 3d

LATE START

ACTIVITY DEFINITION	I	J	DUR	E.S.	E.F.	L.S.	L.F.	T.F.	F.F.
MOVE IN	1	2	3.	0.	3.	0.	3.	0.	0.
SURVEY LAYOUT & MOBILIZATION	2	3	2.	3.	5.	3.	5.	0.	0.
ROUGH GRADING	3	4	5.	5.	10.	5.	10.	0.	0.
WATER TANK FDNS	4	7	4.	10.	14.	10.	14.	0.	0.
EXC FOR SEWERS & MANHOLES	4	8	2.	10.	12.	11.	13.	1.	0.
OVER HEAD POLE LINE	4	5	2.	10.	12.	13.	15.	3.	0.
INSTALL SEWERS&MANHOLES	8	11	3.	12.	15.	13.	16.	1.	0.
UNDERGROUND WATER PIPNG FROM MAINLINE	4	6	1.	10.	11.	14.	15.	4.	0.
ERRECT WATER TANK	7	10	2.	14.	16.	14.	16.	0.	0.
CONNECT PIPING	6	12	2.	11.	13.	15.	17.	4.	4.
PULL IN POWER FEEDER	5	9	1.	12.	13.	15.	16.	3.	0.
INSTALL CONTROL PANELBOX	9	12	1.	13.	14.	16.	17.	3.	3.
BACKFILL	11	12	1.	15.	16.	16.	17.	1.	1.
TANK PIPING AND VALVES	10	12	1.	16.	17.	16.	17.	0.	0.
BUILDING LAYOUT	12	13	2.	17.	19.	17.	19.	0.	0.
EXC BOUNDARY WALL	13	15	15.	19.	34.	19.	34.	0.	0.
LEAD TIME	13	16	5.	19.	24.	22.	27.	3.	0.
EXC GRADE BEAMS	16	17	7.	24.	31.	27.	34.	3.	0.
EXC FDNS ISOLATED FOOTINGS	13	18	5.	19.	24.	29.	34.	10.	0.
EXC UNDERGROUND WATER RESERVOIR	13	14	4.	19.	23.	30.	34.	11.	0.
PURCHASE&DELIVERY AGGREGATE & STEEL	13	19	2.	19.	21.	32.	34.	13.	13.
DUMMY	14	19	0.	23.	23.	34.	34.	11.	11.
DUMMY	18	19	0.	24.	24.	34.	34.	10.	10.
DUMMY	17	19	0.	31.	31.	34.	34.	3.	3.
DUMMY	15	19	0.	34.	34.	34.	34.	0.	0.
LEAD TIME	19	20	5.	34.	39.	34.	39.	0.	0.
LEAD TIME	19	21	5.	34.	39.	35.	40.	1.	0.
POUR CONC BASE FOR GRADE BEAMS	20	23	1.	39.	40.	39.	40.	0.	0.
POUR CONC. BASE FOR BOUND. WALL	21	24	1.	39.	40.	40.	41.	1.	0.
POUR CONC BASE FOR UNGR WTR RESER	21	25	1.	39.	40.	40.	41.	1.	0.
FORM WORK GRADE BEAMS	23	27	15.	40.	55.	40.	55.	0.	0.
INSTALL BLOCK MASONRY BOUND WALL	24	28	15.	40.	55.	41.	56.	1.	0.
PL REINF FOR BASE &WALLS UNGR WTR RESR	25	29	2.	40.	42.	41.	43.	1.	0.
FORMWORK WALLS UNGR WTR RESER	29	33	1.	42.	43.	43.	44.	1.	0.
POUR BASE SLAB&WALLS UNGR WTR RESER	33	36	1.	43.	44.	44.	45.	1.	0.
CURING BASESLAB & WALLS UNGR WTR RESER	36	42	7.	44.	51.	45.	52.	1.	0.
POUR 4 IN THICK CONC SLAB FOR FOOTINGS	19	22	1.	34.	35.	48.	49.	14.	0.
PLACE REINF FOR FOOTINGS	22	26	4.	35.	39.	49.	53.	14.	0.
FORMWORK ROOF SLAB UNGR WTR RESER	42	45	1.	51.	52.	52.	53.	1.	0.
FORMWORK ISOLATED FOOTINGS	26	30	5.	39.	44.	53.	58.	14.	0.
PLACE REIF ROOF SLAB UNGR WTR RESER	45	46	1.	52.	53.	53.	54.	1.	0.
LEAD TIME	46	47	5.	53.	58.	54.	59.	1.	0.
POUR GRADE BEAMS	27	31	2.	55.	57.	55.	57.	0.	0.
CURING BOUNDARY WALL	28	32	7.	55.	62.	56.	63.	1.	0.
CURE GRADE BEAMS	31	36	7.	57.	64.	57.	64.	0.	0.
POUR CONC ISOLATED FOOTINGS	30	34	1.	44.	45.	58.	59.	14.	0.
CURE FOOTINGS	34	41	7.	45.	52.	59.	66.	14.	14.
POUR ROOF SLAB UNGR WTR RESER	46	48	1.	53.	54.	59.	60.	6.	5.
STRIP FORMWORK WALLS UNGR WTR RESER	47	48	1.	58.	59.	59.	60.	1.	0.
STRIP FORMWORK & CURE ROOF SLAB	48	51	8.	59.	67.	60.	68.	1.	0.
STRIP FORMWORK ISOLATED FOOTINGS	31	35	1.	57.	58.	63.	64.	6.	0.
PLASTER BOUNDARY WALL	32	37	8.	62.	70.	63.	71.	1.	0.

DUMMY	35	36	0.	58.	58.	64.	64.	6.	6.
DAMP PROOFING PLINTH	36	39	2.	64.	66.	64.	66.	0.	0.
STRIP FORMWORK ISOLATED FOOTINGS	34	40	1.	45.	46.	45.	66.	20.	0.
DUMMY	40	41	0.	46.	46.	66.	66.	20.	21.
DUMMY	39	41	0.	66.	66.	66.	66.	0.	0.
INSTALL UNDERGROUND PLUMBING	41	44	4.	66.	70.	66.	70.	0.	0.
INSTALL UNDERGROUND SLAB CONDUITS	41	43	2.	66.	68.	68.	70.	2.	0.
COATING DAMP PROOFING MAT UNGR WTR RESER	51	52	1.	67.	68.	68.	69.	1.	0.
INTERNAL PLASTER & CURING UNGR WTR RESER	52	53	0.	68.	76.	69.	77.	1.	0.
DUMMY	43	44	0.	68.	68.	70.	70.	2.	2.
COMPACT AND BACKFILL	44	50	3.	70.	73.	70.	73.	0.	0.
PUBLIC BOUNDARY WALL	37	54	7.	70.	77.	71.	78.	1.	1.
PURCHASE&DELIVERY OF STONE FOR PACKG	44	49	2.	70.	72.	71.	73.	1.	0.
DUMMY	49	50	0.	72.	72.	73.	73.	1.	1.
STONE PACKING & COMPACTION	50	54	5.	73.	78.	73.	78.	0.	0.
BACKFILL AND COMPACT(UNGR WTR RESER)	53	54	1.	76.	77.	77.	78.	1.	1.
POUR CONC BASE SLAB ON PLINTH	54	55	2.	78.	80.	78.	80.	0.	0.
CURE BASE SLAB	55	56	7.	80.	87.	80.	87.	0.	0.
PURCHASE WOOD FOR DR BUCKS,WIND,WIND FR	54	57	2.	78.	80.	85.	87.	7.	0.
CONSTRUCT DR BUCKS,DR FR,WIND FR,WIND	57	58	4.	80.	84.	87.	91.	7.	7.
INSTALL BLOCK MASONRY WALLS UPTO 3FT HT	56	58	4.	87.	91.	87.	91.	0.	0.
CURE BLOCK MASONRY WALLS	58	60	7.	91.	98.	91.	98.	0.	0.
INSTALL CONDUITS IN BLOCK MASONRY WALLS	58	59	3.	91.	94.	95.	98.	4.	0.
DUMMY	59	60	0.	94.	94.	98.	98.	4.	4.
INST BLOCK MASONRY WALLS UPTO 7 FT HT	60	62	6.	98.	104.	98.	104.	0.	0.
INST DR BUCKS&WIND FR WI MTL ANC PARTWAL	58	62	5.	91.	96.	99.	104.	8.	8.
CURE BLOCK MASONRY WALLS	62	65	7.	104.	111.	104.	111.	0.	0.
FORMWORK ROOF BEAMS & PL REINF	65	67	20.	111.	131.	111.	131.	0.	0.
ERECT REINF FOR COLUMNS	60	61	5.	98.	103.	112.	117.	14.	0.
FORMWORK ROOF SLAB & PL REINF	65	66	15.	111.	126.	116.	131.	5.	0.
FORMWORK COLUMNS	61	63	10.	103.	113.	117.	127.	14.	0.
POUR LINTELS ON TOP OF WIND OPENINGS	60	64	8.	98.	106.	121.	129.	23.	0.
POUR CONCRETE COLUMNS	63	68	2.	113.	115.	127.	129.	14.	0.
CURE LINTELS	64	69	7.	106.	113.	129.	136.	23.	23.
STRIP AND CURE COLUMNS	68	69	7.	115.	122.	129.	136.	14.	14.
DUMMY	66	67	0.	126.	126.	131.	131.	5.	5.
SET CONDUITS IN BEAMS & SLABS	67	69	5.	131.	136.	131.	136.	0.	0.
POUR ROOF BEAMS AND ROOF SLAB	69	70	2.	136.	138.	136.	138.	0.	0.
CURE ROOF BEAMS AND ROOF SLAB	70	71	29.	138.	166.	138.	166.	0.	0.
STRIP FORMWORK ROOF BEAMS AND ROOF SLAB	71	72	3.	166.	169.	166.	169.	0.	0.
INSTALL PLUMBING FIXTURES	72	74	10.	169.	179.	169.	179.	0.	0.
INSTALL DOOR FRAMES	72	73	5.	169.	174.	171.	176.	2.	0.
INSTALL WINDOW FRAMES	73	78	5.	174.	179.	176.	181.	2.	0.
TEST PIPING SYSTEMS	74	79	2.	179.	181.	179.	181.	0.	0.
DUMMY	78	79	0.	179.	179.	181.	181.	2.	2.
INTERIOR PLASTER	79	84	25.	181.	206.	181.	206.	0.	0.
LEAD TIME	79	82	10.	181.	191.	192.	202.	11.	0.
INSTALL CERAMIC TILES IN TOILETS	82	83	4.	191.	195.	202.	206.	11.	0.
DUMMY	83	84	0.	195.	195.	206.	206.	11.	11.
MOZAIC OR TERRAZO FLOORING	84	87	15.	206.	221.	206.	221.	0.	0.
FORMWORK STAIRS	72	77	5.	169.	174.	216.	221.	47.	0.
PULL WIRE	72	75	5.	169.	174.	218.	223.	49.	0.
PLACE REINF FOR STAIRS	77	81	2.	174.	176.	221.	223.	47.	0.
CUTTING AND GRINDING MOZAIC FLOOR	87	90	15.	221.	236.	221.	236.	0.	0.
INSTALL RECEPTACLES	75	76	5.	174.	179.	223.	228.	49.	0.
POUR CONCRETE STAIRS	81	86	1.	176.	177.	223.	224.	47.	0.
STRIP FORMWORK AND CURE STAIRS	86	89	7.	177.	184.	224.	231.	47.	0.
INSTALL CONTROL PANEL BOX	76	80	2.	179.	181.	228.	230.	49.	0.
INSTALL HAND RAILS FOR STAIRS	86	88	2.	177.	179.	229.	231.	52.	0.
TESTING INTERIOR WIRING CIRCUITS ETC	80	85	1.	181.	182.	230.	231.	49.	0.

DUMMY	88	89	0.	179.	179.	231.	231.	52.	5.
LEAD TIME	85	94	15.	182.	197.	231.	246.	49.	0.
INSTALL BLOCK MASON PARAPET WALL	89	97	5.	184.	189.	231.	236.	47.	0.
EXTERIOR PLASTER AND CURING	97	99	20.	139.	209.	236.	256.	47.	0.
INSTALL TOILET FIXTURES	90	93	10.	236.	246.	236.	246.	0.	0.
INSTALL DOORS AND WINDOWS	90	92	0.	236.	246.	237.	246.	1.	0.
COMPLETE BALANCE OF WOOD WORK	90	95	5.	236.	241.	241.	246.	5.	5.
FORMWORK OVERHEAD WTR RESERVOIR	89	91	5.	184.	189.	246.	251.	62.	0.
ROOFING AND CURING	97	100	10.	199.	199.	246.	256.	57.	10.
DUMMY	94	95	0.	197.	197.	246.	246.	49.	49.
DUMMY	92	95	0.	245.	245.	246.	246.	1.	1.
DUMMY	93	95	0.	246.	246.	246.	246.	0.	0.
INTERIOR PAINTING	95	101	20.	246.	266.	246.	266.	0.	0.
PLACE REINF FOR OVERHEAD WTR RESER	91	96	2.	189.	191.	251.	253.	62.	0.
POUR CONC OVERHEAD WTR RESERVOIR	96	98	1.	191.	192.	253.	254.	62.	0.
CURING OVERHEAD WTR RESERVOIR	98	103	7.	192.	199.	254.	261.	62.	15.
DUMMY	99	100	0.	209.	209.	256.	256.	47.	0.
INSTALL CUTSTONE	100	102	5.	209.	214.	256.	261.	47.	0.
DUMMY	102	103	0.	214.	214.	261.	261.	47.	0.
EXTERIOR PAINTING	103	107	15.	214.	229.	261.	276.	47.	0.
INSTALL FURNISHINGS	101	104	10.	266.	276.	266.	276.	0.	0.
INSTALL ELECTRICAL FIXTURES	101	105	5.	266.	271.	271.	276.	5.	0.
POLISH FLOORS	101	106	5.	266.	271.	271.	276.	5.	5.
COMP ALL EXT WK(GATE,CARON,LIGHTING&PK)	107	109	10.	229.	239.	276.	286.	47.	0.
DUMMY	105	106	0.	271.	271.	276.	276.	5.	5.
DUMMY	104	106	0.	276.	276.	276.	276.	0.	0.
INTERIOR FINISHING WORK	106	108	10.	276.	286.	276.	286.	0.	0.
DUMMY	109	110	0.	239.	239.	286.	286.	47.	47.
DUMMY	108	110	0.	286.	286.	286.	286.	0.	0.
PUNCHLIST	110	111	10.	286.	296.	286.	296.	0.	0.

TABLE 3e

LATE FINISH

ACTIVITY DEFINITION	I	J	DUR	E.S.	E.F.	L.S.	L.F.	T.F.	F.F.
MOVE IN	1	2	3.	0.	3.	C.	3.	C.	0.
SURVEY LAYOUT & MOBLIZATION	2	3	2.	3.	5.	3.	5.	0.	0.
ROUGH GRADING	3	4	5.	5.	10.	5.	10.	0.	0.
EXC FOR SEWERS & MANHOLES	4	8	2.	10.	12.	11.	13.	1.	0.
WATER TANK FDNS	4	7	4.	10.	14.	10.	14.	0.	0.
OVER HEAD ELEC LINE	4	5	2.	10.	12.	13.	15.	3.	0.
UNDERGROUND WATER PIPNG FROM MAINLINE	4	6	1.	10.	11.	14.	15.	4.	0.
INSTALL SEWERS&MANHOLES	8	11	3.	12.	15.	13.	16.	1.	0.
ERECT WATER TANK	7	10	2.	14.	16.	14.	16.	C.	C.
PULL IN POWER FEEDER	5	9	1.	12.	13.	15.	16.	3.	C.
CONNECT PIPING	6	12	2.	11.	13.	15.	17.	4.	4.
INSTALL CONTROL PANELBOX	9	12	1.	13.	14.	16.	17.	3.	3.
BACKFILL	11	12	1.	15.	16.	16.	17.	1.	1.
TANK PIPING AND VALVES	10	12	1.	16.	17.	16.	17.	C.	C.
BUILDING LAYOUT	12	13	2.	17.	19.	17.	19.	0.	0.
LEAD TIME	13	16	5.	19.	24.	22.	27.	3.	0.
EXC BOUNDARY WALL	13	15	15.	19.	34.	19.	34.	C.	C.
EXC GRADE BEAMS	16	17	7.	24.	31.	27.	34.	3.	0.
EXC FDNS ISOLATED FOOTINGS	13	18	5.	19.	24.	29.	34.	10.	C.
EXC UNDER-GROUND WATER RESERVOIR	13	14	4.	19.	23.	30.	34.	11.	0.
PURCHASE&DELIVERY AGGREGATE & STEEL	13	19	2.	19.	21.	32.	34.	13.	13.
DUMMY	14	19	0.	23.	23.	34.	34.	11.	11.
DUMMY	18	19	0.	24.	24.	34.	34.	10.	10.
DUMMY	17	19	0.	31.	31.	34.	34.	3.	3.
DUMMY	15	19	0.	34.	34.	34.	34.	C.	0.
LEAD TIME	19	20	5.	34.	39.	34.	39.	0.	0.
LEAD TIME	19	21	5.	34.	39.	35.	40.	1.	0.
POUR CONC BASE FOR GRADE BEAMS	20	23	1.	39.	40.	39.	40.	C.	C.
POUR CONC. BASE FOR BOUND. WALL	21	24	1.	39.	40.	40.	41.	1.	0.
POUR CONC BASE FOR UNGR WTR RESER	21	25	1.	39.	40.	40.	41.	1.	0.
PL REINF FOR BASE &WALLS UNGR WTR RESR	25	29	2.	40.	42.	41.	43.	1.	0.
FORMWORK WALLS UNGR WTR RESER	29	33	1.	42.	43.	43.	44.	1.	0.
POUR BASE SLAB&WALLS UNGR WTR RESER	33	38	1.	43.	44.	44.	45.	1.	C.
POUR 4 IN THICK CONC SLAB FOR FOOTINGS	19	22	1.	34.	35.	48.	49.	14.	0.
CURING BASE SLAB & WALLS UNGR WTR RESER	38	42	7.	44.	51.	45.	52.	1.	0.
PLACE REINF FOR FOOTINGS	22	26	4.	35.	39.	49.	53.	14.	0.
FORMWORK ROOF SLAB UNGR WTR RESER	42	45	1.	51.	52.	52.	53.	1.	0.
PLACE REIF ROOF SLAB UNGR WTR RESER	45	46	1.	52.	53.	53.	54.	1.	0.
FORM WORK GRADE BEAMS	23	27	15.	40.	55.	40.	55.	0.	0.
INSTALL BLOCK MASONRY BOUND WALL	24	28	15.	40.	55.	41.	56.	1.	0.
POUR GRADE BEAMS	27	31	2.	55.	57.	55.	57.	C.	C.
FORMWORK ISOLATED FOOTINGS	26	30	5.	39.	44.	53.	58.	14.	0.
LEAD TIME	46	47	5.	53.	58.	54.	59.	1.	0.
POUR CONC ISOLATED FOOTINGS	30	34	1.	44.	45.	58.	59.	14.	0.
POUR ROOF SLAB UNGR WTR RESER	46	48	1.	53.	54.	59.	60.	6.	5.
STRIP FORMWORK WALLS UNGR WTR RESER	47	48	1.	58.	59.	59.	60.	1.	C.
CURING BOUNDARY WALL	28	32	7.	55.	62.	56.	63.	1.	0.
CURE GRADE BEAMS	31	36	7.	57.	64.	57.	64.	C.	0.
STRIP FORMWORK ISOLATED FOOTINGS	31	35	1.	57.	58.	63.	64.	6.	0.
DUMMY	35	36	0.	58.	58.	64.	64.	6.	6.
CURE FOOTINGS	34	41	7.	45.	52.	59.	66.	14.	14.
DAMP PROOFING PLINTH	36	39	2.	64.	66.	64.	66.	0.	0.

STRIP FORMWORK ISOLATED FOOTINGS	34	40	1.	45.	46.	65.	66.	20.	0.
DUMMY	40	41	0.	46.	46.	66.	66.	20.	20.
DUMMY	39	41	0.	66.	66.	66.	66.	0.	0.
STRIP FORMWORK & CURE ROOF SLAB	48	51	8.	59.	67.	60.	68.	1.	0.
COATING DAMP PROOFING MAT UNGR WTR RESER	51	52	1.	67.	68.	68.	69.	1.	0.
INSTALL UNDERGROUND PLUMBING	41	44	4.	66.	70.	66.	70.	0.	0.
INSTALL UNDERGROUND SLAB CONDUITS	41	43	2.	66.	68.	68.	70.	2.	0.
DUMMY	43	44	0.	68.	68.	70.	70.	2.	2.
PLASTER BOUNDARY WALL	32	37	8.	62.	70.	63.	71.	1.	0.
COMPACT AND BACKFILL	44	50	3.	70.	73.	70.	73.	0.	0.
PURCHASE&DELIVERY OF STONE FOR PACKG	44	49	2.	70.	72.	71.	73.	1.	0.
DUMMY	49	50	0.	72.	72.	73.	73.	1.	1.
INTEXT PLASTER & CURING UNGR WTR RESER	52	53	8.	68.	76.	69.	77.	1.	0.
CURING BOUNDARY WALL	37	54	7.	70.	77.	71.	78.	1.	1.
STONE PACKING & COMPACTION	50	54	5.	73.	78.	73.	78.	0.	0.
BACKFILL AND COMPACT(UNGR WTR RESER)	53	54	1.	76.	77.	77.	78.	1.	1.
POUR CONC BASE SLAB ON PLINTH	54	55	2.	78.	80.	78.	80.	0.	0.
CURE BASE SLAB	55	56	7.	80.	87.	80.	87.	0.	0.
PURCHASE WOOD FOR DR BUCKS,WIND,WIND FR	54	57	2.	78.	80.	85.	87.	7.	0.
CONSTRUCT DR BUCKS,DR FR,WIND FR,WIND	57	58	4.	80.	84.	87.	91.	7.	7.
INSTALL BLOCK MASONRY WALLS UPTO 3FT HT	56	58	4.	87.	91.	87.	91.	0.	0.
CURE BLOCK MASONRY WALLS	58	60	7.	91.	98.	91.	98.	0.	0.
INSTALL CONDUITS IN BLOCK MASONRY WALLS	58	59	3.	91.	94.	95.	98.	4.	0.
DUMMY	59	60	0.	94.	94.	98.	98.	4.	4.
INST BLOCK MASONRY WALLS UPTO 7 FT HT	60	62	6.	98.	104.	98.	104.	0.	0.
INST DR BUCKS&WIND FR WI MTL ANC PARTWAL	58	62	5.	91.	96.	99.	104.	8.	8.
CURE BLOCK MASONRY WALLS	62	65	7.	104.	111.	104.	111.	0.	0.
ERECT REINF FOR COLUMNS	60	61	5.	98.	103.	112.	117.	14.	0.
FORMWORK COLUMNS	61	63	10.	103.	113.	117.	127.	14.	0.
POUR LINTELS ON TOP OF WIND OPENINGS	60	64	8.	98.	106.	121.	129.	23.	0.
POUR CONCRETE COLUMNS	63	68	2.	113.	115.	127.	129.	14.	0.
FORMWORK ROOF BEAMS & PL REINF	65	67	20.	111.	131.	111.	131.	0.	0.
FORMWORK ROOF SLAB & PL REINF	65	66	15.	111.	126.	116.	131.	5.	0.
DUMMY	66	67	0.	126.	126.	131.	131.	5.	5.
CURE LINTELS	64	69	7.	106.	113.	129.	136.	23.	23.
STRIP AND CURE COLUMNS	68	69	7.	115.	122.	129.	136.	14.	14.
SET CONDUITS IN BEAMS & SLABS	67	69	5.	131.	136.	131.	136.	0.	0.
POUR ROOF BEAMS AND ROOF SLAB	69	70	2.	136.	138.	136.	138.	0.	0.
CURE ROOF BEAMS AND ROOF SLAB	70	71	28.	138.	166.	138.	166.	0.	0.
STRIP FORMWORK ROOF BEAMS AND ROOF SLAB	71	72	3.	166.	169.	166.	169.	0.	0.
INSTALL DOOR FRAMES	72	73	5.	169.	174.	171.	176.	2.	0.
INSTALL PLUMBING FIXTURES	72	74	10.	169.	179.	169.	179.	0.	0.
INSTALL WINDOW FRAMES	73	78	5.	174.	179.	176.	181.	2.	0.
TEST PIPING SYSTEMS	74	79	2.	179.	181.	179.	181.	0.	0.
DUMMY	78	79	0.	179.	179.	181.	181.	2.	2.
LEAD TIME	79	82	10.	191.	191.	192.	202.	11.	0.
INTERIOR PLASTER	79	84	25.	181.	206.	181.	206.	0.	0.
INSTALL CERAMIC TILES IN TOILETS	82	83	4.	191.	195.	202.	206.	11.	0.
DUMMY	83	84	0.	195.	195.	206.	206.	11.	11.
MOZAIC OR TERRAZO FLOORING	84	87	15.	206.	221.	206.	221.	0.	0.
FORMWORK STAIRS	72	77	5.	169.	174.	216.	221.	47.	0.
PULL WIRE	72	75	5.	169.	174.	218.	223.	49.	0.
PLACE REINF FOR STAIRS	77	81	2.	174.	176.	221.	223.	47.	0.
POUR CONCRETE STAIRS	81	86	1.	176.	177.	223.	224.	47.	0.
INSTALL RECEPTACLES	75	76	5.	174.	179.	223.	228.	49.	0.
INSTALL CONTROL PANEL BOX	76	80	2.	179.	181.	228.	230.	49.	0.
STRIP FORMWORK AND CURE STAIRS	86	89	7.	177.	184.	224.	231.	47.	0.
INSTALL HAND RAILS FOR STAIRS	86	88	2.	177.	179.	229.	231.	52.	0.
TESTING INTERIOR WIRING CIRCUITS ETC	80	85	1.	181.	182.	230.	231.	49.	0.
DUMMY	88	89	0.	179.	179.	231.	231.	52.	5.

CUTTING AND GRINDING MOZAIC FLOOR	87	90	15.	221.	236.	221.	236.	0.	0.
INSTALL BLOCK MASON PARAPET WALL	85	97	5.	194.	189.	231.	236.	47.	0.
LEAD TIME	85	94	15.	182.	197.	231.	246.	49.	0.
INSTALL TOILET FIXTURES	90	93	10.	236.	246.	236.	246.	0.	0.
INSTALL DOORS AND WINDOWS	90	92	9.	236.	245.	237.	246.	1.	0.
COMPLETE BALANCE OF WOOD WORK	90	95	5.	236.	241.	241.	246.	5.	5.
DUMMY	94	95	0.	197.	197.	246.	246.	49.	49.
DUMMY	92	95	0.	245.	245.	246.	246.	1.	1.
DUMMY	93	95	0.	246.	246.	246.	246.	0.	0.
FORMWORK OVERHEAD WTR RESERVOIR	89	91	5.	184.	189.	246.	251.	62.	0.
PLACE REINF FOR OVERHEAD WTR RESER	91	96	2.	189.	191.	251.	253.	62.	0.
POUR CONC OVERHEAD WTR RESERVOIR	56	98	1.	191.	192.	253.	254.	62.	0.
EXTERIOR PLASTER AND CURING	97	99	20.	189.	209.	236.	256.	47.	0.
ROOFING AND CURING	97	100	10.	189.	199.	246.	256.	57.	10.
DUMMY	99	100	0.	209.	209.	256.	256.	47.	0.
CURING OVERHEAD WTR RESERVOIR	98	103	7.	192.	199.	254.	261.	62.	15.
INSTALL CUTSTONE	100	102	5.	209.	214.	256.	261.	47.	0.
DUMMY	102	103	0.	214.	214.	261.	261.	47.	0.
INTERIOR PAINTING	95	101	20.	246.	266.	246.	266.	0.	0.
EXTERIOR PAINTING	103	107	15.	214.	229.	261.	276.	47.	0.
INSTALL FURNISHINGS	101	104	10.	266.	276.	266.	276.	0.	0.
INSTALL ELECTRICAL FIXTURES	101	105	5.	266.	271.	271.	276.	5.	0.
POLISH FLOORS	101	106	5.	266.	271.	271.	276.	5.	5.
DUMMY	105	106	0.	271.	271.	276.	276.	5.	5.
DUMMY	104	106	0.	276.	276.	276.	276.	0.	0.
CLEAR ALL EXT WK(GATE,GARDN,LIGHTING&PK)	107	109	10.	229.	239.	276.	286.	47.	0.
INTERIOR FINISHING WORK	106	108	10.	276.	286.	276.	286.	0.	0.
DUMMY	109	110	0.	239.	239.	286.	286.	47.	47.
DUMMY	108	110	0.	286.	296.	286.	286.	0.	0.
PUNCHLIST	110	111	10.	286.	296.	286.	296.	0.	0.

TABLE 3f

ACTIVITY DEFINITION	I	J	DUR	E.S.	E.F.	L.S.	L.F.	T.F.	F.F.
MOVE IN	1	2	3.	0.	3.	0.	3.	0.	0.
SURVEY LAYOUT & MOBLIZATION	2	3	2.	3.	5.	3.	5.	0.	0.
ROUGH GRADING	3	4	5.	5.	10.	5.	10.	0.	0.
EXC FOR SEWERS & MANHOLES	4	8	2.	10.	12.	11.	13.	1.	0.
WATER TANK FDNS	4	7	4.	10.	14.	10.	14.	0.	0.
OVER HEAD POLE LINE	4	5	2.	10.	12.	13.	15.	3.	0.
UNDERGROUND WATER PIPNG FROM MAINLINE	4	6	1.	10.	11.	14.	15.	4.	0.
INSTALL SEWERS&MANHOLES	8	11	3.	12.	15.	13.	16.	1.	0.
ERECT WATER TANK	7	10	2.	14.	16.	14.	16.	0.	0.
PULL IN POWER FEEDER	5	9	1.	12.	13.	15.	16.	3.	0.
CONNECT PIPING	6	12	2.	11.	13.	15.	17.	4.	4.
INSTALL CONTROL PANELBOX	9	12	1.	13.	14.	16.	17.	3.	3.
BACKFILL	11	12	1.	15.	16.	16.	17.	1.	1.
TANK PIPING AND VALVES	10	12	1.	16.	17.	16.	17.	0.	0.
BUILDING LAYOUT	12	13	2.	17.	19.	17.	19.	0.	0.
LEAD TIME	13	16	5.	19.	24.	22.	27.	3.	0.
EXC BOUNDARY WALL	13	15	15.	19.	34.	19.	34.	0.	0.
EXC GRADE BEAMS	16	17	7.	24.	31.	27.	34.	3.	0.
EXC FDNS ISOLATED FOOTINGS	13	18	5.	19.	24.	29.	34.	10.	0.
EXC UNDERGROUND WATER RESERVOIR	13	14	4.	19.	23.	30.	34.	11.	0.
PURCHASE&DELIVERY AGGREGATE & STEEL	13	19	2.	19.	21.	32.	34.	13.	13.
DUMMY	14	19	0.	23.	23.	34.	34.	11.	11.
DUMMY	18	19	0.	24.	24.	34.	34.	10.	10.
DUMMY	17	19	0.	31.	31.	34.	34.	3.	3.
DUMMY	15	19	0.	34.	34.	34.	34.	0.	0.
LEAD TIME	19	20	5.	34.	39.	34.	39.	0.	0.
LEAD TIME	19	21	5.	34.	39.	35.	40.	1.	0.
POUR CONC BASE FOR GRADE BEAMS	20	23	1.	39.	40.	39.	40.	0.	0.
POUR CONC. BASE FOR BOUND. WALL	21	24	1.	39.	40.	40.	41.	1.	0.
POUR CONC BASE FOR UNGR WTR RESER	21	25	1.	39.	40.	40.	41.	1.	0.
PL REINF FOR BASE &WALLS UNGR WTR RESR	25	29	2.	40.	42.	41.	43.	1.	0.
FORMWORK WALLS UNGR WTR RESER	29	33	1.	42.	43.	43.	44.	1.	0.
POUR BASE SLAB&WALLS UNGR WTR RESER	33	38	1.	43.	44.	44.	45.	1.	0.
POUR 6 IN THICK CONC SLAB FOR FOOTINGS	19	22	1.	34.	35.	48.	49.	14.	0.
CUTTING BASESLAB & WALLS UNGR WTR RESER	38	42	7.	44.	51.	45.	52.	1.	0.
PLACE REINF FOR FOOTINGS	22	26	4.	35.	39.	49.	53.	14.	0.
FORMWORK ROOF SLAB UNGR WTR RESER	42	45	1.	51.	52.	52.	53.	1.	0.
PLACE REIF ROOF SLAB UNGR WTR RESER	45	46	1.	52.	53.	53.	54.	1.	0.
FORM WORK GRADE BEAMS	23	27	15.	40.	55.	40.	55.	0.	0.
INSTALL BLOCK MASONRY BOUND WALL	24	28	15.	40.	55.	41.	56.	1.	0.
POUR GRADE BEAMS	27	31	2.	55.	57.	55.	57.	0.	0.
FORMWORK ISOLATED FOOTINGS	26	30	5.	39.	44.	53.	58.	14.	0.
LEAD TIME	46	47	5.	53.	58.	54.	59.	1.	0.
POUR CONC ISOLATED FOOTINGS	30	34	1.	44.	45.	58.	59.	14.	0.
POUR ROOF SLAB UNGR WTR RESER	46	48	1.	53.	54.	59.	60.	6.	5.
STRIP FORMWORK WALLS UNGR WTR RESER	47	43	1.	58.	59.	59.	60.	1.	0.
CUTTING BOUNDARY WALL	28	32	7.	55.	62.	56.	63.	1.	0.
CURE GRADE BEAMS	31	36	7.	57.	64.	57.	64.	0.	0.
STRIP FORMWORK ISOLATED FOOTINGS	31	35	1.	57.	58.	63.	64.	6.	0.
DUMMY	35	36	0.	58.	58.	64.	64.	6.	6.
CURE FOOTINGS	34	41	7.	45.	52.	59.	66.	14.	14.
LAMP PROOFING PLINTH	36	39	2.	64.	66.	64.	66.	0.	0.
STRIP FORMWORK ISOLATED FOOTINGS	34	40	1.	45.	46.	65.	66.	20.	0.
DUMMY	40	41	0.	46.	46.	66.	66.	20.	20.
DUMMY	39	41	0.	66.	66.	66.	66.	0.	0.

STRIP FORMWORK & CURE ROOF SLAB	48	51	8.	59.	67.	60.	68.	1.	0.
COATING DAMP PROOFING MAT UNGR WTR RESER	51	52	1.	67.	68.	68.	69.	1.	0.
INSTALL UNDERGROUND PLUMBING	41	44	4.	66.	70.	66.	70.	0.	0.
INSTALL UNDERGROUND SLAB CONDUITS	41	43	2.	66.	68.	68.	70.	2.	0.
DUMMY	43	44	0.	68.	68.	70.	70.	2.	2.
PLASTER BOUNDARY WALL	32	37	8.	62.	70.	63.	71.	1.	0.
COMPACT AND BACKFILL	44	50	3.	70.	73.	70.	73.	0.	0.
PURCHASE&DELIVERY OF STONE FOR PACKG	44	49	2.	70.	72.	71.	73.	1.	0.
DUMMY	49	50	0.	72.	72.	73.	73.	1.	1.
INTERIOR PLASTER & CURING UNGR WTR RESER	52	53	8.	68.	76.	69.	77.	1.	0.
CURING BOUNDARY WALL	37	54	7.	70.	77.	71.	78.	1.	1.
STONE PACKING & COMPACTION	50	54	5.	73.	78.	73.	78.	0.	0.
BACKFILL AND COMPACT(UNGR WTR RESER)	53	54	1.	76.	77.	77.	78.	1.	1.
PUR CONC BASE SLAB EX PLINTH	54	55	2.	78.	80.	78.	80.	0.	0.
CURE BASE SLAB	55	56	7.	80.	87.	80.	87.	0.	0.
PURCHASE WOOD FOR DR BUCKS,WIND,WIND FR	54	57	2.	78.	80.	85.	87.	7.	0.
CONSTRUCT DR BUCKS,DR FR,WIND FR,WIND	57	58	4.	80.	84.	87.	91.	7.	7.
INSTALL BLOCK MASONRY WALLS UPTO 3FT HT	56	58	4.	87.	91.	87.	91.	0.	0.
CURE BLOCK MASONRY WALLS	58	60	7.	91.	98.	91.	98.	0.	0.
INSTALL CONDUITS IN BLOCK MASONRY WALLS	58	59	3.	91.	94.	95.	98.	4.	0.
DUMMY	59	60	0.	94.	94.	98.	98.	4.	4.
INST BLOCK MASONRY WALLS UPTO 7 FT HT	60	62	6.	98.	104.	98.	104.	0.	0.
INST DR BUCKS&WIND FR WI MTL ANC PARTWAL	58	62	6.	91.	98.	99.	104.	8.	8.
CURE BLOCK MASONRY WALLS	62	65	7.	104.	111.	104.	111.	0.	0.
ERECT REINF FOR COLUMNS	60	61	5.	98.	103.	112.	117.	14.	0.
FORMWORK COLUMNS	61	63	10.	103.	113.	117.	127.	14.	0.
ROOF LINTELS ON TOP OF WIND OPENINGS	60	64	8.	98.	106.	121.	129.	23.	0.
POUR CONCRETE COLUMNS	63	68	2.	113.	115.	127.	129.	14.	0.
FORMWORK ROOF BEAMS & PL REINF	65	67	20.	111.	131.	111.	131.	0.	0.
FORMWORK ROOF SLAB & PL REINF	65	66	15.	111.	126.	116.	131.	5.	0.
DUMMY	66	67	0.	126.	126.	131.	131.	5.	5.
CURE LINTELS	64	69	7.	106.	113.	129.	136.	23.	23.
STRIP AND CURE COLUMNS	68	69	7.	115.	122.	129.	136.	14.	14.
SET CONDUITS IN BEAMS & SLABS	67	69	5.	131.	136.	131.	136.	0.	0.
POUR ROOF BEAMS AND ROOF SLAB	69	70	2.	136.	138.	136.	138.	0.	0.
CURE ROOF BEAMS AND ROOF SLAB	70	71	29.	138.	166.	138.	166.	0.	0.
STRIP FORMWORK ROOF BEAMS AND ROOF SLAB	71	72	3.	166.	169.	166.	169.	0.	0.
INSTALL DOOR FRAMES	72	73	5.	169.	174.	171.	176.	2.	0.
INSTALL PLUMBING FIXTURES	72	74	10.	169.	179.	169.	179.	0.	0.
INSTALL WINDOW FRAMES	73	78	5.	174.	179.	176.	181.	2.	0.
TEST PIPING SYSTEMS	74	79	2.	179.	181.	179.	181.	0.	0.
DUMMY	78	79	0.	179.	179.	181.	181.	2.	2.
LEAD TIME	79	82	10.	181.	191.	192.	202.	11.	0.
INTERIOR PLASTER	75	84	25.	181.	206.	181.	206.	0.	0.
INSTALL CERAMIC TILES IN TOILETS	82	83	4.	191.	195.	202.	206.	11.	0.
DUMMY	83	84	0.	195.	195.	206.	206.	11.	11.
MOZAIC OR TERRAZO FLOORING	84	87	15.	206.	221.	206.	221.	0.	0.
FORMWORK STAIRS	72	77	5.	169.	174.	216.	221.	47.	0.
PULL WIRE	72	75	5.	169.	174.	218.	223.	49.	0.
PLACE REINF FOR STAIRS	77	81	2.	174.	176.	221.	223.	47.	0.
POUR CONCRETE STAIRS	81	86	1.	176.	177.	223.	224.	47.	0.
INSTALL RECEPTACLES	75	76	5.	174.	179.	223.	228.	49.	0.
INSTALL CONTROL PANEL BOX	76	80	2.	179.	181.	228.	230.	49.	0.
STRIP FORMWORK AND CURE STAIRS	86	89	7.	177.	184.	224.	231.	47.	0.
INSTALL HAND RAILS FOR STAIRS	86	88	2.	177.	179.	229.	231.	52.	0.
TESTING INTERIOR WIRING CIRCUITS ETC	90	85	1.	181.	182.	230.	231.	49.	0.
DUMMY	88	89	0.	179.	179.	231.	231.	52.	5.
CUTTING AND GRINDING MOZAIC FLOOR	87	90	15.	221.	236.	221.	236.	0.	0.
INSTALL BLOCK MASON PARAPET WALL	89	97	5.	184.	189.	231.	236.	47.	0.
LEAD TIME	85	94	15.	182.	197.	231.	246.	49.	0.

INSTALL TOILET FIXTURES	90	93	10.	236.	246.	236.	246.	0.	0.
INSTALL DOORS AND WINDOWS	90	92	9.	236.	245.	237.	246.	1.	0.
COMPLETE BALANCE OF WOOD WORK	90	95	5.	236.	241.	241.	246.	5.	5.
DUMMY	94	95	0.	197.	197.	246.	246.	49.	49.
DUMMY	92	95	0.	245.	245.	246.	246.	1.	1.
DUMMY	93	95	0.	246.	246.	246.	246.	0.	0.
ERECT OVERHEAD WTR RESERVOIR	89	91	5.	184.	189.	246.	251.	62.	0.
PLACE REINF FOR OVERHEAD WTR RESER	91	96	2.	189.	191.	251.	253.	62.	0.
POUR CONC OVERHEAD WTR RESERVOIR	96	98	1.	191.	192.	253.	254.	62.	0.
EXTERIOR PLASTER AND CURING	97	99	20.	149.	209.	236.	256.	47.	0.
ROOFING AND COPING	97	100	10.	189.	199.	246.	256.	57.	10.
DUMMY	99	100	0.	209.	209.	256.	256.	47.	0.
CURING OVERHEAD WTR RESERVOIR	98	103	7.	192.	199.	254.	261.	62.	15.
INSTALL CUTSTONE	100	102	5.	209.	214.	256.	261.	47.	0.
DUMMY	102	103	0.	214.	214.	261.	261.	47.	0.
INTERIOR PAINTING	95	101	20.	246.	266.	246.	266.	0.	0.
EXTERIOR PAINTING	103	107	15.	214.	229.	261.	276.	47.	0.
INSTALL FURNISHINGS	101	104	10.	266.	276.	266.	276.	0.	0.
INSTALL ELECTRICAL FIXTURES	101	105	5.	266.	271.	271.	276.	5.	0.
POLISH FLOORS	101	106	5.	266.	271.	271.	276.	5.	5.
DUMMY	105	106	0.	271.	271.	276.	276.	5.	5.
DUMMY	104	106	0.	276.	276.	276.	276.	0.	0.
CLEAN ALL EXT WK(GATE,GARDN,LIGHTING&PK)	107	109	10.	229.	239.	276.	286.	47.	0.
INTERIOR FINISHING WORK	106	108	10.	276.	286.	276.	286.	0.	0.
DUMMY	109	110	0.	239.	239.	286.	286.	47.	47.
DUMMY	108	110	0.	286.	286.	286.	286.	0.	0.
PUNCHLIST	110	111	10.	286.	296.	286.	296.	0.	0.

MANPOWER LEVELING

Manpower Leveling computer program is used to level out the available men requirements in an economical manner. There are two programs in this system. The first one computes the EST, EFT, LST, LFT, TF and FF and prints the craft requirements as specified in the data. The results are tabulated in Table 4. The other one, i.e., the Manpower Leveling uses a trial and error algorithm. When all possible improvement has been made, two reports are printed. The first one gives a list of manpower usage by craft for all times at which there is a change in manpower. The second gives a schedule for starting the jobs in order to achieve the minimum manpower fluctuation. Table 5 and Table 6 list the results.

The trial and error algorithm consists of two steps. Step 1 distributes the float among various jobs. Step 2 tests for each non-critical job, whether moving to another start date will decrease the manpower fluctuations. If so, the job is moved. The program cycles through the network until it goes through the whole network without any improvement. At this point the outphase begins.

MANPOWER LEVELING

DATA:

CRAFT REQUIREMENTS:

1.	Move In	5 Laborers, 1 Technician, 1 Engineer
2.	Survey Layout & Mobilization	5 Laborers, 1 Technician, 1 Engineer
3.	Rough Grading	8 Laborers
4.	Overhead Pole Line	2 Helpers, 1 Electrician
5.	Ungr. Wtr. Piping from Main Line	2 Laborers
6.	Wtr. Tank Fdns.	5 Laborers
7.	Exc. for Sewers & Manholes	4 Laborers
8.	Pull in Power Feeder	2 Helpers, 1 Electrician
9.	Connect Piping	2 Plumbers
10.	Erect Wtr. Tank	4 Laborers, 1 Plumber
11.	Install Sewers & Manholes	2 Laborers, 1 Mason
12.	Install Control Panel Box	1 Electrician
13.	Tank Piping & Valves	1 Plumber
14.	Backfill	2 Laborers
15.	Building Layout	3 Laborers, 1 Technician, 1 Engineer
16.	Exc. Ungr. Water Reser.	3 Laborers
17.	Excavation Boundary Wall	4 Laborers
18.	Purchase & Delivery of Aggregate and Steel	6 Laborers, 1 Engineer
19.	Lead Time	0
20.	Exc. Fdns. Isolated Footings	4 Laborers
21.	Dummy	0
22.	Dummy	0
23.	Excavation Grade Beams	4 Laborers
24.	Dummy	0
25.	Dummy	0
26.	Lead Time	0
27.	Lead Time	0
28.	Pour 4" Thick Conc. Slab for Footings	3 Laborers, 2 Masons
29.	Pour Grade Beams	6 Laborers, 3 Masons
30.	Pour Conc. Base for Bound. Wall	8 Laborers, 3 Masons
31.	Pour Conc. Base for Ungr. Wtr. Reser.	4 Laborers, 2 Masons
32.	Place Reinf. for Footings	2 Ironworkers
33.	Form Work Grade Beam	4 Scaffolding Men
34.	Inst. Block Masonry Bound Wall	5 Laborers, 2 Masons
35.	PL Reinf. Base Slab & Walls Ungr. Wtr. Reser.	2 Ironworkers
36.	Form Work Isolated Footings	4 Scaffolding Men
37.	Pour Grade Beam	6 Laborers, 2 Masons
38.	Curing Boundary Wall	1 Laborer
39.	Form Work Walls Ungr. Wtr. Reser.	2 Scaffolding Men
40.	Pour Isolated Footings	5 Laborers, 2 Masons
41.	Strip Form Work Isolated Footings	2 Laborers
42.	Cure Grade Beam	1 Laborer
43.	Plaster Boundary Wall	4 Laborers, 2 Masons

CRAFT REQUIREMENTS:

44.	Pour Base Slab & Walls Ungr. Wtr. Reser.	4 Laborers, 2 Masons
45.	Strip Form Work Isolated Footings	2 Laborers
46.	Cure Footings	1 Laborer
47.	Dummy	0
48.	Damp Proofing of Plinth	3 Laborers
49.	Curing Boundary Wall	1 Laborer
50.	Curing Base Slab & Walls Ungr. Wtr. Reser.	1 Laborer
51.	Dummy	0
52.	Dummy	0
53.	Install Ungr. Slab Conduits	1 Electrician
54.	Install Ungr. Slab Plumbing	2 Plumbers
55.	Form Work Roof Slab Ungr. Wtr. Reser.	2 Scaffolding Men
56.	Dummy	0
57.	Purchase & Delivery of Stone for Packing	2 Laborers, 1 Technician
58.	Compact and Backfill	2 Laborers
59.	PL Reinf. Roof Slab Ungr. Wtr. Reser.	2 Ironworkers
60.	Lead Time	0
61.	Pour Roof Slab Ungr. Wtr. Reser.	4 Laborers, 2 Masons
62.	Strip Form Work Walls Ungr. Wtr. Reser.	2 Scaffolding Men
63.	Strip Form Work & Cure Roof Slab	2 Scaffolding Men, 1 Curing Man
64.	Dummy	0
65.	Stone Packing & Compaction	2 Laborers
66.	Coating Damp Proofing Material Ungr. Wtr. Reser.	2 Laborers
67.	Int. & Ext. Plaster & Curing Ungr. Wtr. Reser.	4 Laborers, 2 Masons, 1 Curing Man
68.	Backfill & Compact Ungr. Wtr. Reser.	2 Laborers
69.	Pour Conc. Base Slab on Plinth	10 Laborers, 4 Masons
70.	Purchase & Delivery Wood for Dr. Bucks, Windows & Window Frames	1 Technician
71.	Cure Base Slab	1 Curing Man
72.	Inst. Block Masonry Wall up to 3' Ht.	3 Laborers, 1 Mason
73.	Construct Door Bucks	2 Carpenters
74.	Install Conduits in Masonry Walls	2 Electricians
75.	Cure Block Masonry Walls	1 Curing Man
76.	Inst. Door Bucks & Window Frame with Mtl. Anc. to Part. Wall	2 Helpers
77.	Dummy	0
78.	Erect Reinf. for Columns	3 Ironworkers
79.	Inst. Block Masonry Walls up to 7' Ht.	3 Laborers, 2 Masons
80.	Pour Lintels on Top of Window Openings	3 Laborers, 1 Mason

CRAFT REQUIREMENTS:

81.	Form Work Columns	2 Scaffolding Men
82.	Cure Block Masonry Walls	1 Curing Man
83.	Pour Conc. in Columns	5 Laborers, 1 Mason
84.	Cure Lintels	1 Curing Man
85.	Form Work Roof Slab & PL Reinf.	7 Scaffolding Men, 2 Ironworkers
86.	Form Work Roof Beams & PL Reinf.	8 Scaffolding Men, 2 Ironworkers
87.	Dummy	0
88.	Set Conduits in Beams & Slab	2 Electricians
89.	Strip and Cure Columns	2 Laborers, 1 Curing Man
90.	Pour Roof Beams & Roof Slab	12 Laborers, 3 Masons
91.	Cure Roof Beam & Roof Slab	2 Curing Men
92.	Strip Form Work Roof Beam & Roof Slab	2 Laborers
93.	Install Door Frames	2 Carpenters
94.	Install Plumbing Fixtures	2 Plumbers
95.	Pull Wire	1 Electrician
96.	Form Work Stairs	1 Scaffolding Man
97.	Install Window Frames	2 Carpenters
98.	Test Piping Systems	1 Plumber
99.	Install Receptacles	1 Electrician
100.	Install Control Panel Box	1 Electrician
101.	Place Reinf. for Stairs	1 Iron Worker
102.	Dummy	0
103.	Lead Time	0
104.	Interior Plaster	6 Laborers, 3 Masons
105.	Testing Int. Wiring Circuits, etc.	1 Electrician
106.	Pour Conc. Stairs	4 Laborers, 2 Masons
107.	Install Ceramic Tiles in Toilets	2 Laborers, 1 Mason
108.	Dummy	0
109.	Mozaic or Terrazo Flooring	8 Laborers, 4 Masons
110.	Lead Time	0
111.	Install Hand Rail for Stairs	2 Carpenters
112.	Strip Form Work & Cure Stairs	1 Laborer
113.	Cutting & Grinding Terrazo Floors	2 Machine Men
114.	Dummy	0
115.	Form Work Overhead Wtr. Reser.	2 Scaffolding Men
116.	Install Block Masonry Parapet Wall	2 Laborers, 1 Mason
117.	Install Doors & Windows	2 Carpenters
118.	Install Toilet Fixtures	2 Plumbers
119.	Complete Balance of Woodwork	2 Carpenters
120.	Place Reinf. Overhead Wtr. Reser.	2 Ironworkers
121.	Dummy	0
122.	Dummy	0
123.	Dummy	0
124.	Interior Painting	4 Painters
125.	Pour Conc. Overhead Wtr. Reser.	5 Laborers, 1 Mason
126.	Exterior Plaster, Curing, Incl. Wtr. Reser.	6 Laborers, 2 Masons

CRAFT REQUIREMENTS:

127.	Roofing & Curing	2 Laborers, 1 Mason
128.	Curing Overhead Wtr. Reser.	1 Curing Man
129.	Dummy	0
130.	Install Cut Stone	2 Stone Fixers
131.	Install Furnishings	3 Furnishers
132.	Install Electrical Fixtures	2 Electricians
133.	Polish Floors	3 Machine Men
134.	Dummy	0
135.	Exterior Painting	4 Painters
136.	Dummy	0
137.	Dummy	0
138.	Interior Finishing	1 Carpenter, 1 Plumber, 1 Electrician
139.	Complete all Exterior Work	4 Laborers
140.	Dummy	0
141.	Dummy	0
142.	Punchlist	0

TABLE 4

PAGE I	J	CRITICAL PATH SCHEDULING C	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	DESCRIPTION		ES	EF	LS	LF	FF	TF
1	2	2	3	1	1	0	0	0	0	0	0	0	MOVE IN	DATA0001	0	3	0	3	0	0
2	3	2	5	1	1	0	0	0	0	0	0	0	SURVEY LAYOUT AND MOBILIZATION	DATA0002	3	5	3	5	0	0
3	4	5	8	0	0	0	0	0	0	0	0	0	ROUGH GRADING	DATA0003	5	10	5	10	0	0
4	5	2	2	1	0	0	0	0	0	0	0	0	OVERHEAD POLE LINE	DATA0004	10	12	13	15	0	3
4	6	1	2	0	0	0	0	0	0	0	0	0	UNDERGROUND WTR PIPING FROM MAIN LINE	DATA0005	10	11	14	15	0	4
4	7	4	5	0	0	0	0	0	0	0	0	0	WATER TANK FOUNDATIONS	DATA0006	10	14	10	14	0	0
4	9	4	5	0	0	0	0	0	0	0	0	0	EXC FOR SEWERS AND MANHOLES	DATA0007	10	14	10	14	0	0
5	8	1	2	1	0	0	0	0	0	0	0	0	PULL IN POWER FEEDER	DATA0008	12	13	15	16	0	3
6	12	2	3	0	0	0	0	0	0	0	0	0	CONNECT PIPING	DATA0010	11	13	15	17	4	4
7	10	2	4	1	0	0	0	0	0	0	0	0	ERRECT WATER TANK	DATA0009	14	16	14	16	0	0
8	11	3	2	1	0	0	0	0	0	0	0	0	INSTALL SEWERS AND MANHOLES	DATA0011	0	2	13	16	0	13
9	12	1	1	0	0	0	0	0	0	0	0	0	INSTALL CONTROL PANEL BOX	DATA0012	13	14	16	17	3	3
10	12	1	1	0	0	0	0	0	0	0	0	0	TANK PIPING AND VALVES	DATA0013	16	17	16	17	0	0
11	12	1	2	0	0	0	0	0	0	0	0	0	BACKFILL	DATA0014	3	4	16	17	13	13
12	13	2	3	1	1	0	0	0	0	0	0	0	BUILDING LAYOUT	DATA0015	17	19	17	19	0	0
13	14	4	3	0	0	0	0	0	0	0	0	0	EXC UNGR WTR RESER	DATA0016	19	23	30	34	0	11
13	15	15	4	0	0	0	0	0	0	0	0	0	EXCAVATION BOUNDARY WALL	DATA0017	19	34	19	34	0	0
13	19	2	6	1	0	0	0	0	0	0	0	0	PURCHASE & DELIVERY OF AGGREGATE & STEEL	DATA0018	19	21	32	34	13	13
13	16	5	0	0	0	0	0	0	0	0	0	0	LEAD TIME	DATA0019	19	24	22	27	0	3
13	18	5	4	0	0	0	0	0	0	0	0	0	EXC FOAS ISOLATED FOOTINGS	DATA0020	19	24	29	34	0	10
14	19	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0021	23	23	34	34	11	11
15	19	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0022	34	34	34	34	0	0
15	17	7	4	0	0	0	0	0	0	0	0	0	EXCAVATION GRADE BEAMS	DATA0023	24	31	27	34	0	3
17	19	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0024	31	31	34	34	3	3
18	19	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0025	24	24	34	34	10	10
19	21	5	0	0	0	0	0	0	0	0	0	0	LEAD TIME	DATA0026	34	39	34	39	0	0
19	21	5	0	0	0	0	0	0	0	0	0	0	LEAD TIME	DATA0027	34	39	35	40	0	1
19	22	1	3	2	0	0	0	0	0	0	0	0	POUR 4 IN THICK CONC SLAB FOR FOOTINGS	DATA0028	34	35	48	49	0	14
20	23	1	6	3	0	0	0	0	0	0	0	0	POUR CONC BASE FOR GRADE BEAMS	DATA0029	39	40	39	40	0	0
21	24	1	8	3	0	0	0	0	0	0	0	0	POUR CONC BASE FOR BOUND WALL	DATA0030	39	40	40	41	0	1
21	25	1	4	2	0	0	0	0	0	0	0	0	POUR CONC BASE FOR UNGR WTR RESER	DATA0031	39	40	40	41	0	1
22	26	4	3	0	0	0	0	0	0	0	0	0	PLACE REINF FOR FOOTINGS	DATA0032	35	39	49	53	0	14
23	27	15	4	0	0	0	0	0	0	0	0	0	FORM WORK GRADE BEAM	DATA0033	40	55	41	55	0	0
24	28	15	5	3	0	0	0	0	0	0	0	0	INST BLOCK MASONRY BOUNDARY WALL	DATA0034	40	55	41	56	0	1
25	29	2	3	0	0	0	0	0	0	0	0	0	PL REINF BASE SLABSWALLS UNGR WTR RESER	DATA0035	40	42	41	43	0	1
26	31	5	4	0	0	0	0	0	0	0	0	0	FORMWORK ISOLATED FOOTINGS	DATA0036	39	44	53	58	0	14
27	31	2	6	3	0	0	0	0	0	0	0	0	POUR GRADE BEAMS	DATA0037	55	57	55	57	0	0
28	32	7	1	0	0	0	0	0	0	0	0	0	CURING BOUNDARY WALL	DATA0038	55	62	56	63	0	1
29	33	1	1	0	0	0	0	0	0	0	0	0	FORMWORK WALLS UNGR WTR RESER	DATA0039	42	43	43	44	0	1
30	34	1	5	2	0	0	0	0	0	0	0	0	POUR CONC ISOLATED FOOTINGS	DATA0040	44	45	53	58	0	14
31	35	1	2	0	0	0	0	0	0	0	0	0	STRIP FORMWORK ISOLATED FOOTINGS	DATA0041	57	58	63	64	0	6
31	36	7	1	0	0	0	0	0	0	0	0	0	CURE GRADE BEAMS	DATA0042	57	64	57	64	0	0
32	37	9	4	3	0	0	0	0	0	0	0	0	PLASTER BOUNDARY WALL	DATA0043	62	70	63	71	0	1
33	38	1	4	2	0	0	0	0	0	0	0	0	POUR BASE SLABSWALLS UNGR WTR RESER	DATA0044	43	44	44	45	0	1
34	40	1	2	0	0	0	0	0	0	0	0	0	STRIP FORMWORK ISOLATED FOOTINGS	DATA0045	45	46	65	66	0	20
34	41	7	1	0	0	0	0	0	0	0	0	0	CURE FOOTINGS	DATA0046	45	52	59	66	14	14
35	36	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0047	58	58	64	64	6	6
36	39	2	3	0	0	0	0	0	0	0	0	0	DAMP PROOFING OF PLINTH	DATA0048	64	66	64	66	0	0
37	54	7	1	0	0	0	0	0	0	0	0	0	CURING BOUNDARY WALL	DATA0049	70	77	71	78	1	1
38	42	7	1	0	0	0	0	0	0	0	0	0	CURING BASE SLABSWALLS UNGR WTR RESER	DATA0050	44	51	45	52	0	1

PAGE 2CRITICAL PATH SCHEDULING

I	J	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	DESCRIPTION		ES	EF	LS	LF	FF	TF
39	41	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0051	66	66	66	66	0	0
40	41	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0052	46	46	66	66	20	20
41	43	2	1	0	0	0	0	0	0	0	0	0	INSTALL UNDERGROUND SLAB CONDUITS	DATA0053	66	68	68	70	0	2
41	44	4	2	0	0	0	0	0	0	0	0	0	INSTALL UNDERGROUND SLAB PLUMBING	DATA0054	66	70	66	70	0	0
42	45	1	2	0	0	0	0	0	0	0	0	0	FORMWORK ROOF SLAB UNGR WTR RESER	DATA0055	51	52	52	53	0	1
43	44	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0056	68	68	70	70	2	2
44	45	2	2	1	0	0	0	0	0	0	0	0	PURCHASE AND DELIVERY OF STONE FOR PCKG	DATA0057	70	72	71	73	0	1
44	50	3	2	0	0	0	0	0	0	0	0	0	COMPACT AND BACKFILL	DATA0058	70	73	70	73	0	0
45	46	1	2	0	0	0	0	0	0	0	0	0	PL REINF ROOF SLAB UNGR WTR RESER	DATA0059	52	53	53	54	0	1
46	47	5	0	0	0	0	0	0	0	0	0	0	LEAD TIME	DATA0060	53	58	54	59	0	1
46	48	1	4	2	0	0	0	0	0	0	0	0	POUR ROOF SLAB UNGR WTR RESER	DATA0061	53	54	59	60	5	6
47	48	1	2	0	0	0	0	0	0	0	0	0	STRIP FORMWORK WALLS UNGR WTR RESER	DATA0062	58	59	59	60	0	1
48	51	8	2	1	0	0	0	0	0	0	0	0	STRIP FORMWORK & CURE ROOF SLAB	DATA0063	59	67	60	68	0	1
49	50	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0064	72	72	73	73	1	1
50	54	6	2	0	0	0	0	0	0	0	0	0	STEP PACKING AND COMPACTION	DATA0065	73	78	73	78	0	0
51	52	1	2	0	0	0	0	0	0	0	0	0	COATING DAMP PROOFING MAT UNGR WTR RESER	DATA0066	67	68	68	69	0	1
52	53	9	4	2	1	0	0	0	0	0	0	0	INTERIOR PLASTER & CURING UNGR WTR RESER	DATA0067	68	76	69	77	0	1
53	54	1	2	0	0	0	0	0	0	0	0	0	BACKFILL AND COMPACT UNGR WTR RESER	DATA0068	76	77	77	78	1	1
54	55	2	10	4	0	0	0	0	0	0	0	0	POUR CONC BASE SLAB ON PLINTH	DATA0069	78	80	78	80	0	0
54	57	2	1	0	0	0	0	0	0	0	0	0	PURCHELY WOOD FOR DR BUCKS WIND&WIND FR	DATA0070	78	80	85	87	0	7
55	56	7	1	0	0	0	0	0	0	0	0	0	CURE BASE SLAB	DATA0071	80	87	80	87	0	0
56	58	4	3	1	0	0	0	0	0	0	0	0	INST BLOCK MASONRY WALL UPTO 3FT HT	DATA0072	87	91	87	91	0	0
57	58	4	2	0	0	0	0	0	0	0	0	0	CONSTRUCT DR BUCKS DR FR WIND FR & WIND	DATA0073	80	84	87	91	7	7
58	59	3	2	0	0	0	0	0	0	0	0	0	INSTALL CONDUITS IN MASONRY WALLS	DATA0074	91	94	95	98	0	4
58	60	7	1	0	0	0	0	0	0	0	0	0	CURE BLOCK MASONRY WALLS	DATA0075	91	98	91	98	0	0
58	62	5	2	0	0	0	0	0	0	0	0	0	INST DR BUCKS&WIND FR WI MTL ANC PARTWAL	DATA0076	91	96	99	104	8	8
59	60	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0077	94	94	98	98	4	4
60	61	5	3	0	0	0	0	0	0	0	0	0	ERECT REINF FOR COLUMNS	DATA0078	98	103	112	117	0	14
60	62	6	3	2	0	0	0	0	0	0	0	0	INST BLOCK MASONRY WALLS UPTO 7FT HT	DATA0079	98	104	98	104	0	0
60	64	8	3	1	0	0	0	0	0	0	0	0	POUR LINTELS ON TOP OF WINDOW OPENINGS	DATA0080	98	106	121	129	9	23
61	63	10	2	0	0	0	0	0	0	0	0	0	FORMWORK COLUMNS	DATA0081	103	113	117	127	0	14
62	65	7	1	0	0	0	0	0	0	0	0	0	CURE BLOCK MASONRY WALLS	DATA0082	104	111	104	111	0	0
63	64	2	5	1	0	0	0	0	0	0	0	0	POUR CONCRETE COLUMNS	DATA0083	113	115	127	129	0	14
64	69	7	1	0	0	0	0	0	0	0	0	0	CURE LINTELS	DATA0084	106	113	129	136	23	23
65	66	15	7	2	0	0	0	0	0	0	0	0	FORMWORK ROOF SLAB & PL REINF	DATA0085	111	126	116	131	0	5
65	67	20	8	2	0	0	0	0	0	0	0	0	FORMWORK ROOF BEAMS & PL REINF	DATA0086	111	131	111	131	0	0
66	67	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0087	126	126	131	131	5	5
67	69	5	2	0	0	0	0	0	0	0	0	0	SET CONDUITS IN BEAMS AND SLAB	DATA0088	131	136	131	136	0	0
68	69	7	2	1	0	0	0	0	0	0	0	0	STRIP AND CURE COLUMNS	DATA0089	115	122	129	136	14	14
69	70	2	12	3	0	0	0	0	0	0	0	0	POUR ROOF BEAMS AND ROOF SLAB	DATA0090	136	138	136	138	0	0
70	71	28	2	0	0	0	0	0	0	0	0	0	CURE ROOF BEAMS AND ROOF SLAB	DATA0091	138	166	138	166	0	0
71	72	3	2	0	0	0	0	0	0	0	0	0	STRIP FORMWORK ROOF BEAMS AND ROOF SLAB	DATA0092	166	169	166	169	0	0
72	73	5	2	0	0	0	0	0	0	0	0	0	INSTALL DOOR FRAMES	DATA0093	169	174	171	176	0	2
72	74	10	2	0	0	0	0	0	0	0	0	0	INSTALL PLUMBING FIXTURES	DATA0094	169	179	169	179	0	0
72	75	5	1	0	0	0	0	0	0	0	0	0	PULL WIRE	DATA0095	169	174	213	223	0	49
72	77	5	1	0	0	0	0	0	0	0	0	0	FORMWORK STAIRS	DATA0096	169	174	216	221	0	47
73	74	5	2	0	0	0	0	0	0	0	0	0	INSTALL WINDOW FRAMES	DATA0097	174	179	176	181	0	2
74	79	2	1	0	0	0	0	0	0	0	0	0	TEST PIPNG SYSTEMS	DATA0098	179	181	179	181	0	0
75	76	5	1	0	0	0	0	0	0	0	0	0	INSTALL RECEPTACALES	DATA0099	174	179	223	228	0	49
76	80	2	1	0	0	0	0	0	0	0	0	0	INSTALL CONTROL PANNEL BOX	DATA0100	179	181	228	230	0	49

PAGE 3CPITICAL PATH SCHEDULING

I	J	D	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	DESCRIPTION		ES	EF	LS	LF	FF	TF
77	81	2	1	0	0	0	0	0	0	0	0	0	PLACE REINF FOR STAIRS	DATA0101	174	176	221	223	0	47
79	79	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0102	179	179	181	181	2	2
79	82	10	0	0	0	0	0	0	0	0	0	0	LEAD TIME	DATA0103	181	191	192	202	0	11
73	84	25	6	0	0	0	0	0	0	0	0	0	INTERIOR PLASTER	DATA0104	181	206	181	206	0	0
80	85	1	1	0	0	0	0	0	0	0	0	0	TESTING INTERIOR WIRING CIRCUITS ETC	DATA0105	181	182	230	231	0	49
81	86	1	4	2	0	0	0	0	0	0	0	0	POUR CONC. STAIRS	DATA0106	176	177	223	224	0	47
82	83	4	2	1	0	0	0	0	0	0	0	0	INSTALL CERAMIC TILES IN TOILETS	DATA0107	191	195	202	206	0	11
83	84	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0108	195	195	206	206	11	11
84	87	15	8	4	0	0	0	0	0	0	0	0	MOZAIC ON TERRAZO FLOORING	DATA0109	206	221	206	221	0	0
85	86	15	0	0	0	0	0	0	0	0	0	0	LEAD TIME	DATA0110	182	197	231	246	0	49
85	88	2	2	0	0	0	0	0	0	0	0	0	INSTALL HAND RAILS FOR STAIRS	DATA0111	177	179	229	231	0	52
86	89	2	1	0	0	0	0	0	0	0	0	0	STRIP FORMWORK AND CURE STAIRS	DATA0112	177	184	224	231	0	47
87	90	15	2	0	0	0	0	0	0	0	0	0	CUTTING AND GRINDING MOZAIC FLOORS	DATA0113	221	236	221	236	0	0
89	89	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0114	179	179	231	231	5	52
87	91	5	2	0	0	0	0	0	0	0	0	0	FORMWORK OVERHEAD WTR RESER	DATA0115	184	189	246	251	0	62
88	92	5	2	1	0	0	0	0	0	0	0	0	INSTALL BLOCK MASONRY PARAPET WALL	DATA0116	184	189	231	236	0	47
90	92	0	2	0	0	0	0	0	0	0	0	0	INSTALL DOORS AND WINDOWS	DATA0117	236	245	237	246	0	1
91	93	10	2	0	0	0	0	0	0	0	0	0	INSTALL TOILET FIXTURES	DATA0118	236	246	236	246	0	0
90	95	5	2	0	0	0	0	0	0	0	0	0	COMPLETE BALANCE OF WOOD WORK	DATA0119	236	241	241	246	5	5
91	95	2	2	0	0	0	0	0	0	0	0	0	PLACE REINF OVERHEAD WTR RESER	DATA0120	189	191	251	253	0	62
92	96	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0121	245	245	246	246	1	1
93	95	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0122	245	246	246	246	0	0
94	96	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0123	197	197	245	246	49	49
95	101	20	4	0	0	0	0	0	0	0	0	0	INTERIOR PAINTING	DATA0124	246	266	246	266	0	0
96	98	1	5	1	0	0	0	0	0	0	0	0	POUR CONC OVERHEAD WTR RESER	DATA0125	191	192	253	254	0	62
97	99	20	6	2	0	0	0	0	0	0	0	0	EXTERIOR PLASTER,CURING INCL WTR RESER	DATA0126	189	209	236	256	0	47
97	100	10	2	1	0	0	0	0	0	0	0	0	ROOFING AND CURING	DATA0127	189	199	246	256	10	57
98	103	7	1	0	0	0	0	0	0	0	0	0	CURING OVERHEAD WATER RESER	DATA0128	192	199	254	261	15	62
99	100	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0129	209	209	256	256	0	47
100	102	5	2	0	0	0	0	0	0	0	0	0	INSTALL CUT STONE	DATA0130	209	214	256	261	0	47
101	104	10	3	0	0	0	0	0	0	0	0	0	INSTALL FURNISHINGS	DATA0131	266	276	266	276	0	0
101	105	5	2	0	0	0	0	0	0	0	0	0	INSTALL ELECTRICAL FIXTURES	DATA0132	266	271	271	276	0	5
101	106	5	3	0	0	0	0	0	0	0	0	0	POLISH FLOORS	DATA0133	266	271	271	276	5	5
102	103	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0134	214	214	261	261	0	47
103	107	15	4	0	0	0	0	0	0	0	0	0	EXTERIOR PAINTING	DATA0135	214	229	261	276	0	47
106	106	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0136	276	276	276	276	0	0
105	105	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0137	271	271	276	276	5	5
106	108	10	1	1	1	0	0	0	0	0	0	0	INTERIOR FINISHING	DATA0138	276	286	276	286	0	0
107	109	10	4	0	0	0	0	0	0	0	0	0	COMP ALL EXT WK(GATE,GARDN,LIGHTING & PK)	DATA0139	229	239	276	286	0	47
108	110	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0140	286	286	286	296	0	0
109	110	0	0	0	0	0	0	0	0	0	0	0	DUMMY	DATA0141	239	239	286	286	47	47
110	111	10	0	0	0	0	0	0	0	0	0	0	PUNCH LIST	DATA0142	286	296	286	296	0	0

TABLE 5

PAGE TIME	TOTAL	A	B	C	D	E	F	G	H	I	J
				MARKOVER LEVELING							
0	7	5	1	1	0	0	0	0	0	0	0
2	10	7	2	1	0	0	0	0	0	0	0
5	8	8	0	0	0	0	0	0	0	0	0
10	12	12	0	0	0	0	0	0	0	0	0
11	13	12	1	0	0	0	0	0	0	0	0
14	8	7	1	0	0	0	0	0	0	0	0
15	7	6	1	0	0	0	0	0	0	0	0
16	3	3	0	0	0	0	0	0	0	0	0
17	5	3	1	1	0	0	0	0	0	0	0
19	4	4	0	0	0	0	0	0	0	0	0
20	8	8	0	0	0	0	0	0	0	0	0
21	11	11	0	0	0	0	0	0	0	0	0
25	11	10	1	0	0	0	0	0	0	0	0
27	8	8	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0
38	5	3	2	0	0	0	0	0	0	0	0
39	15	10	5	0	0	0	0	0	0	0	0
40	17	14	3	0	0	0	0	0	0	0	0
41	15	13	2	0	0	0	0	0	0	0	0
43	14	12	2	0	0	0	0	0	0	0	0
44	17	13	4	0	0	0	0	0	0	0	0
45	16	14	2	0	0	0	0	0	0	0	0
50	12	10	2	0	0	0	0	0	0	0	0
52	11	11	0	0	0	0	0	0	0	0	0
54	11	9	2	0	0	0	0	0	0	0	0
55	15	11	4	0	0	0	0	0	0	0	0
56	9	7	2	0	0	0	0	0	0	0	0
57	10	8	2	0	0	0	0	0	0	0	0
58	9	7	2	0	0	0	0	0	0	0	0
59	7	7	0	0	0	0	0	0	0	0	0
60	6	5	1	0	0	0	0	0	0	0	0
63	11	8	3	0	0	0	0	0	0	0	0
64	13	10	3	0	0	0	0	0	0	0	0
65	12	9	3	0	0	0	0	0	0	0	0
68	10	8	2	0	0	0	0	0	0	0	0
69	15	10	4	1	0	0	0	0	0	0	0
71	13	9	3	1	0	0	0	0	0	0	0
73	10	7	2	1	0	0	0	0	0	0	0
77	5	5	0	0	0	0	0	0	0	0	0
79	14	10	4	0	0	0	0	0	0	0	0
80	2	2	0	0	0	0	0	0	0	0	0
82	1	1	0	0	0	0	0	0	0	0	0
83	3	3	0	0	0	0	0	0	0	0	0
87	4	3	1	0	0	0	0	0	0	0	0
91	3	3	0	0	0	0	0	0	0	0	0
93	7	5	2	0	0	0	0	0	0	0	0
99	8	6	2	0	0	0	0	0	0	0	0
104	7	6	1	0	0	0	0	0	0	0	0
111	25	20	5	0	0	0	0	0	0	0	0
112	22	18	4	0	0	0	0	0	0	0	0

PAGE 2 MANPOWER LEVELING

TIME	TOTAL	A	B	C	D	E	F	G	H	I	J
114	20	16	4	0	0	0	0	0	0	0	0
119	19	15	4	0	0	0	0	0	0	0	0
124	16	13	3	0	0	0	0	0	0	0	0
129	13	10	3	0	0	0	0	0	0	0	0
131	5	4	1	0	0	0	0	0	0	0	0
135	2	2	0	0	0	0	0	0	0	0	0
136	15	12	3	0	0	0	0	0	0	0	0
143	2	2	0	0	0	0	0	0	0	0	0
149	3	3	0	0	0	0	0	0	0	0	0
171	5	5	0	0	0	0	0	0	0	0	0
179	4	4	0	0	0	0	0	0	0	0	0
181	9	6	3	0	0	0	0	0	0	0	0
196	15	10	5	0	0	0	0	0	0	0	0
197	14	10	4	0	0	0	0	0	0	0	0
199	13	9	4	0	0	0	0	0	0	0	0
201	11	8	3	0	0	0	0	0	0	0	0
206	12	8	4	0	0	0	0	0	0	0	0
213	13	9	4	0	0	0	0	0	0	0	0
216	12	8	4	0	0	0	0	0	0	0	0
221	7	6	1	0	0	0	0	0	0	0	0
225	10	8	2	0	0	0	0	0	0	0	0
233	12	10	2	0	0	0	0	0	0	0	0
235	16	13	3	0	0	0	0	0	0	0	0
236	15	13	2	0	0	0	0	0	0	0	0
241	13	11	2	0	0	0	0	0	0	0	0
243	12	10	2	0	0	0	0	0	0	0	0
245	10	8	2	0	0	0	0	0	0	0	0
246	7	6	1	0	0	0	0	0	0	0	0
254	6	6	0	0	0	0	0	0	0	0	0
261	9	8	0	0	0	0	0	0	0	0	0
266	9	9	0	0	0	0	0	0	0	0	0
271	10	10	0	0	0	0	0	0	0	0	0
276	7	5	1	1	0	0	0	0	0	0	0
286	0	0	0	0	0	0	0	0	0	0	0

TABLE 6

PAGE 3 MANPOWER LEVELING

I	J	D	START TIME	DESCRIPTION	
1	2	3	0	MOVE IN	DATA0001
2	3	2	3	SURVEY LAYOUT AND MOBILIZATION	DATA0002
3	4	5	5	ROUGH GRADING	DATA0003
4	5	2	11	OVERHEAD POLE LINE	DATA0004
4	6	1	10	UNDERGROUND WTR PIPING FROM MAIN LINE	DATA0005
4	7	4	10	WATER TANK FOUNDATIONS	DATA0006
4	7	4	10	EXC FOR SEWERS AND MANHOLES	DATA0007
5	8	1	13	PULL IN POWER FEEDER	DATA0008
6	12	2	14	CONNECT PIPING	DATA0010
7	10	2	14	ERECT WATER TANK	DATA0010
8	11	3	2	INSTALL SEWERS AND MANHOLES	DATA0011
9	12	1	14	INSTALL CONTROL PANEL BOX	DATA0012
10	12	1	16	TANK PIPING AND VALVES	DATA0013
11	12	1	16	BACKFILL	DATA0014
12	13	2	17	BUILDING LAYOUT	DATA0015
13	14	4	21	EXC UNGR WTR RESER	DATA0016
13	15	15	19	EXCAVATION BOUNDARY WALL	DATA0017
13	19	2	25	PURCHASE & DELIVERY OF AGGREGATE & STEEL	DATA0018
13	16	5	19	LEAD TIME	DATA0019
13	18	5	20	EXC FOR ISOLATED FOOTINGS	DATA0020
14	14	0	25	DUMMY	DATA0021
15	19	0	24	DUMMY	DATA0022
16	17	7	27	EXCAVATION GRADE BEAMS	DATA0023
17	19	0	34	DUMMY	DATA0024
18	19	0	25	DUMMY	DATA0025
19	20	5	34	LEAD TIME	DATA0026
19	21	5	34	LEAD TIME	DATA0027
19	22	1	39	POUR 4 IN THICK CONC SLAB FOR FOOTINGS	DATA0028
20	23	1	39	POUR CONC BASE FOR GRADE BEAMS	DATA0029
21	24	1	40	POUR CONC BASE FOR BOUND WALL	DATA0030
21	25	1	39	POUR CONC BASE FOR UNGR WTR RESER	DATA0031
22	26	4	43	PLACE REINF FOR FOOTINGS	DATA0032
23	27	15	40	FORM WORK GRADE BEAM	DATA0033
24	23	15	41	INST BLOCK MASONRY BOUNDARY WALL	DATA0034
25	29	2	41	PL REINF BASE SLAB&WALLS UNGR WTR RESER	DATA0035
26	30	5	45	FORMWORK ISOLATED FOOTINGS	DATA0036
27	31	2	55	POUR GRADE BEAMS	DATA0037
28	32	7	56	CURING BOUNDARY WALL	DATA0038
29	33	1	43	FORMWORK WALLS UNGR WTR RESER	DATA0039
30	34	1	58	POUR CONC ISOLATED FOOTINGS	DATA0040
31	35	1	57	STRIP FORMWORK ISOLATED FOOTINGS	DATA0041
31	36	7	57	CURE GRADE BEAMS	DATA0042
32	37	8	63	PLASTER BOUNDARY WALL	DATA0043
33	33	1	44	POUR BASE SLAB&WALLS UNGR WTR RESER	DATA0044
34	43	1	59	STRIP FORMWORK ISOLATED FOOTINGS	DATA0045
34	41	7	59	CURE FOOTINGS	DATA0046
35	35	0	58	DUMMY	DATA0047
36	39	2	64	DAMP PROOFING OF PLINTH	DATA0048
37	54	7	71	CURING BOUNDARY WALL	DATA0049
38	42	7	45	CURING BASE SLAB&WALLS UNGR WTR RESER	DATA0050

PAGE 4 MANPOWER LEVELING

I	J	D	START TIME	DESCRIPTION	
39	41	3	66	DUMMY	DATA0051
40	41	0	60	DUMMY	DATA0052
41	43	2	64	INSTALL UNDERGROUND SLAB CONDUITS	DATA0053
41	44	4	66	INSTALL UNDERGROUND SLAB PLUMBING	DATA0054
42	45	1	62	FORMWORK ROOF SLAB UNGR WTR RESER	DATA0055
43	46	3	68	DUMMY	DATA0056
44	47	2	71	PURCHASE AND DELIVERY OF STONE FOR PCKG	DATA0057
44	47	3	73	COMPACT AND BACKFILL	DATA0058
45	46	1	63	PL REINF ROOF SLAB UNGR WTR RESER	DATA0059
46	47	5	64	LEAD TIME	DATA0060
46	48	1	67	POUR ROOF SLAB UNGR WTR RESER	DATA0061
47	48	1	66	STRIP FORMWORK WALLS UNGR WTR RESER	DATA0062
48	51	4	67	STRIP FORMWORK & CURE ROOF SLAB	DATA0063
49	50	0	73	DUMMY	DATA0064
50	54	5	73	STONE PACKING AND COMPACTION	DATA0065
51	52	1	66	COATING DAMP PROOFING MAT UNGR WTR RESER	DATA0066
52	53	2	69	PLASTER & CURING UNGR WTR RESER	DATA0067
53	54	1	77	BACKFILL AND COMPACT UNGR WTR RESER	DATA0068
54	55	2	78	POUR CONC BASE SLAB ON PLINTH	DATA0069
54	57	2	80	PURPOSELY WOOD FOR DR BUCKS WINDWIND FR	DATA0070
55	56	2	83	CURE BASE SLAB	DATA0071
56	58	4	87	INST BLOCK MASONRY WALL UPTO 3FT HT	DATA0072
57	58	4	83	CONSTRUCT DR BUCKS CR FR WIND FR & WIND	DATA0073
58	59	3	81	INSTALL CONDUITS IN MASONRY WALLS	DATA0074
59	60	2	91	CURE BLOCK MASONRY WALLS	DATA0075
59	62	5	94	INST DR BUCKS&WIND FR WI MTL ANC PARTWAL	DATA0076
59	61	0	94	DUMMY	DATA0077
60	61	5	99	ERRECT REINF FOR COLUMNS	DATA0078
60	67	6	98	INST BLOCK MASONRY WALLS UPTO 7FT HT	DATA0079
60	64	8	104	POUR LINTELS ON TOP OF WINDOW OPENINGS	DATA0080
61	63	10	104	FORMWORK COLUMNS	DATA0081
62	65	7	104	CURE BLOCK MASONRY WALLS	DATA0082
63	64	2	126	POUR CONCRETE COLUMNS	DATA0083
64	69	7	112	CURE LINTELS	DATA0084
65	66	15	111	FORMWORK ROOF SLAB & PL REINF	DATA0085
65	67	20	111	FORMWORK ROOF BEAMS & PL REINF	DATA0086
66	67	0	126	DUMMY	DATA0087
67	69	5	131	SET CONDUITS IN BEAMS AND SLAB	DATA0088
68	69	7	128	STRIP AND CURE COLUMNS	DATA0089
69	70	2	136	POUR ROOF BEAMS AND ROOF SLAB	DATA0090
70	71	23	138	CURE ROOF BEAMS AND ROOF SLAB	DATA0091
71	72	3	166	STRIP FORMWORK ROOF BEAMS ANT ROOF SLAB	DATA0092
72	73	5	171	INSTALL DOOR FRAMES	DATA0093
72	74	10	169	INSTALL PLUMBING FIXTURES	DATA0094
72	75	5	174	PULL WIRE	DATA0095
72	77	5	169	FORMWORK STAIRS	DATA0096
73	76	5	176	INSTALL WINDOW FRAMES	DATA0097
74	78	2	179	TEST PIPNG SYSTEMS	DATA0098
75	76	5	201	INSTALL RECEPTACALES	DATA0099
76	80	2	213	INSTALL CONTROL PANNEL BOX	DATA0100
77	81	2	179	PLACE REINF FOR STAIRS	DATA0101

PAGE 5 MANPOWER LEVELING

I	J	D	START	TIME	DESCRIPTION	
78	79	0		191	DUMMY	DATA0102
79	82	10		191	LEAD TIME	DATA0103
79	84	25		191	INTERIOR PLASTER	DATA0104
80	85	1		215	TESTING INTERIOR WIRING CIRCUTS ETC	DATA0105
81	86	1		136	POUR CONC. STAIRS	DATA0106
82	83	4		137	INSTALL CERAMIC TILES IN TOILETS	DATA0107
83	86	0		201	DUMMY	DATA0108
84	87	15		206	MOZAIC ON TERRAZO FLOORING	DATA0109
85	96	15		216	LEAD TIME	DATA0110
86	88	2		197	INSTALL HAND RAILS FOR STAIRS	DATA0111
86	90	7		199	STRIP FORMWORK AND CURE STAIRS	DATA0112
87	93	15		221	CUTTING AND GRINDING MOZAIC FLOORS	DATA0113
88	88	0		199	DUMMY	DATA0114
89	91	5		221	FORMWORK OVERHEAD WTR RESER	DATA0115
89	97	5		221	INSTALL BLOCK MASONRY PARAPET WALL	DATA0116
90	92	9		236	INSTALL DOORS AND WINDOWS	DATA0117
90	93	10		236	INSTALL TOILET FIXTURES	DATA0118
90	95	5		236	COMPLETE BALANCE OF WOOD WORK	DATA0119
91	96	2		233	PLACE REINF OVERHEAD WTR RESER	DATA0120
92	95	0		245	DUMMY	DATA0121
93	95	0		246	DUMMY	DATA0122
94	95	0		231	DUMMY	DATA0123
95	131	20		246	INTERIOR PAINTING	DATA0124
96	98	1		235	POUR CONC OVERHEAD WTR RESER	DATA0125
97	99	20		226	EXTERIOR PLASTER,CURING INCL WTR RESER	DATA0126
97	100	10		246	ROOFING AND COPING	DATA0127
98	113	7		236	CURING OVERHEAD WATER RESER	DATA0128
99	100	0		246	DUMMY	DATA0129
100	102	5		256	INSTALL CUT STONE	DATA0130
101	106	10		266	INSTALL FURNISHINGS	DATA0131
101	105	5		256	INSTALL ELECTRICAL FIXTURES	DATA0132
101	106	5		271	POLISH FLOORS	DATA0133
102	103	0		261	DUMMY	DATA0134
103	107	15		261	EXTERIOR PAINTING	DATA0135
104	106	0		276	DUMMY	DATA0136
105	106	0		271	DUMMY	DATA0137
106	108	10		276	INTERIOR FINISHING	DATA0138
107	107	10		276	COMP ALL EXT WK(GATE,GARDN,LIGHTING & PK)	DATA0139
108	110	0		286	DUMMY	DATA0140
109	110	0		236	DUMMY	DATA0141
110	111	10		286	PUNCH LIST	DATA0142

ESTIMATED COST OF ACTIVITIES

The traditional method has been used in estimating the cost of the activities and that is by taking off material quantities from the drawings, by assigning material costs, labor costs, overhead costs and estimated costs of supervision and equipment. The summation of costs of activities results in the total cost of completing the project. In this report, cost estimates are very approximate.

Cost of activities is indicated in Rupees, which is a Pakistani currency and the conversion is that $1.00 is equal to Rupees $10.00. Abbreviation RS is used for Rupees.

The arrow network of the project is broken up into three portions. The cost of activities calculated are used for cost control computations for the first portion of the network only.

ESTIMATED COST OF ACTIVITIES:

First Portion of Network

Node No.	Description	Estimated Cost (RS)
1, 2	Move In	500
2, 3	Survey Layout & Mobilization	3,000
3, 4	Rough Grading	1,000
4, 5	Overhead Pole Line	2,000
4, 6	Ungr. Wtr. Piping from Main Line	2,000
4, 7	Wtr. Tank Fdns.	1,000
4, 8	Exc. for Sewers & Manholes	100
5, 9	Pull in Power Feeder	100
6, 12	Connect Piping	1,000
7, 10	Erect Water Tank	3,000
8, 11	Install Sewers & Manholes	2,000
9, 12	Install Control Panel Box	200
10, 12	Tank Piping Valves	200
11, 12	Backfill	100
12, 13	Building Layout	2,000
13, 14	Exc. Ungr. Wtr Reser.	200
13, 15	Exc. Boundary Wall	1,000
13, 19	Purchase & Delivery Aggregate & Steel	60,000
13, 16	Lead Time	--
13, 18	Exc. Fdns. Isolated Footings	500
14, 19	Dummy	--
15, 19	Dummy	--
16, 17	Exc. Grade Beams	700
17, 19	Dummy	--
18, 19	Dummy	--
19, 20	Lead Time	--
19, 21	Lead Time	--
19, 22	Pour 4" Thick Slab for Footings	600
20, 23	Pour Grade Beam Base Layer	1,200
21, 24	Pour Conc. Base for Boundary Wall	1,000
21, 25	Pour Conc. Base for Ungr. Wtr. Reser.	200
22, 26	PL Reinf. Footings	300
23, 27	Form Work Grade Beam	2,500
24, 28	Install Block Masonry Boundary Wall	2,000
25, 29	PL Reinf. for Base Slab & Walls Ungr. Wtr. Reser.	400
26, 30	Form Work Isolated Footings	1,200
27, 31	Pour Grade Beams	400
28, 32	Curing Boundary Wall	200
29, 33	Form Work Walls Ungr. Wtr. Reser.	300
30, 34	Pour Isolated Footings	400
31, 35	Strip Form Work Isolated Footing	200
31, 36	Cure Grade Beams	200
32, 37	Plaster Boundary Wall	1,200
33, 38	Pour Base Slab Wall Ungr. Wtr. Reser.	200
34, 40	Strip Form Work Isolated Footings	100
34, 41	Cure Footings	200
35, 36	Dummy	--
36, 39	Damp Proofing Plinth	300

ESTIMATED COST OF ACTIVITIES:

Second Portion of Network

Node No.	Description	Estimated Cost (RS)
37, 54	Curing Boundary Wall	200
38, 42	Cure Base Slab & Walls Ungr. Wtr. Reser.	200
39, 41	Dummy	--
40, 41	Dummy	--
41, 43	Inst. Ungr. Slab Conduits	1,000
41, 44	Inst. Ungr. Slab Plumbing	800
42, 45	Form Work Roof Slab Ungr. Wtr Reser.	300
43, 44	Dummy	--
44, 49	Purchase & Delivery Stone for Pckg.	3,000
44, 50	Compact & Backfill	200
45, 46	PL Reinf. Roof Slab Ungr. Wtr. Reser.	200
46, 47	Lead Time	--
46, 48	Pour Roof Slab Ungr. Wtr. Reser.	150
47, 48	Strip Form Work Walls Ungr. Wtr. Reser.	100
48, 51	Strip Form Work & Cure Roof Slab Ungr. Wtr. Reser.	400
49, 50	Dummy	--
50, 54	Stone Packing & Compaction	500
51, 52	Coating With Damp Proof. Mat. Ungr. Wtr. Reser.	100
52, 53	Int. & Ext. Plaster & Curing Ungr. Wtr. Reser.	500
53, 54	Backfill & Compact (Ungr. Wtr. Reser.)	50
54, 55	Pour Conc. Base Slab on Plinth	500
54, 57	Purchase Wood for Dr. Bucks, Windows and Window Frames	30,000
55, 56	Cure Base Slab	200
56, 58	Install Block Masonry Part. Walls up to 3' Ht.	500
57, 58	Construct Door Bucks	600
58, 59	Install Conduits in Masonry Walls	500
58, 60	Cure Block Masonry Walls	200
58, 62	Install Dr. Bucks & Wind. Frames With Mtl. Anc. to Part. Walls	200
59, 60	Dummy	--
60, 61	Erect Reinf. for Columns	600
60, 62	Install Block Masonry Walls up to 7' Ht. incl. Form Work	1,000
60, 64	Pour Lintels on top of Wind. Openings	600
61, 63	Form Work Columns	800
62, 65	Cure Block Masonry Walls	200
63, 68	Pour Conc. Column	300
64, 69	Cure Lintels	200
65, 66	Form Work Roof Slab	2,100
65, 67	Form Work Roof Beam	3,200
66, 67	Dummy	--
67, 69	Set Conduits in Beams & Slabs	500

ESTIMATED COST OF ACTIVITIES:

Third Portion of Network

Node No.	Description	Estimated Cost (RS)
68, 69	Strip & Cure Column	300
69, 70	Pour Roof Beams & Roof Slab	2,500
70, 71	Cure Roof Slab & Roof Beams	800
71, 72	Strip Form Work Roof Slab & Roof Beams	600
72, 73	Install Door Frames	400
72, 74	Install Plumbing Fixtures	1,000
72, 75	Pull Wire	300
72, 77	Form Work Stairs	200
73, 78	Install Window Frames	600
74, 79	Test Piping Systems	60
75, 76	Install Receptacles	250
76, 80	Install Control Panel Box	300
77, 81	Place Reinf. for Stairs	100
78, 79	Dummy	--
79, 82	Lead Time	--
79, 84	Interior Plaster	4,500
80, 85	Testing Int. Wiring, Circuits, etc.	50
81, 86	Pour Conc. Stairs	150
82, 83	Install Ceramic Tiles in Toilets	3,000
83, 84	Dummy	--
84, 87	Mozaic or Terrazo Flooring	7,000
85, 94	Lead Time	--
86, 88	Install Hand Rails for Stairs	300
86, 89	Strip Form Work & Cure Stairs	200
87, 90	Cutting & Grinding Mozaic Floors	1,000
88, 89	Dummy	--
89, 91	Form Work Overhead Wtr. Reser.	500
89, 97	Install Block Masonry Parapet Wall	800
90, 92	Install & Construct Doors & Windows	200
90, 93	Install Toilet Fixtures	7,000
90, 95	Complete Balance of Wood Work	1,000
91, 96	Place Reinf. Overhead Wtr. Reser.	200
92, 95	Dummy	--
93, 95	Dummy	--
94, 95	Dummy	--
95, 101	Interior Painting	8,000
96, 98	Pour Conc. Overhead Water Reser.	200
97, 99	Ext. Plaster & Curing incl. Overhead Reser.	3,200
97, 100	Roofing & Curing	1,000
98, 103	Cure Overhead Wtr. Reser.	200
99, 100	Dummy	--
100, 102	Install Cut Stone	1,000
101, 104	Install Furnishings	2,000
101, 105	Install Elect. Fixtures	4,000
101, 106	Polish Floors	500
102, 103	Dummy	--
103, 107	Ext. Painting	3,000

ESTIMATED COST OF ACTIVITIES:

Third Portion of Network

Node No.	Description	Estimated Cost (RS)
104, 106	Dummy	--
105, 106	Dummy	--
106, 108	Int. Finishing	1,000
107, 109	Comp. all Ext. Work, Gate, Garden, Lighting, Parking, etc.	3,000
108, 110	Dummy	--
109, 110	Dummy	--
110, 111	Punchlist	1,000

COST CONTROL

Cost Control of Project Costs is set up on the basis of the CPM activities. The basis of CPM Cost Control is the network with activity costs assigned. The actual cost of work to date is compared with the cost estimates. This requires the collection of actual costs on an activity basis. Cost Control Method helps in assessing the cost of project until the present time and also in forecasting the future project cost.

A table is set up for the completed activities and the activities to be completed giving details of estimated total cost, cost to date, estimated cost to complete, actual total cost and cost variation. (See Tables 7a and 7b)

Another table is set up for activities' original estimate, actual or new estimate, activity variation, percent activity variation and project variation percent. (See Tables 8a and 8b)

Having this actual information, comparing it with estimated, the final cost can be forecast by two different methods which are as follows:

1. The summation of Column 6 (Project Variation Percent) yields a percentage which indicates whether the project is overrun or underrun. Positive sign indicates overrun and a negative sign indicates underrun. (See Tables 8a and 8b)

2. The summation of Column 4 (Activity Variation) divided by the total estimated cost, multiplied by 100 also yields the percentage which indicates whether the project is overrun or underrun. (See Tables 8a and 8b)

Final Project Forecast

$$\text{Percentage of Overrun or Underrun of the Estimated Project Cost} = \frac{\text{Estimated Cost to This Date}}{\text{Estimated Project Cost}} \times 100$$

$$\text{Final Project Percentage Overrun or Underrun} = \frac{\text{Percentage of Project Overrun or Underrun to Date}}{\text{Percentage of Project Overrun or Underrun of the Estimated Cost}} \times 100$$

To illustrate the above, first a portion of the original network is chosen.

COST OF ACTIVITIES FOR THE FIRST PORTION OF THE PROJECT

Node No.	Description	Estimated Cost (RS)
1, 2	Move In	500
2, 3	Survey Layout & Mobilization	3,000
3, 4	Rough Grading	1,000
4, 5	Overhead Pole Line	2,000
4, 6	Ungr. Wtr. Piping from Main Line	2,000
4, 7	Wtr. Tank Fdns.	1,000
4, 8	Exc. for Sewers & Manholes	100
5, 9	Pull in Power Feeder	100
6, 12	Connect Piping	1,000
7, 10	Erect Water Tank	3,000
8, 11	Install Sewers & Manholes	2,000
9, 12	Install Control Panel Box	200
10, 12	Tank Piping Valves	200
11, 12	Backfill	100
12, 13	Building Layout	2,000
13, 14	Exc. Ungr. Wtr. Reser.	200
13, 15	Exc. Boundary Wall	1,000
13, 19	Purchase & Delivery Aggregate & Steel	60,000
13, 16	Lead Time	--
13, 18	Exc. Fdns. Isolated Footings	500
14, 19	Dummy	--
15, 19	Dummy	--
16, 17	Exc. Grade Beams	700
17, 19	Dummy	--
18, 19	Dummy	--
19, 20	Lead Time	--
19, 21	Lead Time	--
19, 22	Pour 4" Thick Slab for Footings	600
20, 23	Pour Grade Beam Base Layer	1,200
21, 24	Pour Conc. Base for Boundary Wall	1,000
21, 25	Pour Conc. Base for Ungr. Wtr. Reser.	200
22, 26	PL Reinf. Footings	300
23, 27	Form Work Grade Beam	2,500
24, 28	Install Block Masonry Boundary Wall	2,000
25, 29	PL Reinf. for Base Slab & Walls Ungr. Wtr. Reser.	400
26, 30	Form Work Isolated Footings	1,200
27, 31	Pour Grade Beams	400
28, 32	Curing Boundary Wall	200
29, 33	Form Work Walls Ungr. Wtr. Reser.	300
30, 34	Pour Isolated Footings	400
31, 35	Strip Form Work Isolated Footing	200
31, 36	Cure Grade Beams	200
32, 37	Plaster Boundary Wall	1,200
33, 38	Pour Base Slab Wall Ungr. Wtr. Reser.	200
34, 40	Strip Form Work Isolated Footings	100
34, 41	Cure Footings	200
35, 36	Dummy	--
36, 39	Damp Proofing Plinth	300

TABLE 7a

NODE NO.	DESCRIPTION	EST. TOTAL COST (RS)	COST TO DATE	ESTIMATED COST TO COMPLETE	ACTUAL TOTAL COST	COST VARIATION
1, 2	Move In	500	450		450	-50
2, 3	Survey Layout & Mobilization	3,000	2,500		2,500	-500
3, 4	Rough Grading	1,000	1,200		1,200	+200
4, 5	Overhead Pole Line	2,000	2,200		2,200	+200
4, 6	Ungr. Wtr. Piping From Main Line	2,000	1,900		1,900	-100
4, 7	Wtr. Tank Fdns	1,000	900		900	-100
4, 8	Exc. for Sewers & Manholes	100	150		150	+50
5, 9	Pull in Power Feeder	100	95		95	-5
6, 12	Connect Piping	1,000	850		850	-150
7, 10	Erect Wtr. Tank	3,000	3,100		3,100	+100
8, 11	Install Sewers & Manholes	2,000	2,400		2,400	+400
9, 12	Install Control Panel Box	200	350		350	+150
10, 12	Tank Piping & Valves	200	175		175	-25
11, 12	Backfill	100	250		250	+150
12, 13	Building Layout	2,000	2,100		2,100	+100
13, 14	Exc. Ungr. Wtr. Reser.	200	375			+175
13, 15	Exc. Foundary Wall	1,000	850			-150
13, 19	Purchase & Delivery Aggreg. and Steel	60,000	56,000			-4,000
13, 16	Lead Time	--	--			
13, 18	Exc. Fdns. Isolated Footings	500	460		460	-40
14, 19	Dummy	--				
15, 19	Dummy	--				
16, 17	Exc. Grade Beams	700	920		920	+220
17, 19	Dummy	--				
18, 19	Dummy	--				
19, 20	Lead Time	--				
19, 21	Lead Time	--				
19, 22	Pour 4" Thick Conc. Slab for Footings	600	710		710	+110
20, 23	Pour Grade Beams Base Layer	1,200	1,320		1,320	+120

TABLE 7b

NODE NO.	DESCRIPTION	EST. TOTAL COST (RS)	COST TO DATE	ESTIMATED COST TO COMPLETE	ACTUAL TOTAL COST	COST VARIATION
21, 24	Pour Conc. Base for Boundary Wall	1,000	875		875	-125
21, 25	Pour Conc. Base for Ungr. Wtr. Reser.	200	300		300	+100
22, 26	PL Reinf. Footings	300	325		325	+25
23, 27	Form Work Grade Beams	2,500	2,100		2,100	-400
24, 28	Inst. Block Mason. Bound. Wall	2,000	1,200	800		0
25, 29	PL Reinf. for Base Slab & Walls Ungr. Wtr. Reser.	400	300	200		+100
26, 30	Form Work Isolated Footings	1,200	600	900		+300
27, 31	Pour Grade Beams	400	350		350	-50
28, 32	Curing Bound. Wall	200	200	100		+100
29, 33	Form Work Walls Ungr. Wtr. Reser.	300	200	250		+150
30, 34	Pour Isolated Footings	400	300	100		0
31, 35	Strip Form Work Isolated Footings	200	100	150		+50
31, 36	Cure Grade Beams	200	220		220	+20
32, 37	Plaster Boundary Wall	1,200	1,000	400		+200
33, 38	Pour Base Slab, Walls Ungr. Wtr. Reser.	200	175	50		+25
34, 40	Strip Form Work Isolated Footings	100	95	20		+15
34, 41	Cure Footings	200	160	70		+30
35, 36	Dummy	--				
36, 39	Damp Proofing Plinth	300	310		310	+10

TABLE 8a

(1) Activity	(2) Original Estimate	(3) Actual or New Estimate	(4) Activity Variation 3-2	(5) % Activity Variation (4/2) 100	(6) Project Variation % age $\frac{4}{\text{Total Cost}} \times 100$
1, 2	500	450	-50	-10	-0.024
2, 3	3,000	2,500	-500	-16.67	-0.243
3, 4	1,000	1,200	200	20	0.097
4, 5	2,000	2,200	200	10	0.097
4, 6	2,000	1,900	-100	-5	-0.049
4, 7	1,000	900	-100	-10	-0.049
4, 8	100	150	+50	+50	+0.024
5, 9	100	95	-5	-5	0.002
6, 12	1,000	850	-150	-15	-0.073
7, 10	3,000	3,100	+100	3.34	+0.049
8, 11	2,000	2,400	+400	20	+0.195
9, 12	200	350	+150	75	0.073
10, 12	200	175	-25	-12.5	-0.012
11, 12	100	250	+150	150	+0.073
12, 13	2,000	2,100	+100	5	+0.049
13, 14	200	375	+175	87.5	+0.085
13, 15	1,000	850	-150	-15.0	-0.073
13, 19	60,000	56,000	-4,000	-6.67	-1.95
13, 16	--	--	--	--	--
13, 18	500	460	-40	-8	-0.019
14, 19	--	--	--	--	--
15, 19	--	--	--	--	--
16, 17	700	920	+220	31.43	+0.107
17, 19	--	--	--	--	--
18, 19	--	--	--	--	--
19, 20	--	--	--	--	--
19, 21	--	--	--	--	--
19, 22	600	710	+110	18.34	0.054
20, 23	1,200	1,320	+120	10	0.058

Note: Total Cost of Project = RS 2,05010/-

TABLE 8b

(1) Activity	(2) Original Estimate	(3) Actual or New Estimate	(4) Activity Variation 3-2	(5) % Activity Variation (4/2) 100	(6) Project Variation % age $\frac{4}{\text{Total Cost}} \times 100$
21, 24	1,000	875	-125	-12.5	-0.061
21, 25	200	300	+100	50	0.049
22, 26	300	325	+25	8.34	0.012
23, 27	2,500	2,100	-400	-16.0	-0.195
24, 28	2,000	2,000	0	0	0
25, 29	400	500	+100	25	0.048
26, 30	1,200	1,500	+300	25	0.146
27, 31	400	350	-50	-12.5	-0.024
28, 32	200	300	+100	50	0.049
29, 33	300	450	+150	50	0.073
30, 34	400	400	0	0	0
31, 35	200	250	+50	25	0.024
31, 36	200	220	+20	10	0.009
32, 37	1,200	1,400	+200	16.67	0.097
33, 38	200	225	+25	12.5	0.012
34, 40	100	115	+15	15	0.007
34, 41	200	230	+30	15	0.015
35, 36	--	--	--	--	--
36, 39	300	310	+10	3.34	0.005
TOTAL	RS 93,700	RS 91,105	-2,595	641.62	-1.263%

CALCULATIONS

1. Total Project Estimated Cost = RS 205010/-

2. Overrun or Underrun Percentage:

   a) Column 6 of the Table yields a value of -1.263% which means that the point in time where project was checked it is underrun by 1.263%.

   b) This could be checked by another method and that is

$$\frac{\text{Sum of Activity Variation}}{\text{Total Estimated Cost}} \times 100$$

$$\frac{-2595}{205010} \times 100 = 1.263\%$$

The above results coincide with the result calculated by method (a)

∴ It concludes that the project is underrun by 1.263%.

3. Final Project Cost:

$$\text{Underrun Percentage Up to This Point} = \frac{\text{Estimated Cost to This Pt.}}{\text{Estimated Project Cost}} \times 100$$

$$= \frac{93700}{205010} \times 100 = 45.70\%$$

$$\therefore \text{Overall Underrun Percentage Until Completion of Project} = \frac{1.263}{45.70} \times 100 = 2.76\%$$

Therefore, project is underrun by an amount = RS 5658.276

Hence, the anticipated project cost = RS 199,351.724

Similarly cost can be checked at other points of the project and forecast of future costs could be made.

MINIMUM COST OF EXPEDITING

A portion of the network of the whole project has been used to illustrate as to how the minimum cost of the project can be expedited. It can be achieved in two ways:

1. By expediting costs on activity basis.
2. By expediting costs on overall project basis.

COST OF EXPEDITING AN ACTIVITY

The network is examined for cost expediting on activity basis as follows:

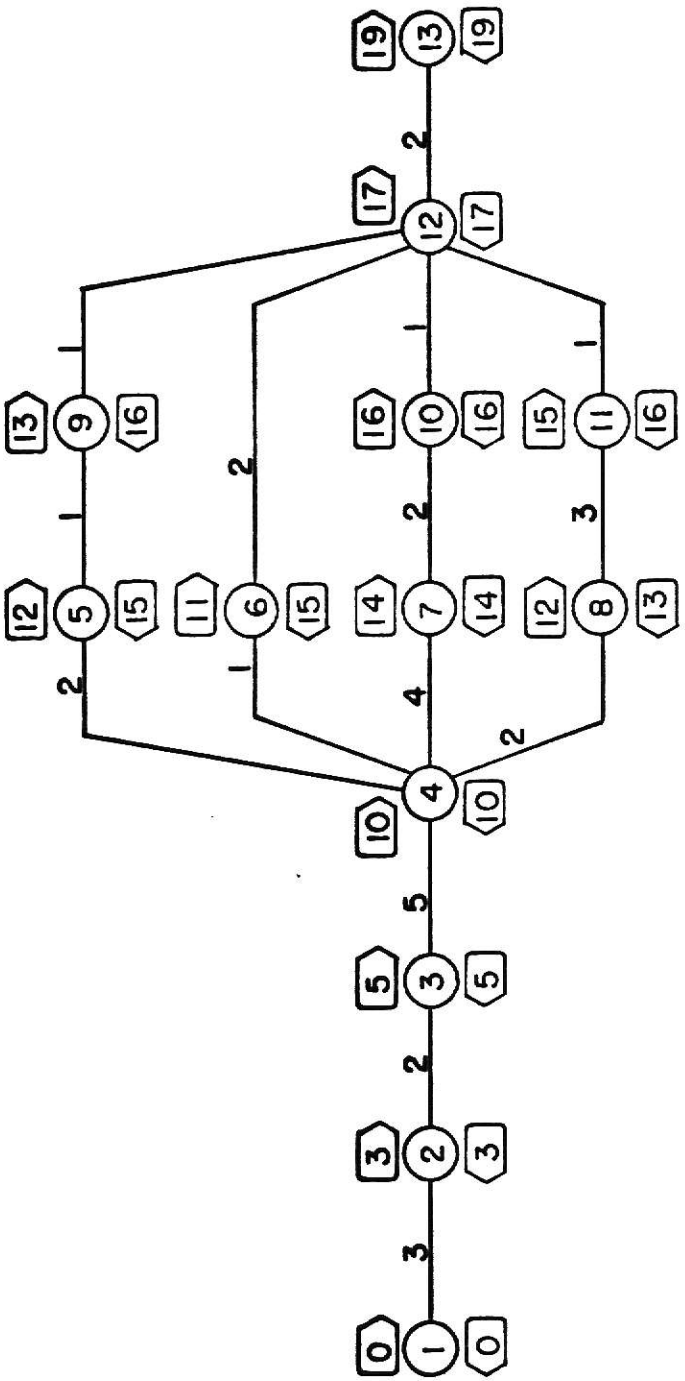
Step 1

A Table is prepared for the normal time and crash time for expediting the operations. Normal Time is the duration in which an operation is executed, i.e., with ordinary man-power, etc. Crash Time is defined as the shortest time within which an activity can be accomplished by using a larger crew, overtime, or extra shifts--or all three. Thus, when the project is executed on crash basis, the cost of activities increases, thereby resulting in higher costs but shorter project completion time. This higher cost is due to the premium time costs, inefficiency of large crews, increased material costs (such as extra form, high early strength cement), etc.

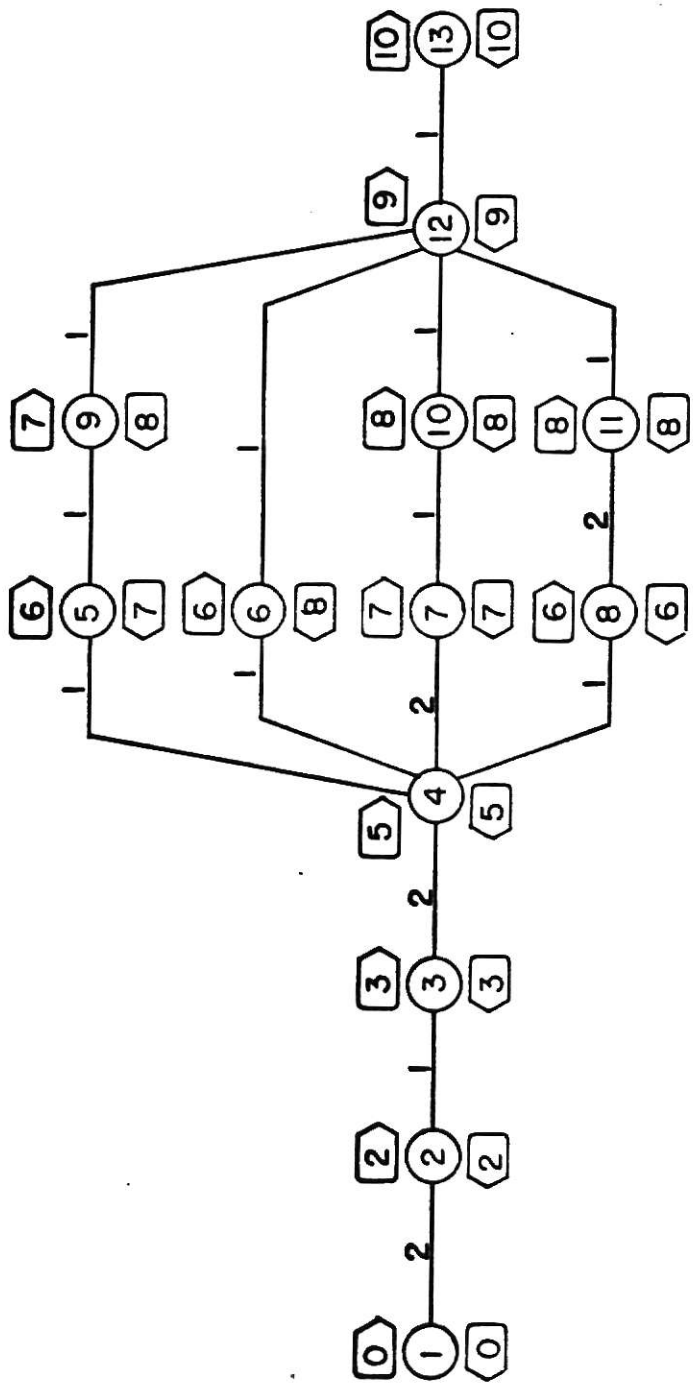
Node No.	Description	Normal Time	Method of Expediting	Crash Time
1, 2	Move In	3	Overtime	2
2, 3	Survey Layout & Mobilization	2	Extra Crews, Overtime	1
3, 4	Rough Grading	5	Extra Crew, Overtime	2
4, 5	Overhead Pole Line	2	Extra Crew, Overtime	1
4, 6	Ungr. Wtr. Piping From Main Line	1		1
4, 7	Wtr. Tank Fdns.	4	Extra Men	2
4, 8	Exc. for Sewers & Manholes	2	Extra Men	1
5, 9	Pull in Power Feeder	1		1
6, 12	Connect Piping	2	Extra Crew & Overtime	1
7, 10	Erect Wtr. Tank	2	Extra Men	1
8, 11	Install Sewers & Manholes	3	Extra Men	2
9, 12	Install Control Panel Box	1		1
10, 12	Tank Piping & Valves	1		1
11, 12	Backfill	1		1
12, 13	Building Layout	2	Extra Crews & Overtime	1

Step 2

Earliest Start Times, Latest Finish Times and Floats are calculated for the normal plan and the full crash plan (See Table 9). EPO's, LPO's and the durations are shown on the networks (Fig. 6 and Fig. 7).



NORMAL PLAN
FIG. 6



FULL CRASH PLAN
FIG. 7

Step 3

The Normal and the Crash Results are Compared, as shown in Table 9.

TABLE 9

Activity	Normal E.S.	Crash E.S.	Crash L.F.	Normal L.F.	Normal Float	Crash Float
1, 2	0	0	2	3	0	0
2, 3	3	2	3	5	0	0
3, 4	5	3	5	10	0	0
4, 5	10	5	7	15	3	0
4, 6	10	5	8	15	4	2
4, 7	10	5	7	14	0	0
4, 8	10	5	6	13	1	0
5, 9	12	6	8	16	3	1
6, 12	11	6	9	17	4	2
7, 10	14	7	8	16	0	0
8, 11	12	6	8	16	1	0
9, 12	13	7	9	17	3	1
10, 12	16	8	9	17	0	0
11, 12	15	8	9	17	1	0
12, 13	17	9	10	19	0	0

Note: The project crash duration is 9 days shorter than normal.

Step 4

Normal and crash cost of activities table is set up and by plotting graphs between cost and time, the costs can be estimated for various durations.

TABLE 10

	Node No.	Normal Cost	Description	Source of Extra Cost	Crash Cost
*	1, 2	500	Move In	Overtime	750
*	2, 3	3,000	Survey Layout & Mobilization	Extra Crews & Overtime	5,100
*	3, 4	1,000	Rough Grading	Extra Crews & Overtime	2,400
	4, 5	2,000	Overhead Pole Line	Extra Men	3,200
	4, 6	2,000	Ungr. Wtr. Piping From Main Line		2,000
*	4, 7	1,000	Wtr. Tank Fdns.	Extra Men	2,000
	4, 8	100	Exc. for Sewers & Manholes	Extra Men	200
	5, 9	100	Pull In Power Feeder		100
	6, 12	1,000	Connect Piping	Extra Crew & Overtime	1,500
*	7, 10	3,000	Erect Wtr. Tank	Extra Men	5,800
	8, 11	2,000	Install Sewers & Manholes	Extra Crew	3,000
	9, 12	200	Install Control Panel Box		200
*	10, 12	200	Tank Piping & Valves		200
	11, 12	100	Backfill		100
*	12, 13	2,000	Building Layout	Extra Crew & Overtime	3,800
	TOTAL	18,200			30,350

*Indicates activities on the critical path.

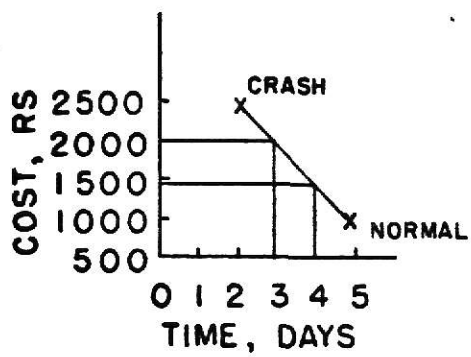
COST OF EXPEDITING AN ACTIVITY (Cont'd)

Since the project crash duration has reduced by nine days hence the crash cost to pick up nine days is RS 12150/- or RS 1350/- per day. However, if it is not desired to expedite the completion of the project by nine days, then by using the linear connection between Normal and Crash points of activities, economical solutions can be obtained, e.g., as shown in the plot below for activity 3, 4, the Normal Cost is RS 1000/-, the Crash Cost is RS 2400/-; hence, for a cost difference of RS 1400/- the operation is expedited three days, or at an average cost of RS 466.67/- per day. Also, if it is desired to complete this activity in four days or three days, the cost respectively can be obtained from the plots. Similarly, all the activities can be expedited.

PLOTS OF COST-TIME RELATIONSHIP

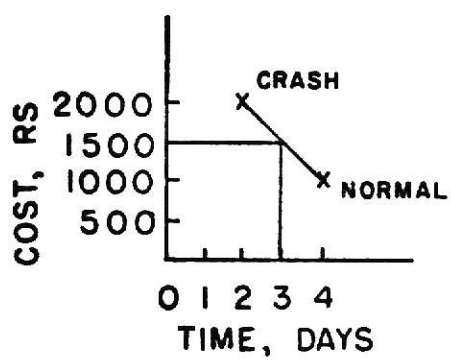
Assumption in linear relationship between normal and crash points.

ACTIVITY 3, 4



At day 4, cost = RS 1466.67
At day 3, cost = RS 1933.33

ACTIVITY 4, 7



At day 3, cost = RS 1500/-

Fig. 8

COST OF EXPEDITING THE PROJECT:

The network is examined for expediting the cost of the project as follows:

1. Table 11 lists the normal and crash information developed previously in columns 1 to 5. Column 6 of the table lists the cost of expediting each activity per day. This is computed by dividing the difference in crash and normal costs by the difference in normal and crash times. Column 7 lists the normal total float for the network. Columns 8 to 16 list the floats as the project duration is reduced by one day, i.e., by shortening the activities on the critical path with the least cost.

2. Table 12 lists the activity durations with reduced time and also indicates the order in which the activities on the critical path have been shortened.

3. Table 13 lists the cost of activities on the critical path for the project to be expedited one day. Selection of least cost is indicated by the encircled figures.

4. Figure 9 shows the plot of various solutions for expediting the project. "x" indicates the possible solution available while the dot indicates the minimum cost. The line connecting the dots gives the least cost of expediting the project.

5. Figure 10 shows the plot of the project costs versus the time obtained from the above analysis.

TABLE 11

Activity	Duration Days		Cost		Cost to Expedite	Float Time Remaining as Project Time (P) is Reduced									
	Normal	Crash	Normal	Crash	One Day	19	18	17	16	15	14	13	12	11	10
1, 2	3	2	500	750	250	0	0	0	0	0	0	0	0	0	0
2, 3	2	1	3,000	5,100	2,100	0	0	0	0	0	0	0	0	0	0
3, 4	5	2	1,000	2,400	466.67	0	0	0	0	0	0	0	0	0	0
4, 5	2	1	2,000	3,200	1,200	3	3	3	3	3	2	1	1	1	0
4, 6	1	1	2,000	2,000	2,000	4	3	4	4	4	3	2	2	2	1
4, 7	4	2	1,000	2,000	500	0	0	0	0	0	0	0	0	0	0
4, 8	2	1	100	200	100	1	1	1	1	1	0	0	0	0	0
5, 9	1	1	100	100	100	3	3	3	3	3	2	1	1	1	0
6, 12	2	1	1,000	1,500	500	4	4	4	4	4	3	2	2	2	1
7, 10	2	1	3,000	5,800	2,800	0	0	0	0	0	0	0	0	0	0
8, 11	3	2	2,000	3,000	1,000	1	1	1	1	1	0	0	0	0	0
9, 12	1	1	200	200	200	3	3	3	3	3	2	1	1	1	0
10, 12	1	1	200	200	200	0	0	0	0	0	0	0	0	0	0
11, 12	1	1	100	100	100	1	1	1	1	1	0	0	0	0	0
12, 13	2	1	2,000	3,800	1,800	0	0	0	0	0	0	0	0	0	0

FLOAT SITUATION AS PROJECT IS CUT FROM NINETEEN TO TEN DAYS

TABLE 12

ACTIVITY DURATIONS, REDUCED TIME

Activity Number	Duration		Project Length			(○) Means Duration at Crash Value					
	Normal	Crash	18	17	16	15	14	13	12	11	10
1, 2	3	(2)	(2)								
2, 3	2	(1)								(1)	
3, 4	5	(2)		4	3	(2)					
4, 5	2	1									
4, 6	1	1									
4, 7	4	(2)					3	(2)			
4, 8	2	(1)						(1)			
5, 9	1	1									
6, 12	2	1									
7, 10	2	(1)									(1)
8, 11	3	(2)									(2)
9, 12	1	1									
10, 12	1	1									
11, 12	1	1									
12, 13	2	(1)							(1)		

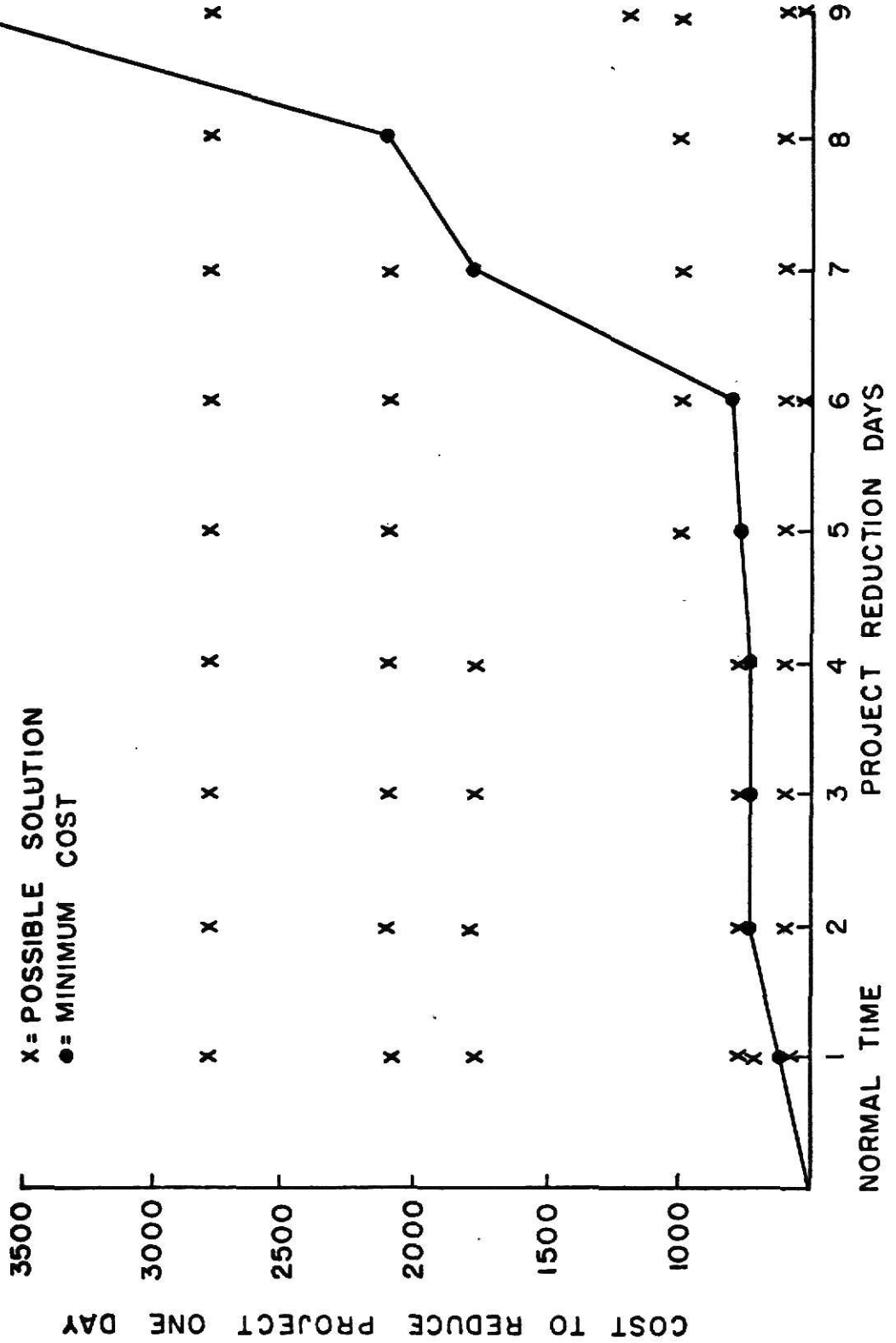
SELECTION OF LEAST COST OF EXPEDITING THE PROJECT

TABLE 13

Activity	Daily Cost To Expedite	18	17	16	15	14		13		12		11		10			Project Days
						1	2	1	2	1	2	1	2	1	2	3	Critical Path
1, 2	250	(250)	*	*	*	*		*		*		*		*			
2, 3	2,100	2,100	2,100	2,100	2,100	2,100		2,100		2,100		(2,100)		*			
3, 4	466.67	466.67	(466.67)	(466.67)	(466.67)	*		*		*		*		*			
4, 5	1,200															1,200	
4, 6	2,000																
4, 7	500	500	500	500	500	(500)		(500)		*		*		*			
4, 8	100						100		(100)		*		*		*		
5, 9	100															100	
6, 12	500																
7, 10	2,800	2,800	2,800	2,800	2,800	2,800		2,800		2,800		2,800		(2,800)			
8, 11	1,000						1,000		1,000		1,000		1,000		(1,000)		
9, 12	200															200	
10, 12	200	200	* 200	* 200	* 200	* 200		* 200		* 200		* 200		* 200			
11, 12	100						100		100		100		100		100		
12, 13	1,800	1,800	1,800	1,800	1,800	1,800		1,800		(1,800)							
Least Expensive Cost to Expedite in Rupees		250	466.67	466.67	466.67	500		600		1,800		2,100		3,800			

*Indicates activities on crash duration.

( ) Activity expedited one day.



PLOT OF VARIOUS SOLUTIONS FOR EXPEDITING THE PROJECT

FIG. 9

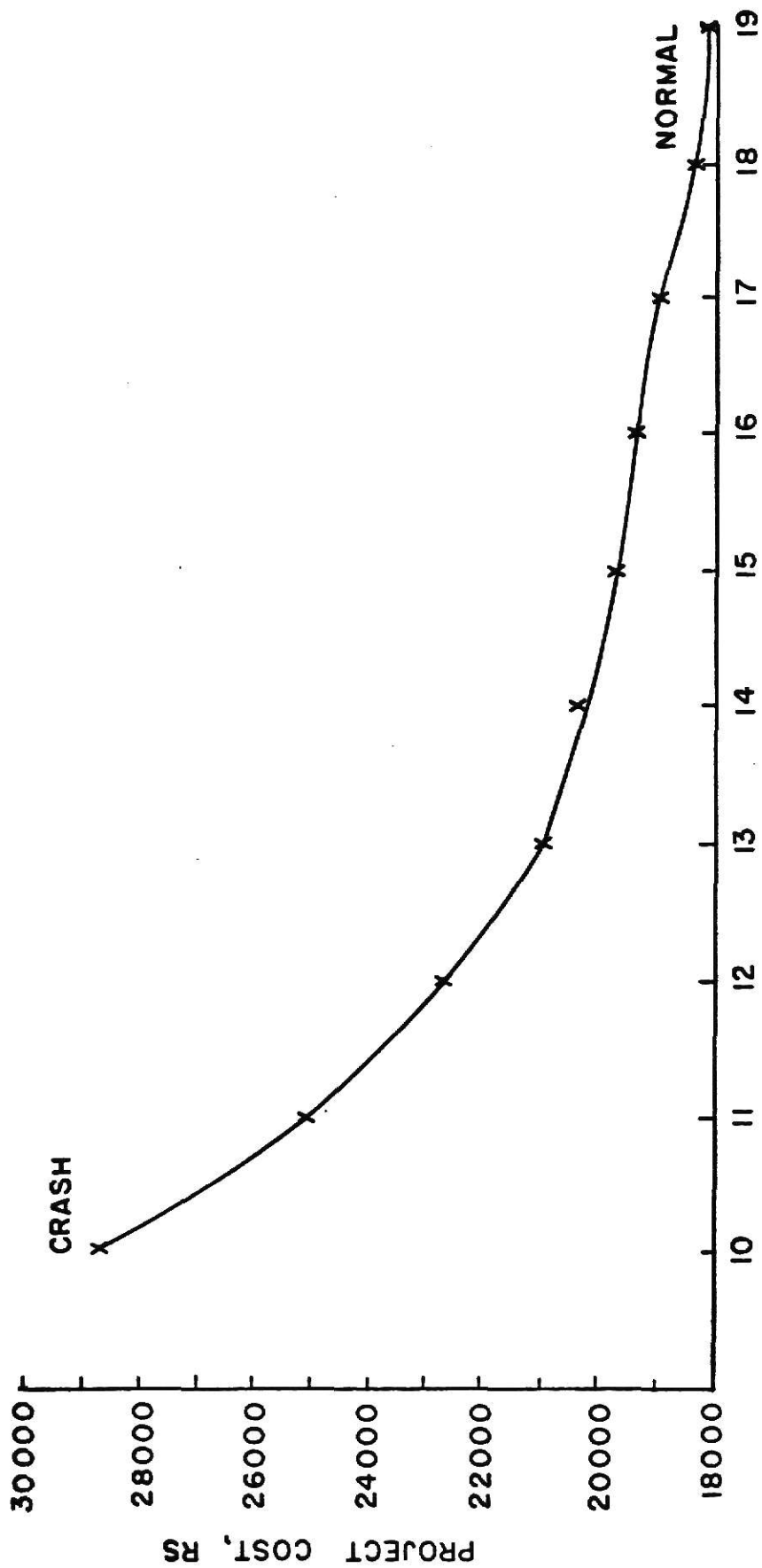
PROJECT COSTS WITH REDUCED TIME

Hence, the project costs calculated from the least cost analysis are as follows:

Completion Time	Project Cost
19	RS 18,200
18	RS 18,450
17	RS 18,916.67
16	RS 19,383.33
15	RS 19,850
14	RS 20,350
13	RS 20,950
12	RS 22,750
11	RS 24,850
10	RS 28,650

Note:

Note the crash cost calculated by this method is RS 28,650/-, while the total crash cost value is RS 30,350/-. This clearly points out the fallacy of a total crash program which expedites activities which have no need to be shortened.



PROJECT COST VS. TIME
FIG. 10

UPDATING

A portion of the original project's network is used to illustrate the technique of updating the project. Assume that the project has been in progress for 35 working days. According to the original schedule, if each operation were started at its Earliest Start Times and there were no delays or speed ups during the 35 days, the following list would describe the standing of the project at the end of the 35th working day.

1. Operations (1,2), (2,3), (3,4), (4,5), (4,6), (4,7), (4,8), (5,9), (6,12), (7,10), (8,11), (9,12), (10,12), (11,12), (12,13), (13,14), (13,15), (13,19), (13,16), (13,18), (14,19), (15,19), (16,17), (17,19), (18,19), (19,22), were completed.

2. Operations (19,20) have been in progress 1 day and will be completed in 4 days.

   Operations (19,21) have been in progress 1 day and will be completed in 4 days.

3. Operations (20,23), (21,24), (21,25), (22,26), (23,27), (24,28), (25,29), (26,30), (27,31), (28,32), (29,33), (30,34), (31,35), (31,36), (32,37), (33,38), (34,40), (34,41), (35,36), (36,39), were not started.

Instead of the above conditions, assume that the following is actually what has happened during the first 35 working days.

1. Operations (1,2), (2,3), (3,4), (4,5), (4,6), (4,7), (4,8), (5,9), (6,12), (7,10), (8,11), (9,12), (10,12), (11,12), (12,13), (13,15), were completed as originally scheduled.

2. Operations (13,14) have been in progress 2 days and will be completed in 4 more days.

   Operations (13,18) have been in progress 4 days and will be completed in 2 more days.

   Operations (16,17) have been in progress 6 days and will be completed in 3 more days.

Operations (13,19) (Delivery) have been delayed drastically and the supplier estimates that the delivery would require 5 days from this day.

3. Operations (19,22) have been revised from original estimates of 1 day to an estimate of 2 days.

   Operations (26,30) have been revised from original estimates of 5 days to an estimate of 7 days.

   Operations (32,37) have been revised from original estimates of 8 days to an estimate of 10 days.

4. Operations (25,29) have been revised from original estimates of 2 days to an estimate of 1 day.

5. No other operations have been started and the original time estimates for these operations still appear accurate.

This information is summarized in the Table.

TABLE 14

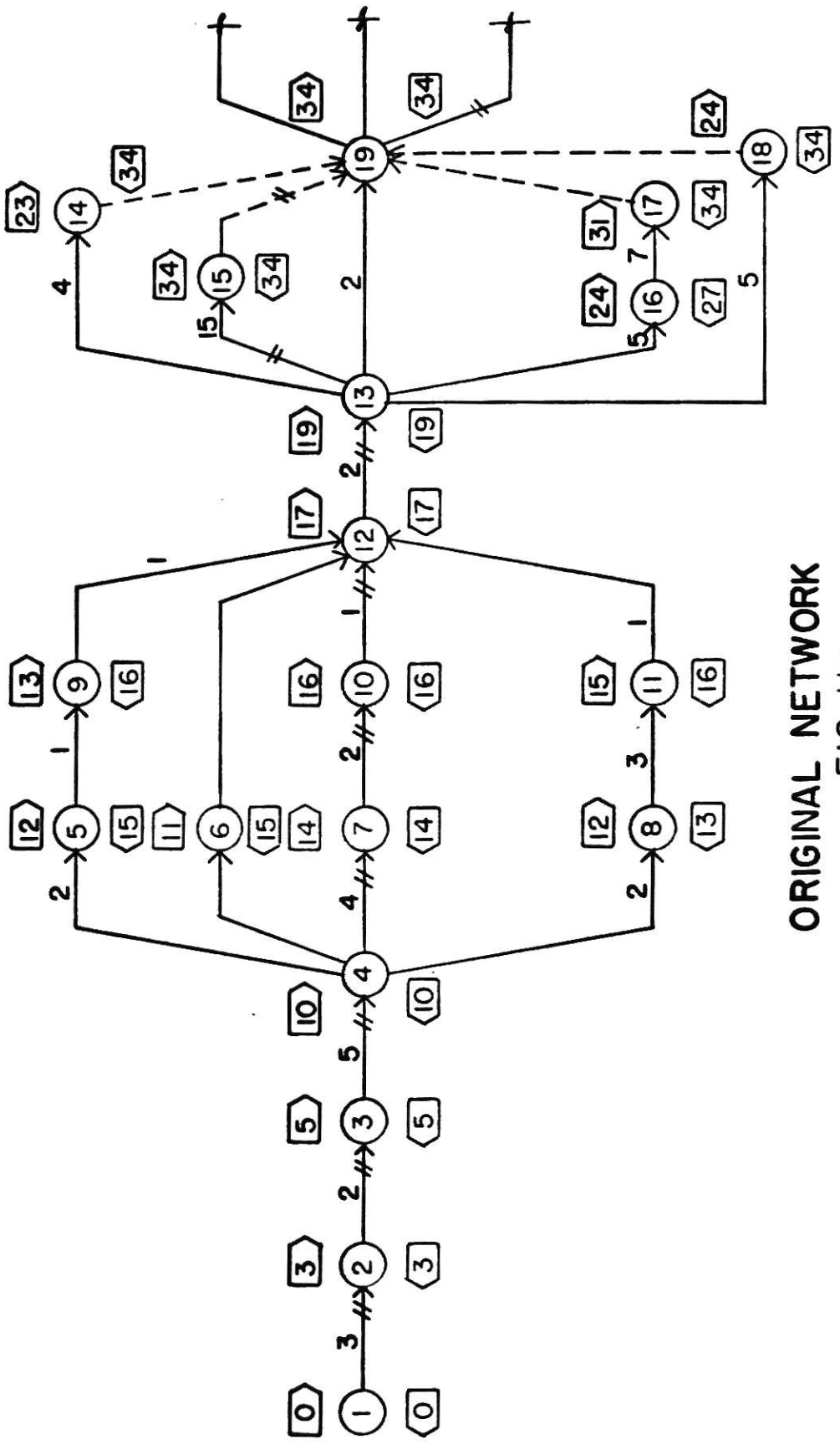
Operation No.	(1) Completed Operations: Day of Completion	(2) Operations Now in Process: Days to Complete	(3) Operation Not Yet Begun: Estimated Days to Perform
1, 2	3		
2, 3	2		
3, 4	5		
4, 5	2		
4, 6	1		
4, 7	4		
4, 8	2		
5, 9	1		
6, 12	2		
7, 10	2		
8, 11	3		
9, 12	1		
10, 12	1		
11, 12	1		
12, 13	2		
13, 14		4	
13, 15	15		
13, 19		5	
13, 16			5
13, 18		2	
(Dummy) 14, 19	--	--	--
15, 19	--	--	--
16, 17		3	
(Dummy) 17, 19	--	--	--

Operation No.	(1) Completed Operations Day of Completion	(2) Operations Now in Process Days to Complete	(3) Operation Not Yet Begun Estimated Days to Perform
(Dummy) 18, 19	--	--	--
19, 20			5
19, 21			5
19, 22			2
20, 23			1
21, 24			1
21, 25			1
22, 26			4
23, 27			15
24, 28			15
25, 29			1
26, 30			7
27, 31			2
28, 32			7
29, 33			1
30, 34			1
31, 35			1
31, 36			7
32, 37			10
33, 38			1
34, 40			1
34, 41			7
(Dummy) 35, 36			-
36, 39			2
37, 54			7
38, 42			7
(Dummy) 39, 41			0
40, 41			0
(Dummy) 41, 43			2
41, 44			4
42, 45			1
(Dummy) 43, 44			0
44, 49			2
44, 50			3
45, 46			1
46, 47			5
46, 48			1
47, 48			1
48, 51			8
(Dummy) 49, 50			0
50, 54			5
51, 52			1
52, 53			8
53, 54			1

Note: The days are in working days.

This information is placed on the original network. First the time of the update, i.e., 35 is entered as the Earliest Start Time for the beginning operation. Next, zero duration is entered for the completed operations. For the operations which are in process, the remaining duration to complete is placed on the network and finally the estimated duration time for the operations which have not been started is entered. Then with new durations, the EPO's and LPO's are calculated and critical path is determined.

In case the updating of the project network results in the change in critical path, this indicates that the attention must be diverted from pushing the operations on the original critical path to those on the updated critical path, if the project is to be completed in the revised completion time.



ORIGINAL NETWORK
FIG. IIa

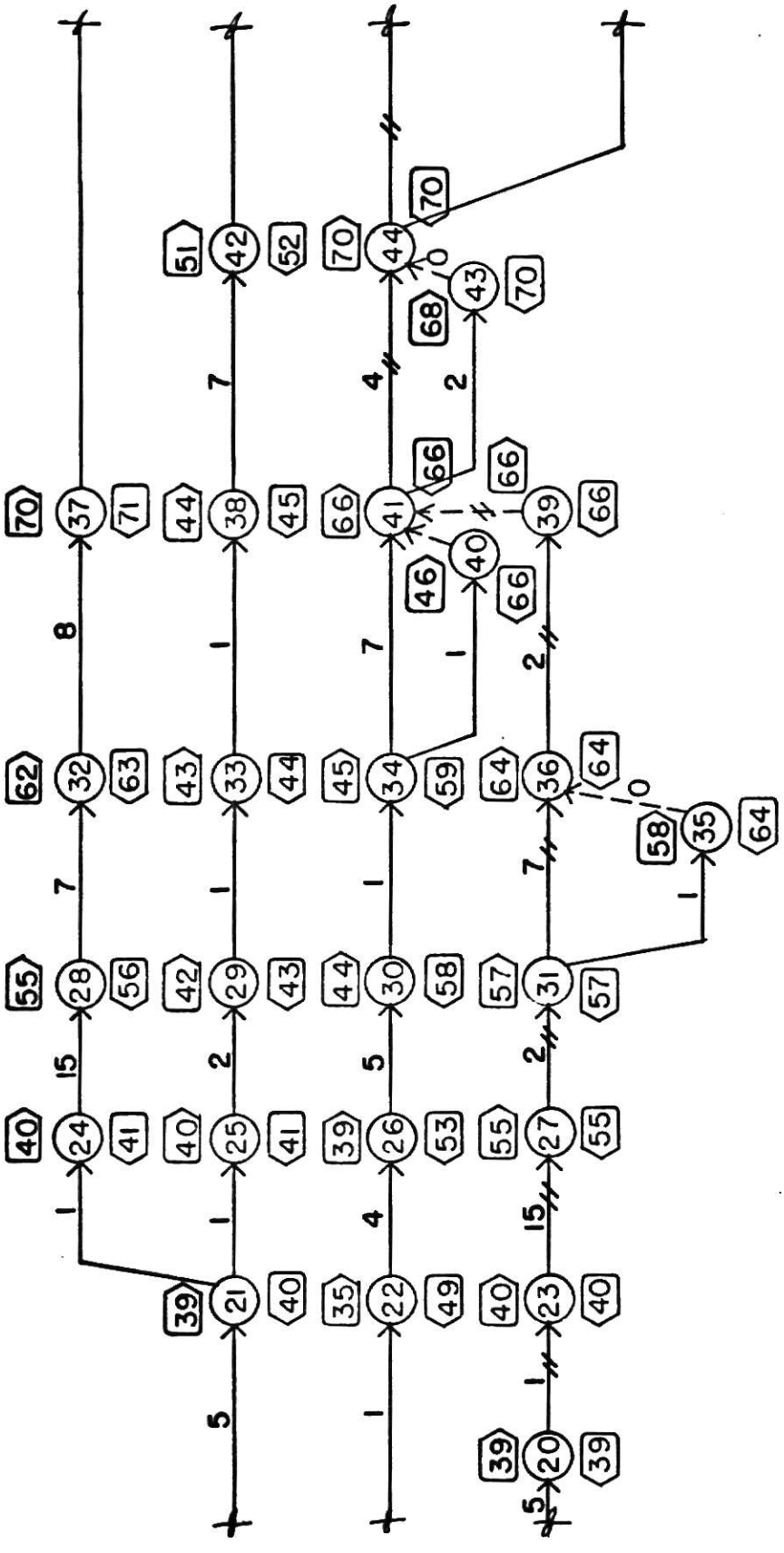

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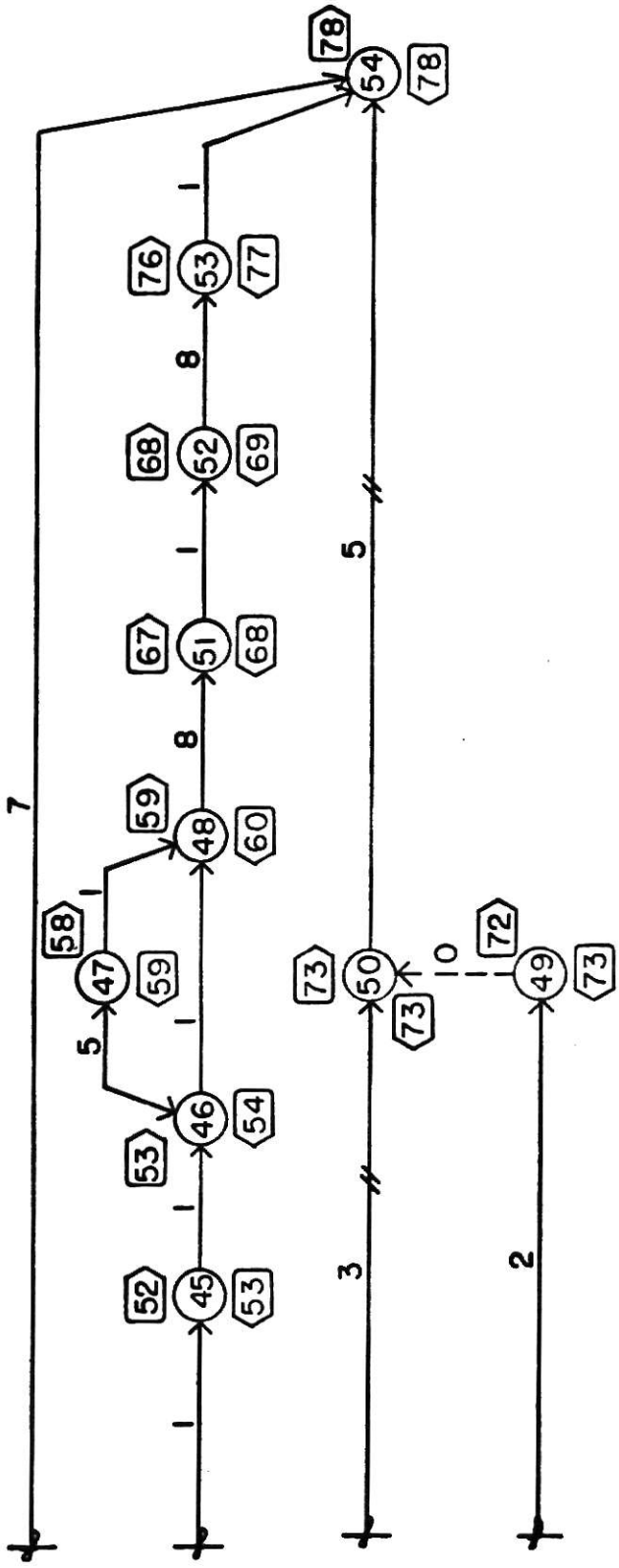
FIG. 11b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68
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48
60
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1
47
59
5
1
53
46
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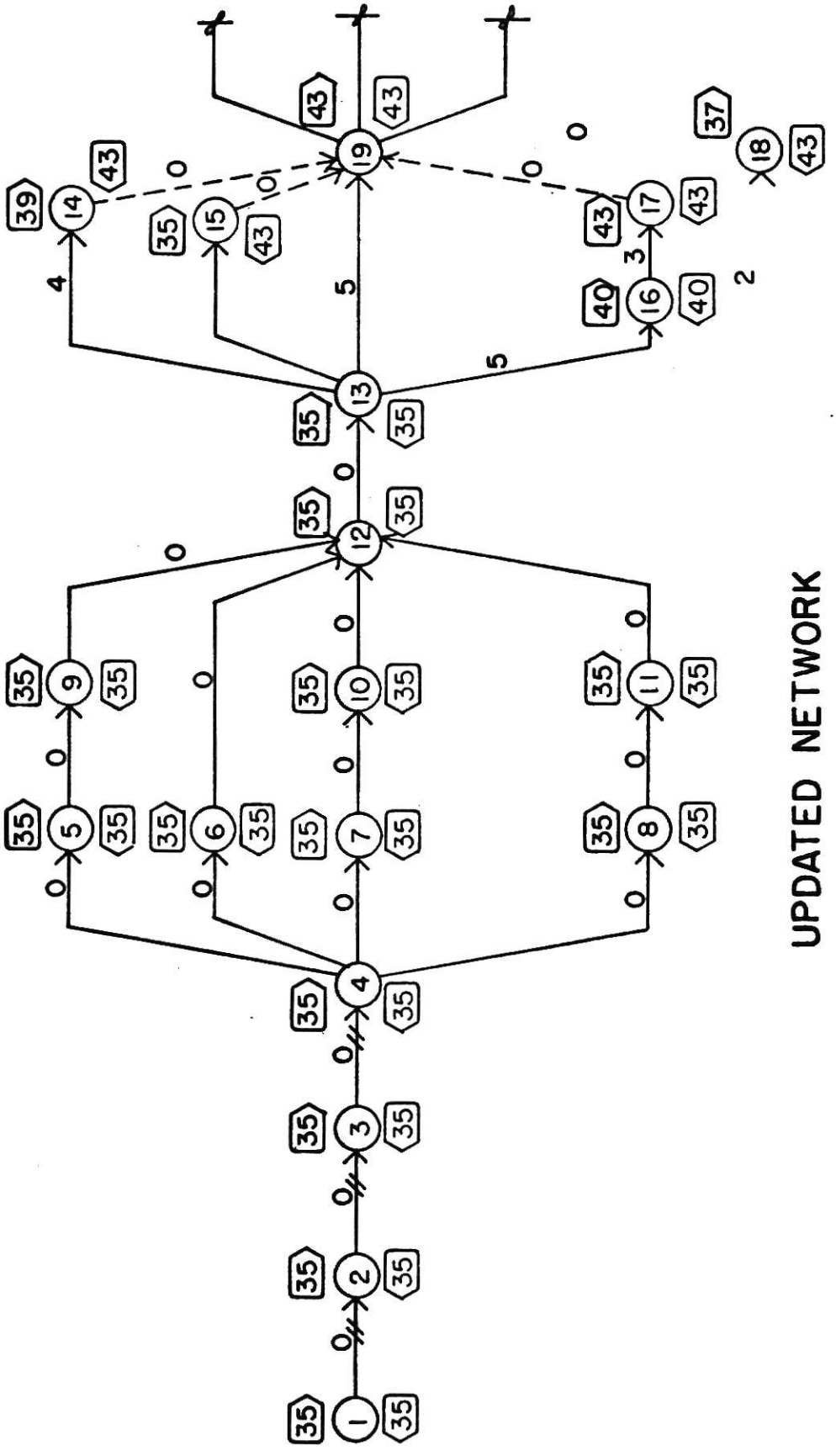
52
45
53
1
7
5
73
50
73
10
72
49
73
3
2

FIG. 11c



UPDATED NETWORK

FIG. 12a

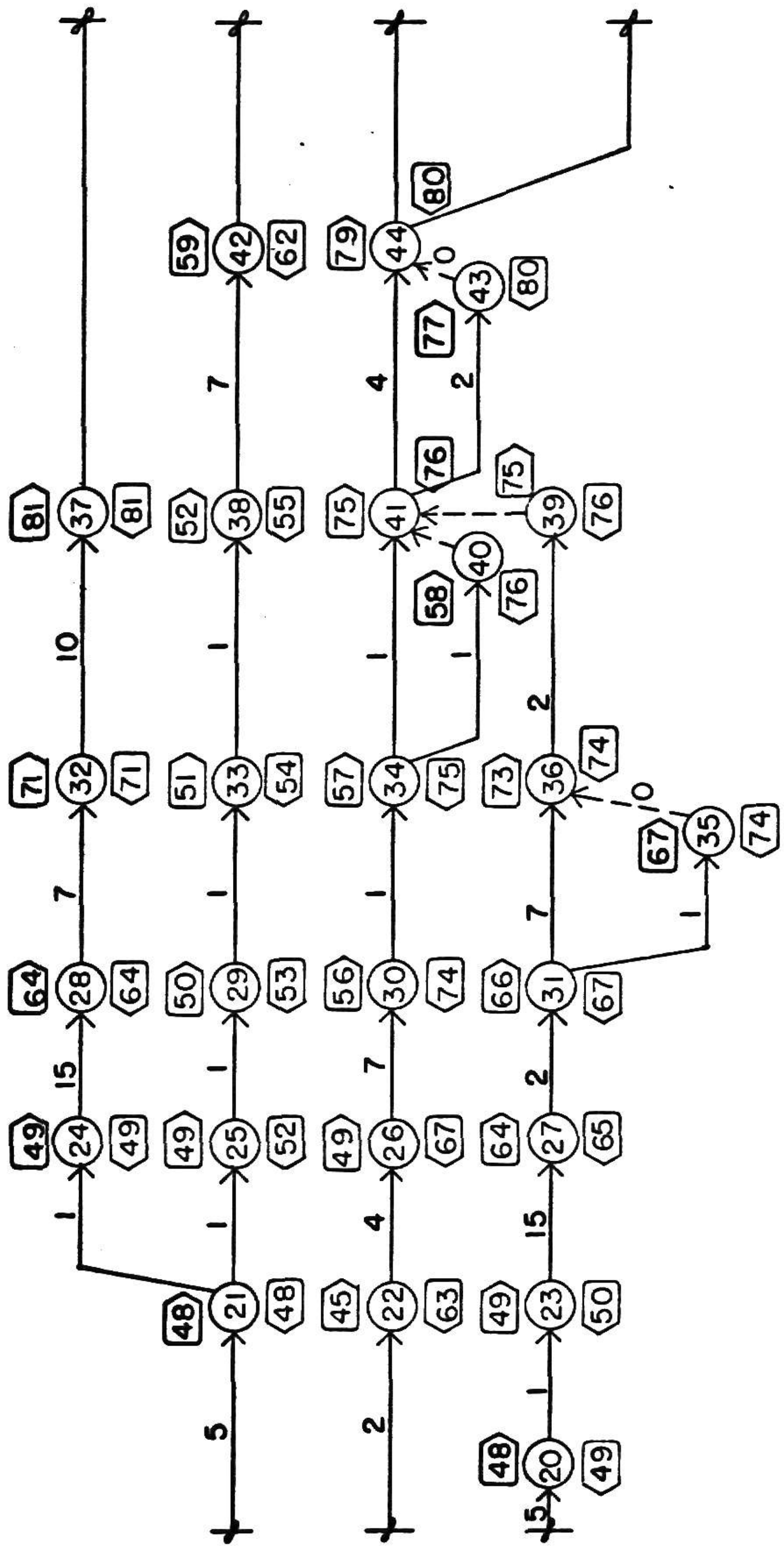
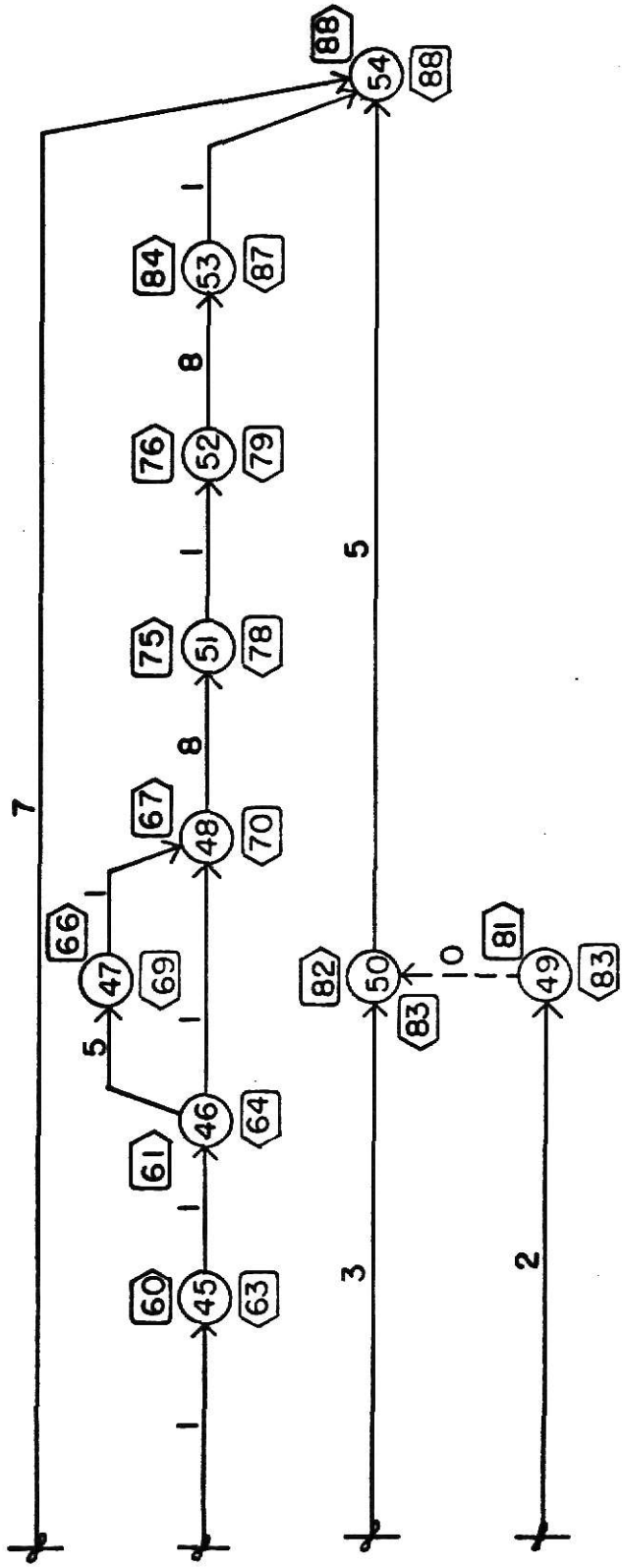


FIG. 12 b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69
5
1
61
46
64
1
60
45
63
1
7
5
82
50
83
0
81
49
83
3
2

FIG. 12c

CONCLUSIONS

Conclusions drawn from the theory of CPM are as follows:

1. Management support is essential for successful application.

2. The planner has to incorporate his knowledge of CPM with practical aspects of the job, cooperating with those people who are directly involved in the work.

3. To prove CPM to be a successful guide and an effective utilization technique, the participants are required to follow it faithfully.

4. From the experience so far it has been proved that if CPM is applied properly it produces a saving that justifies the expenditure necessary for the planning.

Conclusions drawn from the numerical example are as follows:

1. The actual cost incurred on the project was RS 220,000/.

2. Cost calculated by the use of CPM comes out to be RS 205,010/.

3. This cost difference is obviously by merely sequencing the operations only. If the whole project had been subjected to the least cost method the difference would have been even more significant.

4. The actual project completion time was 360 days.

5. Completion time calculated with the help of CPM is 296 days.

6. If the cost controls, least cost of expedition method, progress controls had been applied to the project it would have resulted in saving of time and money.

ACKNOWLEDGMENTS

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APPENDIX A

```
      $JOB
      C     CRITICAL PATH PROGRAM   1974   FORTRAN 4
      C     ROSENBAUGH V H
 1          DIMENSION NUM(1000),J(1000),I(1000),TEPOI(1000)
 2          DIMENSION TLPOJ(1000),DUR(1000)
 3        5 FORMAT(I2)
 4       51 FORMAT(I3,6X,I3,1X,I3,F9.2)
 5       52 FORMAT(24X,26H CRITICAL PATH SCHEDULING  //)
 6       53 FORMAT(2X,70H   NO.   I    J    DUR      EST      LST      EFT      LF
          1T      TF       FF  /)
 7       54 FORMAT(3X,3I5,7F8.2)
 8       55 FORMAT(2X,1H*,3I5,7F8.2)
 9       56 FORMAT(/4X,30HTOTAL TIME ON CRITICAL PATH IS ,F7.2  /)
10       57 FORMAT(3X,42H ACTIVITIES ON CRITICAL PATH INDICATED BY *  //)
11          DO 300 K=1,1000
12          NUM(K)=0
13          I(K)=0
14          J(K)=0
15          TEPOI(K)=0.0
16          TLPOJ(K)=0.0
17          DUR(K)=0.0
18       300 CONTINUE
19          READ(5,5) NACTS
20          DO 100 K=1,NACTS
21       100 READ(5,510) NUM(K),I(K),J(K),DUR(K)
22          TEPOI(1)=0.0
23          TEPOI(2)=0.0
24          K2=2
25          K3=1
26        9 DO 10 N=1,NACTS
27          K1=N
28          IF(J(N)-K2)10,50,10
29       50 K3=1
30          K4=I(K1)
31          TT=TEPOI(K4)+DUR(K1)
32          IF(TEPOI(K2)-TT)51,10,10
33       51 TEPOI(K2)=TT
34       10 CONTINUE
35          IF(K3)11,20,11
36       11 K2=K2+1
37          K3=0
38          TEPOI(K2)=0.0
39          GO TO 9
40       20 K2=K2-2
41          TLPOJ(K2+1)=TEPOI(K2+1)
42          NUMN=K2+1
43          TLPOJ(K2)=TLPOJ(K2+1)
44       14 DO 115 N1=1,NACTS
45          K1=N1
46          IF(I(K1)-K2)115,30,115
47       30 K4=J(K1)
48          TT=TLPOJ(K4)-DUR(K1)
49          IF(TT-TLPOJ(K2))31,115,115
50       31 TLPOJ(K2)=TT
51          GO TO 115
52      115 CONTINUE
53          IF(K2-1)16,60,16
54       16 K2=K2-1
55          TLPOJ(K2)=TLPOJ(NUMN)
56          GO TO 14
```

```
      60 WRITE(6,520)
         WRITE(6,530)
         TOTD=0.0
         DO 65 N2=1,NACTS
         K1=J(N2)
         K2=I(N2)
         EST=TEPOI(K2)
         EFT=EST+DUR(N2)
         TLFT=TLPOJ(K1)
         TLST=TLFT-DUR(N2)
         IF(TLST)401,401,402
     401 TLST=0.0
     402 CONTINUE
         TF=TLPOJ(K1)-TEPOI(K2)-DUR(N2)
         IF(TF)301,301,302
     301 TF=0.0
     302 CONTINUE
         FF=TEPOI(K1)-TEPOI(K2)-DUR(N2)
         IF(FF)303,303,304
     303 FF=0.0
     304 CONTINUE
         IF(IF)250,250,240
     240 WRITE(6,540)NUM(N2),K2,K1,DUR(N2),EST,TLST,EFT,TLFT,TF,FF
         GO TO 65
     250 WRITE(6,550)NUM(N2),K2,K1,DUR(N2),EST,TLST,EFT,TLFT,TF,FF
         IF(TLFT-TOTD)65,65,66
      66 TOTD=TLFT
      65 CONTINUE
         WRITE(6,560)TOTD
         WRITE(6,570)
         STOP
         END
```

APPENDIX B

MANPOWER LEVELING

There are two programs in this system. The first computes the critical path and puts the output on SYSLST & SYS001 (for use in the manpower leveling). The manpower leveling uses a trial and error algorithm. When all possible improvement has been made, two reports are printed. The first one gives a list of manpower usage by craft for all times at which there is a change in manpower. The second gives a schedule for starting the jobs in order to achieve the minimum manpower fluctuation.

The trial and error algorithm consists of two steps. Step 1 distributes the float among the various jobs. Step 2 tests for each non-critical job, whether moving to another start date will decrease the manpower fluctuations. If so, the job is moved. The program cycles through the network until it goes through the whole netowrk without any improvement. At this point the output phase begins.

INPUT/OUTPUT FORMAT

A. Input

cc		
	1-3	I-node
	4-6	J-node
	7-10	Duration (14 Format) can be in any units
	11-30	No. of men/craft (2 Columns/craft)
	31	Blank (except for card after last job)
	32-80	Description

B. Output

1. CPM output (on printer)

   I, J, D, Craft Requirements, Description, Early Start, Early Finish, Late Start, Late Finish, Total Float, Free Float.

2. Manpower Leveling Output (printer)

   a) I, J, D, Craft Identification, Description, Start Time.

   b) Table of number of men required in each craft at any time there is a change in the number of men required.

```
$JOB
      DEFINE FILE 11(2001,103,E,I1),12(2001,108,E,I2),13(2000,060,L,I3)  CPM00010
      DIMENSION II(2001),IJ(2001),IP(2001),IS(2001),IC(2001),ID(2001),   CPM00020
     1          ICR(10),IDES(13),IES(1000),ILE(1000)                     CPM00030
      EQUIVALENCE(ID(1),IC(1)),(IES(1),III(1)),(ILE(1),IJ(1))            CPM00040
      N2=5                                                               CPM00050
      N3=7                                                               CPM00060
      N33=5                                                              CPM00070
      DO 100 N=1,2001                                                    CPM00080
      READ (N2,1) II(N),IJ(N),ID(N),(ICR(I),I=1,10),IND,(IDES(I),I=1,13)CPM00090
    1 FORMAT(213,I4,1012,I1,12A4,A1)                                     CPM00100
      WRITE(N3,1) II(N),IJ(N),ID(N),(ICR(I),I=1,10),IND,                 CPM00110
     1(IDES(I),I=1,13)                                                   CPM00120
      IP(N)=N-1                                                          CPM00130
      IS(N)=N+1                                                          CPM00140
      IF(IND)101,100,101                                                 CPM00150
  100 CONTINUE                                                           CPM00160
  101 N=N-1                                                              CPM00170
      DO 102 I=1,N                                                       CPM00180
  102 IC(I)=N+2                                                          CPM00190
      IFT=0                                                              CPM00200
      IS(N)=-1                                                           CPM00210
      ILT=-1                                                             CPM00220
      IFL=0                                                              CPM00230
      ILL=0                                                              CPM00240
      INL=0                                                              CPM00250
      IPON=1                                                             CPM00260
 1142 IF(III(IPON)-20000)1152,1143,1143                                  CPM00270
 1143 IF(IPON-2000)1133,1211,1211                                        CPM00280
 1133 IPON=IPON+1                                                        CPM00290
      GO TO 1142                                                         CPM00300
 1152 ISAVE=III(IPON)                                                    CPM00310
      INL=IPON                                                           CPM00320
  103 IC(IPON)=IC(IPON)-1                                                CPM00330
      III(IPON)=III(IPON)+10000                                          CPM00340
      IPON=IPON+1                                                        CPM00350
      IF(ISAVE-III(IPON))104,103,104                                     CPM00360
  104 INO=IPON-1                                                         CPM00370
      ISAVE=IS(INO)                                                      CPM00380
      IS(INO)=-1                                                         CPM00390
      ILL=INO                                                            CPM00400
      IFL=INL                                                            CPM00410
      IF(ISAVE+1)105,1172,105                                            CPM00420
  105 IP(ISAVE)=0                                                        CPM00430
 1162 ISEAP=1                                                            CPM00440
 1172 IF(III(ISEAP)-IJ(INL))106,1191,106                                 CPM00450
  106 IF(III(ISEAP)-IJ(INL)-10000)107,1182,107                           CPM00460
  107 IF(III(ISEAP)-IJ(INL)-20000)1185,1192,1185                         CPM00470
 1185 ISEAP=ISEAP+1                                                      CPM00480
      IF(ISEAP-2001)1172,1172,1192                                       CPM00490
 1192 IF(IS(INL)+1)108,1193,108                                          CPM00500
  108 INL=IS(INL)                                                        CPM00510
      GO TO 1162                                                         CPM00520
 1182 ISEAP=ISEAP                                                        CPM00530
  109 IC(ISEAP)=IC(ISEAP)-1                                              CPM00540
      IF(IC(ISEAP))1173,1173,110                                         CPM00550
  110 ISEAP=ISEAP+1                                                      CPM00560
      IF(III(ISEAP)-III(ISEAP))1184,109,1184                             CPM00570
 1184 ISEAP=ISEAP-1                                                      CPM00580
      IF(IS(ISEAP)+1)111,1192,111                                        CPM00590
```

```
      111 ISAVE=IP(ISI)                                                 CPM00600
          IS(ILL)=ISI                                                   CPM00610
          IP(ISI)=ILL                                                   CPM00620
          ILL=ISEAR                                                     CPM00630
          IF(ISAVE)905,906,905                                          CPM00640
      905 IS(ISAVE)=IS(ISEAR)                                           CPM00650
      906 ISI=IS(ISEAR)                                                 CPM00660
          IP(ISI)=ISAVE                                                 CPM00670
          IS(ILL)=-1                                                    CPM00680
          GO TO 1192                                                    CPM00690
     1191 ISI=ISEAR                                                     CPM00700
          ISAVE=II(ISI)                                                 CPM00710
      112 IC(ISEAR)=IC(ISEAR)-1                                         CPM00720
          II(ISEAR)=II(ISEAR)+10000                                     CPM00730
          ISEAR=ISEAR+1                                                 CPM00740
          IF(II(ISEAR)-ISAVE)113,112,113                                CPM00750
      113 IS(ILL)=ISI
          IS2=ILL
          ILL=ISEAR-1                                                   CPM00780
          ISEAR=IS(ILL)                                                 CPM00790
          IS(ILL)=-1                                                    CPM00800
          IF(ISEAR+1)901,902,901                                        CPM00810
      901 IP(ISEAR)=IP(ISI)                                             CPM00820
      902 ISAVE=IP(ISI)                                                 CPM00830
          IF(ISAVE)903,904,903                                          CPM00840
      903 IS(ISAVE)=ISEAR                                               CPM00850
      904 IP(ISI)=IS2                                                   CPM00860
          GO TO 1192                                                    CPM00870
     1192 IF(ILT+1)1194,1193,1194                                       CPM00880
     1193 ILT=ILL                                                       CPM00890
          GO TO 1196                                                    CPM00900
     1194 IS(ILL)=ILT                                                   CPM00910
     1196 II(ILL)=II(ILL)+10000                                         CPM00920
          ISAVE=ILL                                                     CPM00930
          ILL=IP(ILL)                                                   CPM00940
          IF(ILL)1196,114,1196                                          CPM00950
      114 ILT=ISAVE                                                     CPM00960
          GO TO 1143                                                    CPM00970
     1211 DO 115 JN=1,N                                                 CPM00980
      115 READ(12'JN,1)II(JN),IJ(JN),ID(JN)                             CPM00990
     1231 ISI=ILT                                                       CPM01000
          I3=1                                                          CPM01010
      116 WRITE(13'I3,1)II(ISI),IJ(ISI),ID(ISI)                         CPM01020
          IF(ISI-ILT)117,1251,117                                       CPM01030
      117 ISI=IS(ISI)                                                   CPM01040
          GO TO 116                                                     CPM01050
     1251 DO 118 JN=1,1000                                              CPM01060
          IFS(JN)=0                                                     CPM01070
      118 ILF(JN)=99999                                                 CPM01080
     1261 DO 119 JI=1,N                                                 CPM01090
          READ(13'JN,1)II,JI,ID1                                        CPM01100
          IF(IFS(JI)-IFS(II)-ID1)1271,119,119                           CPM01110
     1271 IFS(JI)=IFS(II)+ID1                                           CPM01120
      119 CONTINUE                                                      CPM01130
          IPL=IFS(JI)                                                   CPM01140
          ILF(JI)=IFS(JI)                                               CPM01150
     1291 DO 120 JN=1,N                                                 CPM01160
          READ(13'JN+1-JN,1)II,JI,ID1                                   CPM01170
          IF(ILF(JI)-99999)121,1204,121                                 CPM01180
      121 IF(ILF(II)-ILF(JI)+ID1)120,120,1202                           CPM01190
```

```
      1202 ILE(I1)=ILE(J1)-ID1                                          CPM01200
       123 CONTINUE                                                     CPM01210
      1232 I2=1                                                         CPM01220
           I1=1                                                         CPM01230
           IJP=1                                                        CPM01240
           IJL=1                                                        CPM01250
           WRITE(NPR,8000)IJP                                           CPM01260
  8000 FORMAT(1HL,'PAGE',I6,'CRITICAL PATH SCHEDULING')                 CPM01270
           WRITE(NPR,2000)                                              CPM01280
  2000 FORMAT(1H ,3X,'I',3X,'J',4X,'D',' C1 C2 C3 C4 C5 C6 C7 C8 C9C10', CPM01290
          1 10X,'DESCRIPTION',33X,'ES',4X,'EF',4X,'LS',4X,'LF',4X,'FF',4X, CPM01300
          1'TF')                                                        CPM01310
           DO 123 JN=1,N                                                CPM01320
           READ(12'12,1)I3,J1,ID1,(ICR(I),I=1,10),IND,(IDES(I),I=1,13)  CPM01330
           IS1=IES(I3)                                                  CPM01340
           LF=ILE(J1)                                                   CPM01350
           LS=LF-ID1                                                    CPM01360
           IEF=IS1+ID1                                                  CPM01370
           ITF=LF-IEF                                                   CPM01380
           IEF=IES(J1)-IEF                                              CPM01390
           WRITE (NPR,2)I3,J1,ID1,(ICR(I),I=1,10),(IDES(I),I=1,13),IS1,IEF,LSCPM01400
          1,LF,IEF,ITF                                                  CPM01410
       2 FORMAT(I4,1X,I3,1X,I4,1X,10I3,1X,12A4,A1,6I6)                  CPM01420
           JTC=0                                                        CPM01430
           DO 122 I=1,10                                                CPM01440
       122 JTC=JTC+ICR(I)                                               CPM01450
           LS=LS+1                                                      CPM01460
           WRITE(11'11,3)I3,J1,ID1,(ICR(I),I=1,10),(IDES(I),I=1,13),IS1,LS, CPM01470
          1ITF,IEF,JTC                                                  CPM01480
       3 FORMAT(2I3,I4,10I2,1X,12A4,A1,5I5)                             CPM01490
           IJL=IJL+1                                                    CPM01500
           IF(IJL-50)123,123,8002                                       CPM01510
  8002 IJL=1                                                            CPM01520
           IJP=IJP+1                                                    CPM01530
           WRITE(NPR,9000) IJP                                          CPM01540
           WRITE(NPR,2000)                                              CPM01550
       123 CONTINUE                                                     CPM01560
           WRITE (11'11,4)                                              CPM01570
       4 FORMAT(30X,'1',75X)                                            CPM01580
      1262 CALL EXIT                                                    CPM01590
      1173 DO 1901 I=1,N                                                CPM01600
      1901 WRITE(NPR,1902)I(I),IJ(I),IP(I),IS(I),IC(I)                  CPM01610
      1902 FORMAT(5I10)                                                 CPM01620
           GO TO 1903                                                   CPM01630
      1204 WRITE (NPR,5)                                                CPM01640
         5 FORMAT(' ','ERROR MORE THAN ONE FINISH NODE')                CPM01650
      1903 WRITE(11'1,4)                                                CPM01660
           STOP                                                         CPM01670
           END                                                          CPM01680

$ENTRY
```

```
      $JOB
 1          DEFINE FILE 11(2001,108,E,I1),12(4000,060,E,I2)                    MPL00010
 2          DIMENSION IGET(11),NT1(1000),NT2(1000),ICR(10),IDES(13),IGET1(11),MPL00020
           1MI(2000),MJ(2000),MD(2000),MLS(2000)                               MPL00030
 3          NPR=6                                                              MPL00040
 4          I1=1                                                               MPL00050
 5        100 READ (11'I1,1111,IJ,ID,(ICR(I),I=1,10),JLS,(IDES(I),I=1,13),     MPL00060
           1IES,ILS,ITF,IFF,JTC                                                MPL00070
 6          1 FORMAT(2I3,I4,1012,I1,12A4,A1,5I5)                               MPL00080
 7            IF(JLS)9,600,101                                                 MPL00090
 8        600 I=I1-1                                                           MPL00100
 9            MI(I)=IT                                                         MPL00110
10            MJ(I)=IJ                                                         MPL00120
11            MD(I)=ID                                                         MPL00130
12            MLS(I)=ILS                                                       MPL00140
13            GO TO 100                                                        MPL00150
14        101 NJ=I1-2                                                          MPL00160
15            IF(NJ)9,9,9005                                                   MPL00170
16       9005 I1=I1-1                                                          MPL00180
17            I1=999                                                           MPL00190
18            IJ=MJ(NJ)                                                        MPL00200
19            ID=MD(NJ)                                                        MPL00210
20            ILS=MLS(NJ)                                                      MPL00220
21            LL=ID+ILS+1                                                      MPL00230
22            NUMMO=IJ                                                         MPL00240
23            NJN=-1                                                           MPL00250
24            J14=1                                                            MPL00260
25            NJJ=0                                                            MPL00270
26            J16=1                                                            MPL00280
27            J3=1                                                             MPL00290
28        1140 DO 102 J=1,NUMMO                                                MPL00300
29            NT2(J)=9999                                                      MPL00310
30        102 NT1(J)=1                                                         MPL00320
31            DO 33 I=1,NJ                                                     MPL00330
32              4 FORMAT (2I3,I4,75X,I5,15X)                                   MPL00340
33            ILS=MLS(I)                                                       MPL00350
34            II=MI(I)                                                         MPL00360
35            IJ=MJ(I)                                                         MPL00370
36            ID=MD(I)                                                         MPL00380
37            IF(ILS-NT2(II))34,35,35                                          MPL00390
38         34 NT2(II)=ILS                                                      MPL00400
39         35 IF(ILS+ID-NT1(IJ))33,33,36                                       MPL00410
40         36 NT1(IJ)=ILS+ID                                                   MPL00420
41         33 CONTINUE                                                         MPL00430
42            NT2(NUMMO)=NT1(NUMMO)                                            MPL00440
43            IF(NJN)901,907,2424                                              MPL00450
44        900 NJN=0                                                            MPL00460
      C     SHIFT                                                             MPL00470
45            DO 3124 JN=1,NJ                                                  MPL00480
46            II=MI(JN)                                                        MPL00490
47        3124 MLS(JN)=NT1(II)                                                 MPL00500
48            GO TO 1140                                                       MPL00510
      C     SPREAD                                                            MPL00520
49         907 IF(J3)909,9,901                                                 MPL00530
50         901 JN=J                                                            MPL00540
51         909 J3=0                                                            MPL00550
52         902 IF(JN-NJ)908,905,9                                              MPL00560
53         903 JN=JN+1                                                         MPL00570
54         911 II=MI(JN)                                                       MPL00580
55             ILS=MLS(JN)                                                     MPL00590
```

```
54          NEWT=(ILS-NT1(III))/2                                          MPL00600
57          IF(NEWT-11936,936,904                                          MPL00610
59        936 MLS(JN)=ILS-NEWT                                             MPL00620
53          J3=-1                                                          MPL00630
61       1199 IF(III-MI(JN+1)) 1140,932,1140                               MPL00640
61        935 IF(J3)1150,902,9                                             MPL00650
          C     ZERO TABLES                                                MPL00660
62        905 DO 193 I=1,11                                                MPL00670
63        194 IGET(I)=0                                                    MPL00680
64            DO 46 I=1,LL                                                MPL00690
65         46 WRITE (13*I,5)(IGET(J),J=1,11)                              MPL00700
          C     SET UP GENERAL TABLE                                       MPL00710
64            DO 5500 I=1,NJ                                              MPL00720
67          5 FORMAT (1115)                                               MPL00730
68            READ (11*I,1)II,IJ,ID,(ICR(JJ),JJ=1,10),J15,(IDES(JJ),JJ=1,13),MPL00740
             1IRS,ILS,ITF,IFF,JTC                                          MPL00750
69            ILS=MLS(I)                                                  MPL00760
70            IF(JTC)9,5500,5999                                          MPL00770
71       5999 J7=0                                                        MPL00780
72            READ (13*ILS,5)(IGET(JJ),JJ=1,11)                          MPL00790
73            DO 44 JJ=2,11                                               MPL00800
74         44 IGET(JJ)=IGET(JJ)+ICR(JJ-1)                                 MPL00810
75            WRITE (13*ILS,5)(IGET(JJ),JJ=1,11)                          MPL00820
76            READ (13*ILS+10,5)(IGET(JJ),JJ=1,11)                        MPL00830
77            DO 55 JJ=2,11                                               MPL00840
78         55 IGET(JJ)=IGET(JJ)-ICR(JJ-1)                                 MPL00850
79            WRITE (13*ILS+10,5)(IGET(JJ),JJ=1,11)                       MPL00860
80       5500 CONTINUE                                                    MPL00870
          C     CALCULATE TOTAL CRAFTS IN GENERAL TABLE                    MPL00880
81            DO 65 N=1,LL                                                MPL00890
82            READ(13*N,5)(IGET(I),I=1,11)                                MPL00900
83            DO 104 JJ=2,11                                              MPL00910
84         104 IGET(1)=IGET(1)+IABS(IGET(JJ))                             MPL00920
85          65 WRITE (13*N,5)(IGET(I),I=1,11)                             MPL00930
86          60 NIMPT=0                                                    MPL00940
87             NJN=1                                                      MPL00950
88             JN=1                                                       MPL00960
89          26 NT42=-1                                                    MPL00970
          C     IF NO CRAFTS MOVE EARLIER                                  MPL00980
90          27 READ(11*JN,1)II,IJ,ID,(ICR(I),I=1,10),J15, (IDES(I),I=1,13),MPL00990
             1IRS,ILS,ITF,IFF,JTC                                          MPL01000
91             ILS=MLS(JN)                                                 MPL01010
92             IF(JTC)9,5624,801                                           MPL01020
93       5624 IF(ILS-NT1(III))9,24,5625                                    MPL01030
94       5625 ILS=NT1(III)                                                 MPL01040
95             MLS(JN)=ILS                                                 MPL01050
96             GO TO 1140                                                  MPL01060
97          801 JJGT=9999                                                  MPL01070
98              IF(ILS-NT1(III))7,7,8                                      MPL01080
99            7 IF(ILS+ID-NT2(IJ))23,24,9                                 MPL01090
          C     IF MINUS IMPROVEMENT GO TO NEXT JOB                        MPL01100
          C     IF ZERO IMPROVEMENT MOVE TO NEW ST TIME (IF EARLIER)       MPL01110
          C     IF IMPROVEMENT GO TO NEXT JOB                              MPL01120
100         24 IF(NIMPT)2424,1230,7911                                     MPL01130
101       1230 IF(NJST-ILS)7911,2424,2424                                  MPL01140
102       2424 JN=JN+1                                                     MPL01150
103            IF(JN-NJ)26,26,9302                                         MPL01160
104       9302 IF(NIMPT)3,39,40                                            MPL01170
          C     LEFT AND RIGHT ELBOW ROOM                                  MPL01180
105          3 J2=0                                                        MPL01190
```

```
      91 NST=MT1(I1)                                                    MPL01200
         GO TO 93                                                       MPL01210
      93 J9=1                                                           MPL01220
     111 NST=ILS                                                        MPL01230
      92 J16=1-J16                                                      MPL01240
         IF (J16)9,93,94                                                MPL01250
      93 IF(J9)9,95,96                                                  MPL01260
C        INCREMENT NST                                                  MPL01270
      94 NST=NST+1                                                      MPL01280
         IF (NST-LL)7108,24,24                                          MPL01290
 7108 READ(13'NST,5)(IGET(I),I=1,111)                                   MPL01300
         IF(IGET(1))9,96,97                                             MPL01310
      97 IF(J9)9,97,99                                                  MPL01320
      99 NST=NST+10                                                     MPL01330
     107 IF(NST-NST(IJ))109,109,108                                     MPL01340
      97 IF(NST-ILS)109,113,113                                         MPL01350
     113 IF(J16)9,91,7                                                  MPL01360
     109 IF(J16)9,110,94                                                MPL01370
     107 IF(J16)9,95,111                                                MPL01380
     111 READ(13'NST,5)(IGET(I),I=1,111)                                MPL01390
         IF(IGET(1))9,95,94                                             MPL01400
C        INCREMENT NET                                                  MPL01410
      96 NET=NST+10                                                     MPL01420
     117 NET=NET+1                                                      MPL01430
         IF(NET-LL)7107,24,24                                           MPL01440
 7107 READ(13'NET,5)(IGET(I),I=1,111)                                   MPL01450
         IF(IGET(1))9,107,106                                           MPL01460
     106 NST=NET-10                                                     MPL01470
         IF(J9)9,97,103                                                 MPL01480
C        CALCULATE IMPROVEMENT                                          MPL01490
      95 IF(JOUT-9999997,11,87                                          MPL01500
      11 NET=ILS                                                        MPL01510
         JOUT=0                                                         MPL01520
         J7=1                                                           MPL01530
      12 J4=1                                                           MPL01540
      17 READ(13'NET,5)(IGET(I),I=1,111)                                MPL01550
         IF(J7)9,8814,1619                                              MPL01560
 8814 IF(IGET(1))9,16,1115                                              MPL01570
 1619 IF(IGET(1))9,8816,1114                                            MPL01580
 8816 JOUT=JOUT-J16                                                     MPL01590
         GO TO 83                                                       MPL01600
 1115 IF(NET-ILS)1116,1047,1116                                         MPL01610
 1116 IF(NET-ILS-10)1114,1047,1114                                      MPL01620
C        IF JOB NEW START OR FINISH=OLD FIN.YRST.-REVISE TABLES         MPL01630
C        REVISE GENERAL TABLE                                           MPL01640
 1047 JL=-1                                                             MPL01650
 1117 J17=-1                                                            MPL01660
         J14=1                                                          MPL01670
         READ(13'ILS,5)(IGET(I),I=1,111)                                MPL01680
         N=ILS                                                          MPL01690
 9119 DO 1120 I1=2,11                                                   MPL01700
 1121 IGET(I1)=IGET(I1-ICP(I1-1)                                        MPL01710
 1120 IGET(I1)=0                                                        MPL01720
         DO 1121 I1=2,11                                                MPL01730
 1121 IGET(I)=IGET(I)+IABS(IGET(I1))                                    MPL01740
         WRITE(13'N,5)(IGET(I),I=1,111)                                 MPL01750
         IF(J12)1127,2,1129                                             MPL01760
 1127 N=N+10                                                            MPL01770
 1129 READ (13'N,5)(IGET(I),I=1,111)                                    MPL01780
 9125 DO 1126 I1=2,11                                                   MPL01790
```

```
161    1126 IGET(L1)=IGET(L1)+ICP(L1-1)                                  MPL01800
162         J12=1                                                        MPL01810
163         GO TO 1128                                                   MPL01820
164    1129 IF(JL)501,519,503                                            MPL01830
165     501 J14=-1                                                       MPL01840
166         IF(J13)1134,1137,1114                                        MPL01850
167    1114 IMP=0                                                        MPL01860
168         NDIF=J7-J8                                                   MPL01870
169         READ(13'NRT,5)(IGET(I),I=1,11)                               MPL01880
170         DO 22 L=2,11                                                 MPL01890
171         J3=IGET(L)                                                   MPL01900
172         NDP=ICP(L-1)                                                 MPL01910
173         IF(NDIF)15,20,19                                             MPL01920
174      21 IDELT=J3-NDP                                                 MPL01930
175         GO TO 22                                                     MPL01940
176      19 IDELT=J3+NDP                                                 MPL01950
177      22 IMP=IMP-IABS(IDELT)                                          MPL01960
178         J11=IMP+IGET(1)                                              MPL01970
179         IF(J7)81,82,81                                               MPL01980
180      82 LIMP=L1MP+NDT                                                MPL01990
181         GO TO 83                                                     MPL02000
182      81 JOUT=JOUT+NDT                                                MPL02010
183         GO TO 83                                                     MPL02020
184      16 LIMP=LIMP-JTC                                                MPL02030
185      83 IF(JP-1)85,84,85                                             MPL02040
186      84 NST=NST+10                                                   MPL02050
187         J8=0                                                         MPL02060
188         GO TO 17                                                     MPL02070
189      85 IF(J7)87,99,87                                               MPL02080
190      87 J7=0                                                         MPL02090
191         L1MP=JOUT                                                    MPL02100
192         NST=NST                                                      MPL02110
193         GO TO 12                                                     MPL02120
194      88 IF(L1MP-NIMP)89,89,90                                        MPL02130
195      90 NIMP=LIMP                                                    MPL02140
196         NNST=NST                                                     MPL02150
197      99 IF(JL)1121,1130,1130                                         MPL02160
C       RETURN GENERAL TABLE TO ORIGINAL CONDITION                      MPL02170
198    1131 M=ILS                                                        MPL02180
199    1132 J13=-1                                                       MPL02190
200         GO TO 1125                                                   MPL02200
201    1134 M=M+10                                                       MPL02210
202    1135 J13=0                                                        MPL02220
203         GO TO 1119                                                   MPL02230
204    1137 JL=0                                                         MPL02240
205    1138 IF(J16)9,96,94                                               MPL02250
206    7911 NIMPT=NIMPT+NIMP                                             MPL02260
207         JL=0                                                         MPL02270
208         J=0                                                          MPL02280
209         GO TO 1117                                                   MPL02290
210     519 IF(JK)9,560,561                                             MPL02300
211     561 M=NNST                                                      MPL02310
212         GO TO 505                                                    MPL02320
213     560 M=NNST+10                                                   MPL02330
214     505 JL=1                                                        MPL02340
215         IF(JK)9,1125,1119                                            MPL02350
216    1117 READ(13'M,5)(IGET(I),I=1,11)                                 MPL02360
217         GO TO 1119                                                   MPL02370
218     503 IF(JK)9,512,513                                             MPL02380
219     512 JK=1                                                        MPL02390
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      GO TO 561                                                          MPL02400
  513 ILS=NRST                                                           MPL02410
      MLS(JM)=ILS                                                        MPL02420
      GO TO 1140                                                         MPL02430
    9 WRITE(NPR,47)                                                      MPL02440
   47 FORMAT ('1 ERROR TERMINATION')                                     MPL02450
      CALL EXIT                                                          MPL02460
   39 IJP=1                                                              MPL02470
      IJL=1                                                              MPL02480
      WRITE(NPR,9000)IJP                                                 MPL02490
 9000 FORMAT(1H1,'PAGE',I6,' MANPOWER LEVELING')                         MPL02500
      WRITE(NPR,2721)                                                    MPL02510
 2721 FORMAT('  TIME  TOTAL   A   B   C   D   E   F   G   H   I   J')    MPL02520
      DO 193 I=1,11                                                      MPL02530
  193 IGET1(I)=0                                                         MPL02540
      DO 306 K=1,LL                                                      MPL02550
      READ (12'K,5)(IGET(I),I=1,11)                                      MPL02560
      IF(IGET(11))515,306,515                                            MPL02570
  515 DO 304 I=2,11                                                      MPL02580
  304 IGET1(I)=IGET1(I)+IGET(I)                                          MPL02590
      IGET1(1)=0                                                         MPL02600
      DO 305 I=2,11                                                      MPL02610
  305 IGET1(I)=IGET1(I)+IGET1(I)                                         MPL02620
      JK=K-1                                                             MPL02630
      WRITE(NPR,18)JK,(IGET1(I),I=1,11)                                  MPL02640
   18 FORMAT(' ',I4,2X,I5,1X,10I4)                                       MPL02650
      IJL=IJL+1                                                          MPL02660
      IF(IJL-50)306,306,8010                                             MPL02670
 8010 IJL=1                                                              MPL02680
      IJP=IJP+1                                                          MPL02690
      WRITE(NPR,9000)IJP                                                 MPL02700
      WRITE(NPR,2721)                                                    MPL02710
  306 CONTINUE                                                           MPL02720
      IJL=0                                                              MPL02730
      IJP=IJP+1                                                          MPL02740
      WRITE(NPR,9000)IJP                                                 MPL02750
      WRITE(NPR,2723)                                                    MPL02760
 2723 FORMAT(' ','    I    J     D START TIME  DESCRIPTION',/)           MPL02770
      DO 301 JM=1,NJ                                                     MPL02780
      READ (11'JM,1)II,IJ,ID,(ICR(I),I=1,10),J15,(IDES(I),I=1,13),      MPL02790
     1IES,ILS,ITF,IFF,JTC                                                MPL02800
      ILS=MLS(JM)-1                                                      MPL02810
      IJL=IJL+1                                                          MPL02820
      IF(IJL-50)301,301,8020                                             MPL02830
 8020 IJL=0                                                              MPL02840
      IJP=IJP+1                                                          MPL02850
      WRITE(NPR,9000)IJP                                                 MPL02860
      WRITE(NPR,2720)                                                    MPL02870
  301 WRITE (NPR,3000)II,IJ,ID,ILS,(IDES(I),I=1,13)                      MPL02880
 3000 FORMAT (' ',2I5,I6,III,2X,12A4,A1)                                 MPL02890
      STOP                                                               MPL02900
      END                                                                MPL02910
```

$ENTRY

Project Management With CPM

by

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Karachi, Pakistan, 1974

AN ABSTRACT OF A MASTER'S REPORT

Submitted in partial fulfillment of

the requirements for the degree

MASTER OF SCIENCE

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1976

ABSTRACT

A basic approach to CPM is presented, emphasizing and underlining the basic concepts. The mathematics of the network analysis as it is applied to critical path computations are illustrated. The fundamental structure can be visualized as a network in which points or nodes correspond to events and arrows correspond to activities. This fundamental structure is convenient in expressing the sequence, and interrelationships existing in the project. This report describes the application of the Critical Path Method in scheduling and planning and its use as a management tool in the construction industry. A tool of this type has economic justification within the construction industry since each job is unique and requires a different planning approach. CPM as a tool is not limited to specific project areas, but can be utilized throughout the project management, engineering procurement and construction levels. The types of CPM output and presentation are important and each project level has its own preference and needs. Although 80% of the effort in CPM is spent in activity analysis and network preparation, which requires essentially construction judgment, practical experience and common sense, still its use with appreciable competence results in saving in time and money and an orderly execution. A construction project (Defense Society Bungalow, Karachi, Pakistan) is presented to illustrate a few applications of CPM techniques in which the basic concepts are incorporated.