EFFECTIVE USE OF CPM

Srilal Perera

1. Introduction

CPM is extremely important in the planning, scheduling and control of work in construction projects. Yet in construction projects, the use of CPM is very rare. In most projects CPM is used only during the initial stages of construction.

In construction work, the network is subjected to changes very frequently due to various reasons, like. the high degree of uncertainty, variations and alterations relating to the work. The:efore, the network should be revised and updated at regular intervals in order to keep it effective and useful.

The analysis of large networks become extremely tedious for the site engineer and the programmes and this leads to ignoring CPM completely. This study is mainly directed towards simplifying the analysis and at the same time make the network show a more realistic sequence of operations.

2. Lead and Lag Time Relationships

In real practice, there are many instances where there are lead or lag times between activities. These relationships are very rarely incorporated into the network and this is one main reason for the failure of CPM.

There are three types of such relationships:

a) Start to start relationship

This is useo to show that an act'vity can start a certain period of time after the start of another activity. For example, plastering of walls could be started when a certain amount of brickwork is completed.

b) Finish to finish relationship

This is used to show that an activity can finish a certain period of time after the finish of another activity. For example, brickwork should be completed to complete plastering.

c) Finish to start relationship

This is used to show that an activity can start a certain period of time after the finish of another activity. For example, after signing the contract a certain amount of time will lapse before the contractor commences work

The following notations are used to represent these three types of relationships.

S = Start to finish relationship
F = Finisn to finish relationship
Y = Finish to start relationship

The following examples show how these are represented in the network.

(i) Activity B can start N days after the start of activity A.

$$A \xrightarrow{(NS)} B$$

(ii) Activity B can finish N days after the finish of activity A.

$$A \xrightarrow{(NF)} B$$

(iii) Activty B can start N days after the finish of activity A.

$$A \xrightarrow{(NY)} B$$

3. Intermediate Target Dates

Predetermined starting or completing dates of certain activities are known as intermediate target dates.

The following examples show how these are represented in the network.

(i) Activity B should start N days after the start of the project.

$$A \xrightarrow{(ST = N)} B$$

(ii) Activity B should finish N days after the start cf the project.

$$A \xrightarrow{(FIN = N)} B$$

4. Fragnets and Subnets

It is very important that for tne network to be effective it should be properly formulated. This will be quite clear from the example that is given here. It was already stated that large networks are difficult to analyse manually. It is much worse when lead and lag times and intermediate target dates are incorporated in them.

This problem is solved with the introduction of fragnets and subnets. For example, in a multi storeyed building we could have a separate network for each storey. These small networks are called fragnets. The time details obtained by analysing these fragnets are fed into the main network. Each fragnet will be just one activity in the main network.

With the introduction of fragnets, when it comes to updating a network, the analysis is simplified considerably. For example, due to some delays or changes in the first flooi of a building, the netwcrk has to be corrected. The fragnet for the first floor is analysed with the necessary corrections and the corrected time details are fed into the main network. None of the other frognets are altered. Thus only a fraction of activities will have to be considered when it comes to updating.

In very large projects fragnets alone may not be sufficient. For example, if there are more than one multi-storeyed building in the same project, then each building will have a network called the subnet. The fragnets feed the subnets and the subnets feed the main network.

5. Time Computations

The time computations are done by the traditional CPM technique-, ([1], [2], [3], [4], [5], [6]) The only modification is the introduction of lead or lag and intermediate target dates.

Thus, the earliest start time (ES) of an activity is the largest time value of the following:

(a) the earliest finish times of the preceding activities.
(b) The starting times from start to start lead time relationships.
(c) The starting times from finish to start lag time relationships.
(d) Intermediate starting target date.

The earliest finish time (EF) of all activities is the largest time value of the following:

(a) EF = ES + DURATION
(b) The finish times from finish to finish lag time relationships.

The latest finish time (LF) of an activity is the smallest time value of the following:

(a) The latest start times of the following activities.
(b) The finish times from finish to finish lag time relationships.
(c) Intermediate finishing target date.

The latest start time (LS) of an activity is the smallest time value of the following:

(a) LS = LF — DURATION
(b) The starting times from start to start lead time relationships.

6. Example Project

Consider a three-storeyed building as an example. The network is split up into the following fragnets.

(1) Excavation for foundation
(2) Concrete foundation
(3) Ground floor
(4) First floor
(5) Second floor
(6) Roof structure

Each of these fragnets will have a detailed breakdown of activities within that item. Table 1 gives all such details with respect to the fragnet for the first floor. The fragnets are analysed first. The analysis for the first floor is shown in Figure 1.

Once the fragnets are analysed the time details are fed into the main network as follows. From Table 1 it can be seen that the total duration to complete all activities within the first floor is 83 days. Therefore, the duration for the activity "first floor" in the main network for the whole project is 83 days. However, it should be noted that the work on the second floor could commence soon after concreting the first floor slab, that is, 27 days after the start of the activity "first floor". Thus, there is a start to start lead time relationship between activities "first floor" and "second floor" (Table 2) in the main network. Similarly, all other durations and lead and lag time relationships are obtained by analysing the other fragnets.

The site preparations begin 7 days after signing the contract. This is indicated by a finish to start lag time relations between activities "assign contract" and" site preparations" (Table 2).

Concreting of the final block in the foundations will be completed 3 days after the completion of excavations. This is indicated by a finish to finish lag time relationship between activities "Excavation for foundations" and "concrete foundation" (Table 2).

TABLE 1

ACTIVITY LIST FOR THE FIRST FLOOR

ACTIVITY			ACTIVTIES		TIME DETAILS				
CODE	DESCRIPTION	DUR	PRECEDING	FOLLOWING	ES	EF	LS	LF	TF
A01	Concrete columns	10	A00	A03	0	10	0	10	0
A02	Concrete stairway	8	A00	A07	0	8	39	47	39
A03	Concrete floor slab	17	A01	A04	10	27	10	27	0
A04	Brickwork	27	A03	7SA05, 8FA05 7SA06, 10FA06 7SA07, 5FA07	27	54	27	54	0
A05	Windows and doors	18	7SA04, 8FA04	A10	34	62	53	71	19/9
A06	Plumbing	21	7SA04 10FA04	A10	34	64	50	71	16/7
A07	Plaster	12	7SA04 5FA04 A02	5SA08 12FA08 5SA09 10FA09	34	59	47	59	13/0
A08	Joinery	17	5SA07 12FA07	A10	39	71	54	71	15/2
A09	Electrics	15	52A07, 10FA07	A10	39	69	56	71	17/2
A10	Decorate	10	A05, A06, A08 A09	A11	71	81	71	81	0
A11	Clean out	2	A10	E	81	83	81	83	0

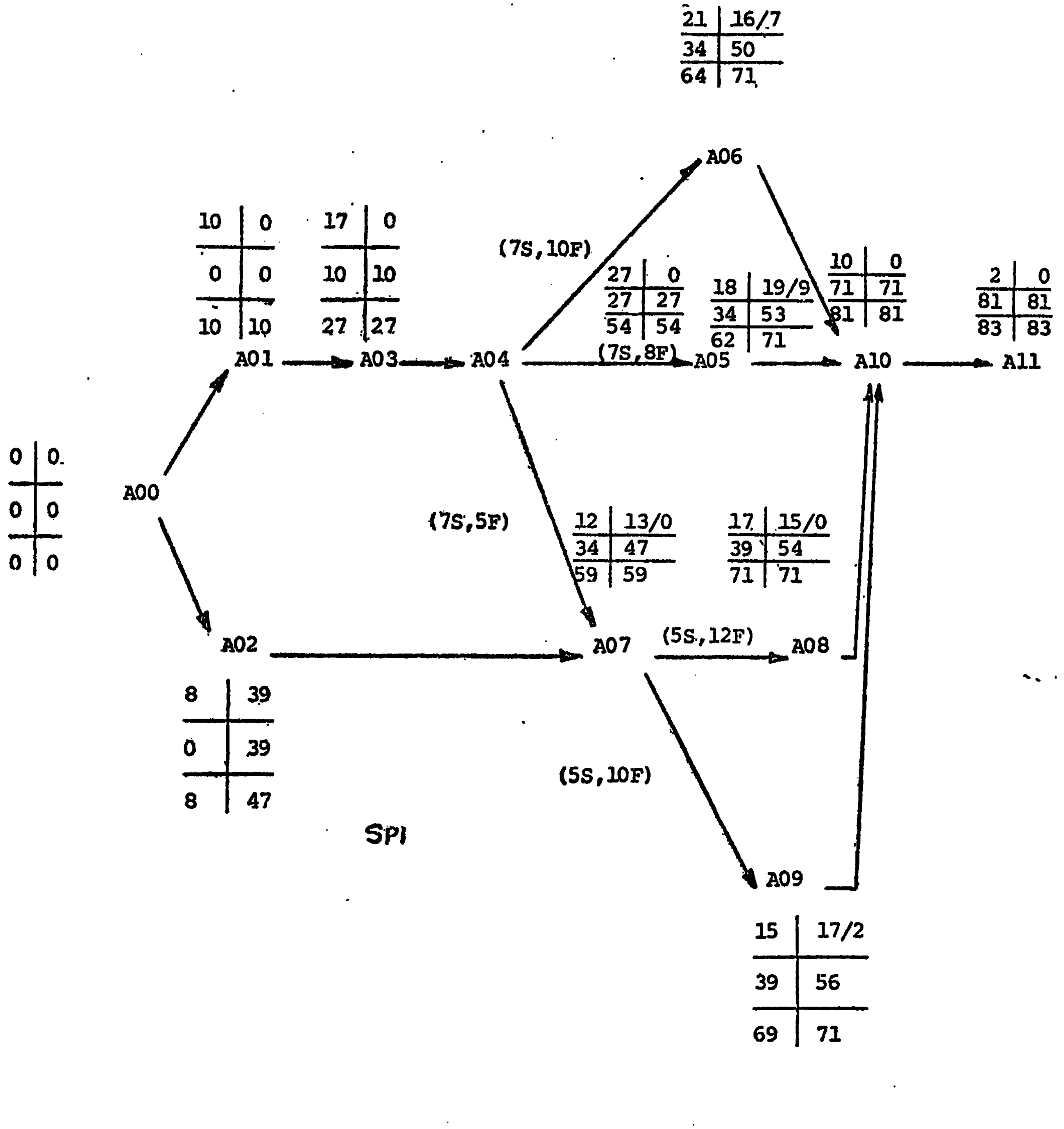

Figure 1 - Network for the first floor (B08)

TABLE 2

ACTIVITY LIST FOR THE THREE-STOREYED BUILDING

ACTIVITY			ACTIVITIES		TIME DETAILS				
OODE	DESCRIPTION	DUR	PRECEDING	FOLLOWING	ES	EF	LS	LF	TF
B01	Acquisition of land	45	B00	B04	0	45	0	45	52
B02	Complete plans and	60	B00	B03	0	60	0	60	0
B03	Assign Contract	30	B02	7YB04	60	90	60	90	0
B04	Site preparations	10	7YB03, B01	B05	97	107	97	107	0
B05	Excavations for the foundations	12	B04	6SB06, 3FB06	107	119	107	128	0/9
B06	Concrete foundations	18	6SB05, 3FB05	10SB07	113	131	113	131	0
B07	Ground floor	95	10SB06	32SB0,8 B11	123	218	123	258	0/40
B08	First floor	83	32SB07	275B09, B11	155	238	155	258	0/20
B09	Second floor	76	27SB08	9SB10, B11	182	258	182	258	0
B10	Roof structure	17	9SB09	B11	191	208	241	258	50
B11	Clean out	7	B07, B08, B09 B10	E	258	265	258	265	0

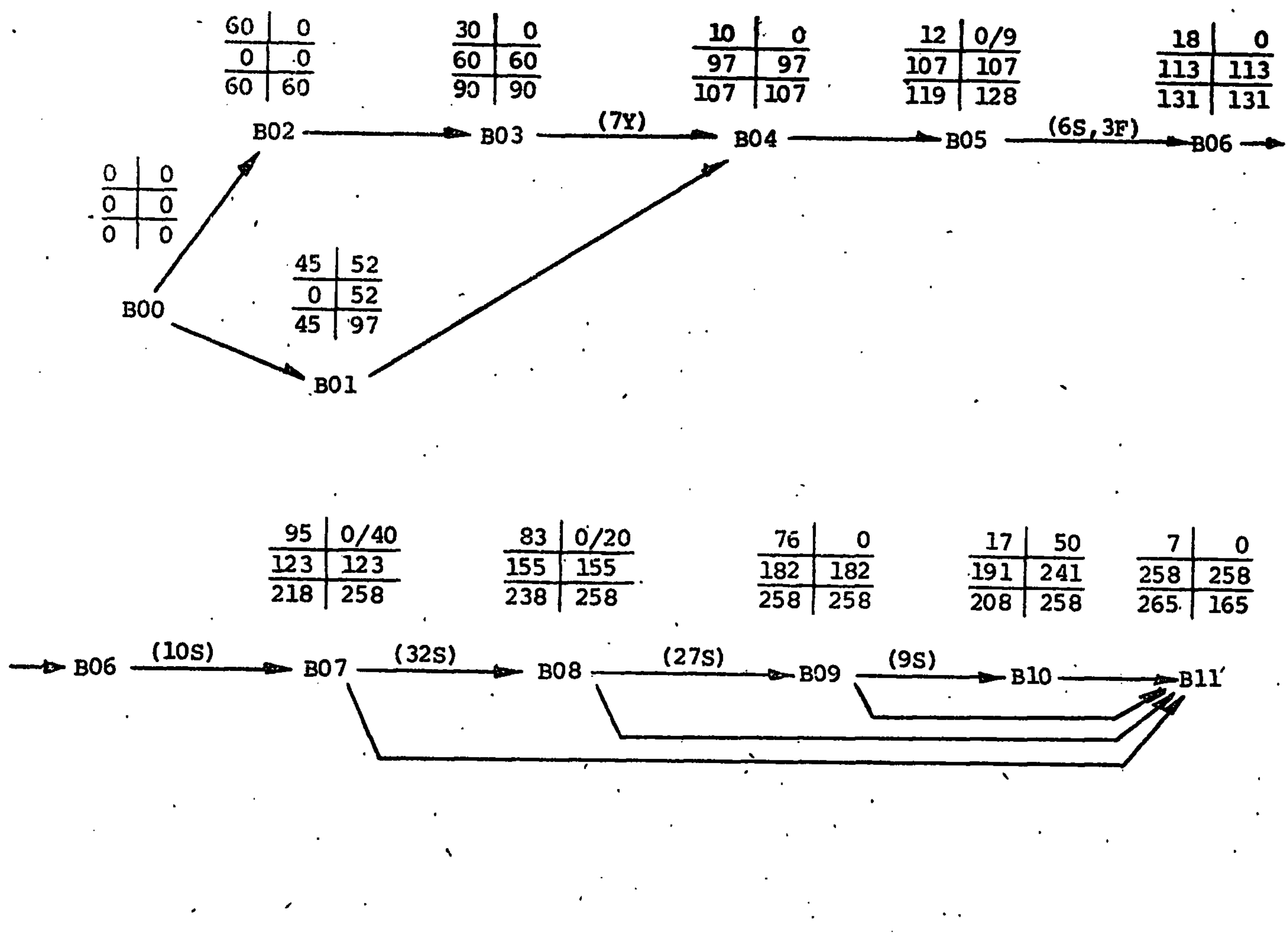

Figure 2 - Network for the three-storeyed building

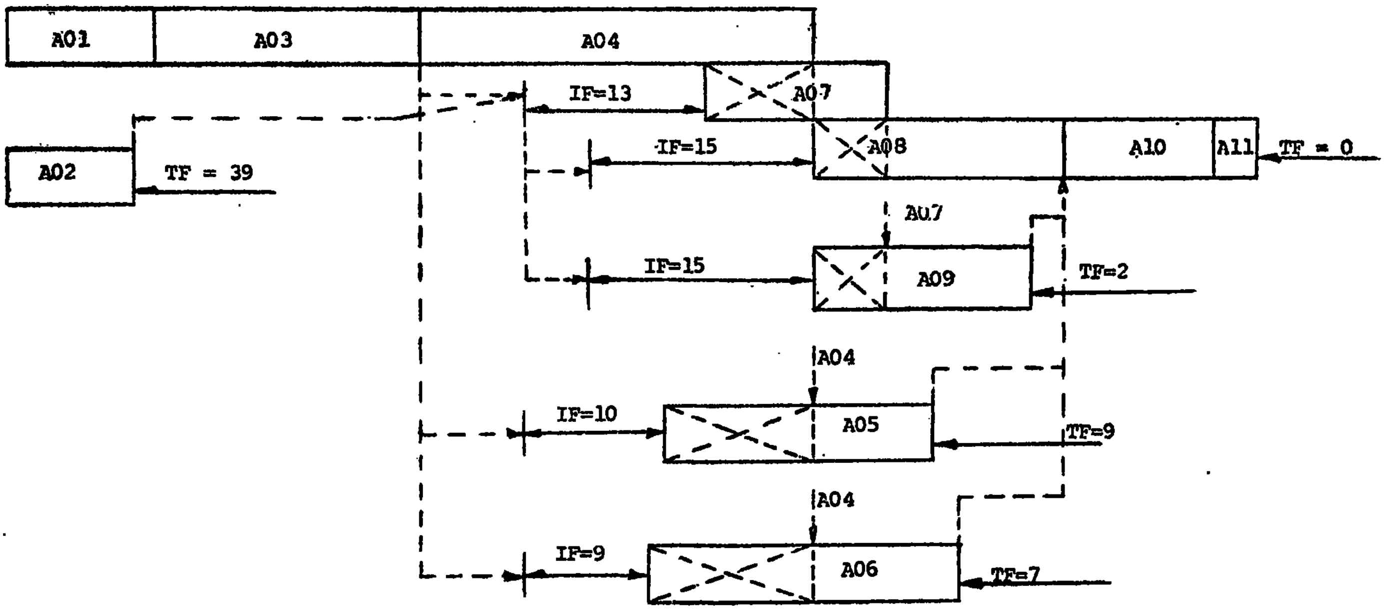

Figure 3 - Chain bar chart for the first floor

This procedure of formulating a network with the introduction of fragnets, subnets and lead or lag time relationships simplfies network analysis considerably.

7. The Chain Bar Chart

Once the network is analysed and the time details are available, a bar chart is drawn showing the sequence and the time lengths of activities. The traditional bar chart that is widely used is the Gantt chart [1, 2, 3, 4, 5, 6]. However, this chart gives very little information and is of limited use.

A more effective chart is the chain bar chart (Figure 3). In this type of chart activities having equal floats and falling in the same chain of operations will follow one another in the same line. The top most line contains all the critical activities. This gives a clear indication of the chain of operations.

In addition to this the floats are indicated, which is of utmost importance in checking whether the project is on schedule or not. The total float is obtained from the following equations.

$$TF = LS - ES \quad \ldots\ldots 1$$
$$TF = LF - EF \quad \ldots\ldots 2$$

The internal float is the difference between equation (1) and (2). This is a float within an activity and is indicated by crossing a section as shown in activities A07, A08, A09, A05 and A06 (Figure 3).

By marking the progress on this chart a regular check could be kept on the project performance. It will also indicate when the critical path changes.

A good understanding of network analysis and the bar charts by all site personnel is of great importance to make CPM effective in construction projects.

References

1. Ahuja, H. N.,—*Construction Performance Control by Networks.*
2. Harris, F. and Mc Caffer, R.,—*Construction Management.*
3. Moder, J. J. & Phillips, C. R.—*Project Management with CPM and PERT.*
4. Pilcher, Roy,—*Principles of Construction Management*
5. Woodward, J. F.,—*Construction Management and Designs*
6. Woodward, J. F.,— *Planning and Control of Project Networks.*