

1 PROGRAMMING TECHNIQUES

- Bar charts
- Linked bar charts
- Arrow diagrams
- Precedence diagrams
- Line-of-balance diagram
- Time-chainage diagrams

1.1 Bar charts and linked bar charts

The bar chart is laid out with the timescale in days/weeks/months/years along the top axis and a list of tasks or activities down the left-hand side. The time required for each activity is represented by a horizontal line (or bar), with the length of the line indicating the duration of the activity. They are also called traditionally as “Gantt charts”.

At present, there are several software packages that produce bar charts. Some examples are the following:

- CS Project Professional / Crest Software
- Easyplan – Asta Development
- Microsoft Project / Microsoft Ltd.
- Powerproject / Asta Development
- Project Commander / PMSC Software

These software packages require the user to enter a logic by creating links between the activities on the programme. This let the user update easily the planning process, even on site. These links can be the established by the following relationships:

- Finish-to-start
- Start-to-start
- Finish-to-finish

One of the problems with these charts is the tendency of the planner/manager to work backwards from the completion date stated in the contract documents. The resulting bar chart is only useful to theoretically justify the completion of works but is nowhere to be seen later on.

Bar charts are well suited to depicting construction sequences and are readily understood at all levels of management. They can be used to develop the programme prepared at the tender stage into the master programme and likewise into the short-term planning through the contract period. They are easily updated. A colour coding system can be introduced for progress recording.

Bar charts have limitations, and a key disadvantage is that they do not show dependency. The use of a linked bar chart can overcome this problem, but it introduces complexity in understanding.

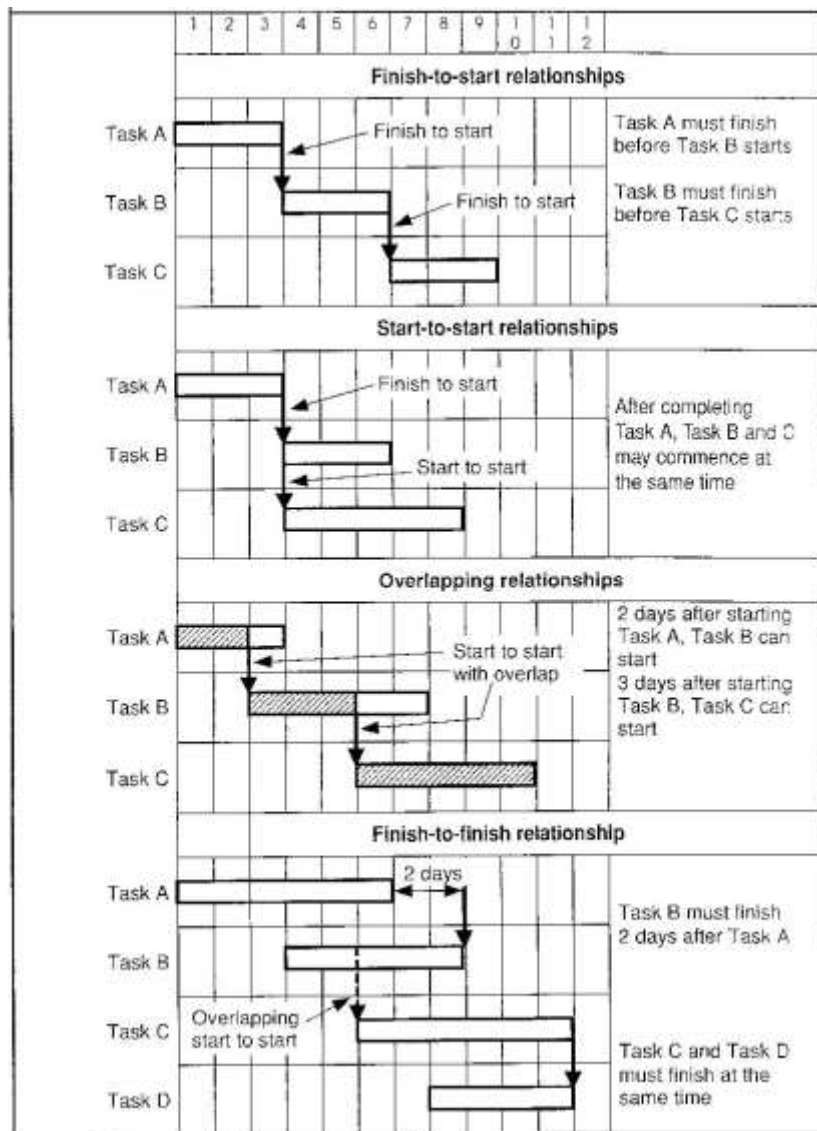


Figure 1. (Cooke et al, 2009).

1.2 Arrow diagrams

These diagrams are characterised because the arrow represents the activity and the circle or node between the arrows is the event. By numbering the events, the arrow activities can be identified. This is usually done in numerical order starting at the beginning of the network and progressing to the end, ensuring that the number at the tail of the arrow is smaller than that at the head.

Each activity is given a duration, and the earliest and latest event times of the activity can be calculated by making forward and backward passes through the network. These times are recorded in the event circles. From this information, a schedule can be produced which will facilitate calculation of the total float or float time (spare time) for each activity. Dummy activities, which usually have no duration or value, can be introduced to indicate dependencies not shown by the arrow activities.

1.3 Precedence diagrams

Precedence diagrams follow the same logical procedures as arrow networks except that the activities and their dependencies are drawn differently. The precedence diagram consists of a series of boxes interlinked with lines. The box or node represents the activity and the linking arrow indicates the relationships of the activities to one another. The box contains an activity label or name and duration. There is space for the earliest and latest start and finish times of the activity and a reference number may also be included if required.

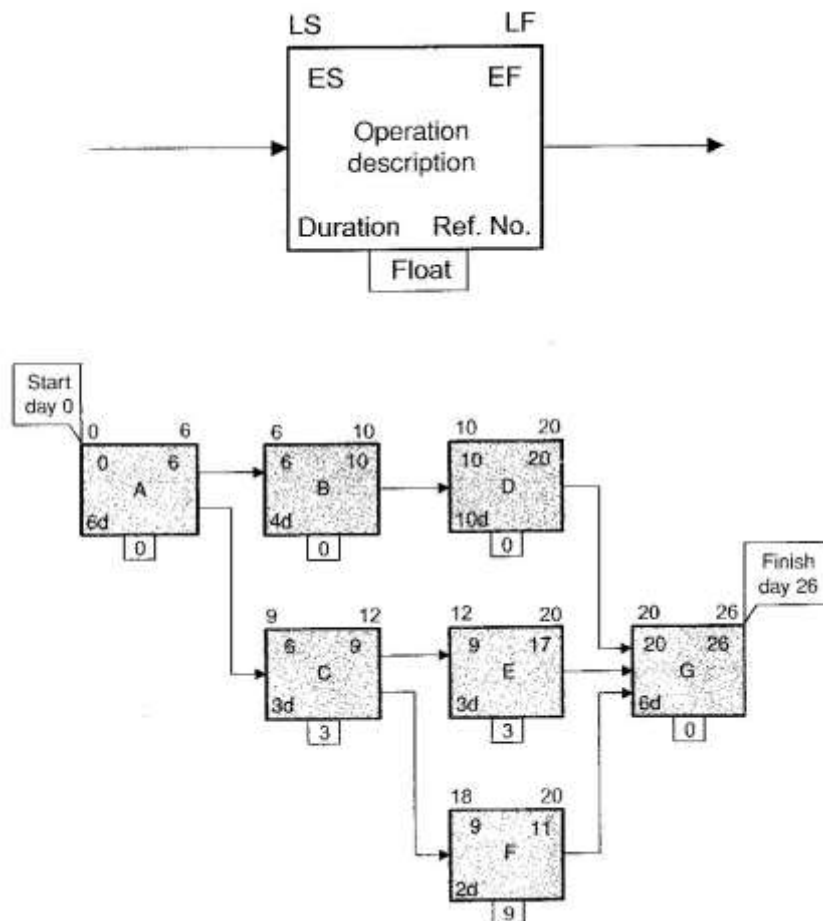


Figure 2. (Cooke et al, 2009).

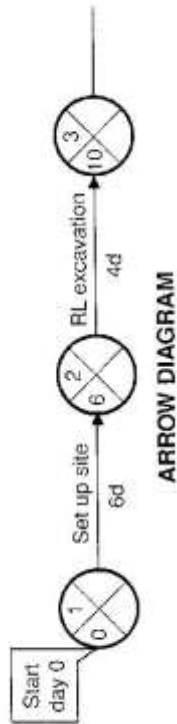
Both the boxes and the lines may be given a time value. The tie given in the box represents the duration of the activity, while any time on the line or arrow adds a dependency which might be a lead or a lag as required.

The precedence approach introduces the idea of activity boxes, rather than activity arrows, which permits a number of different relationships to be expressed between activities. This approach relates more closely to the real situation on a construction project. We can include the following relationships:

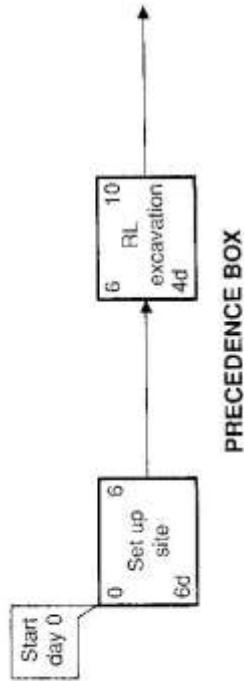
- Finish-to-start
- Start-to-start
- Finish-to-finish
- Start-to-finish

1.4 Relationships in linked bar charts, arrow diagrams and precedence box

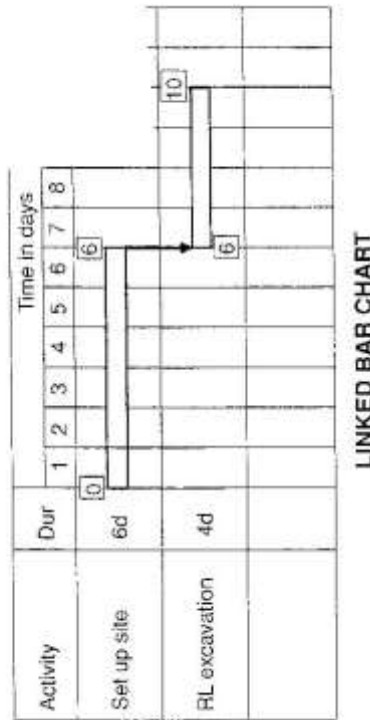
FINISH-TO-START RELATIONSHIPS



ARROW DIAGRAM

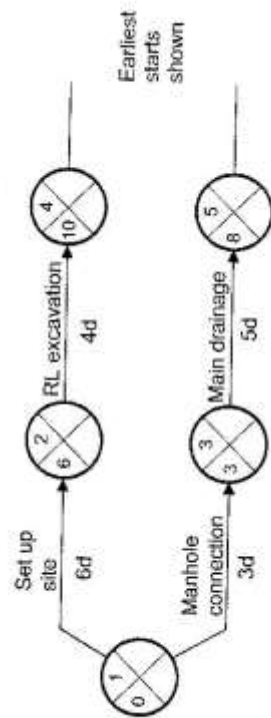


PRECEDENCE BOX

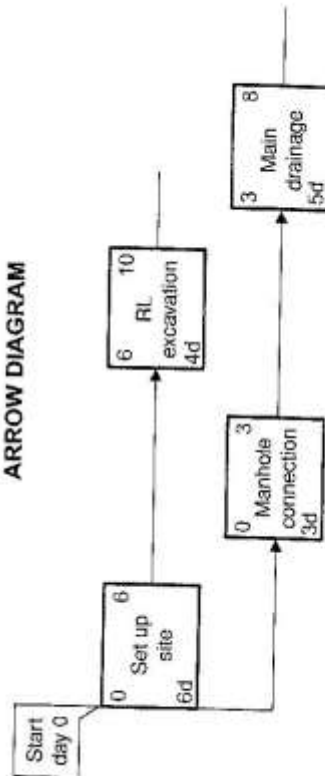


LINKED BAR CHART

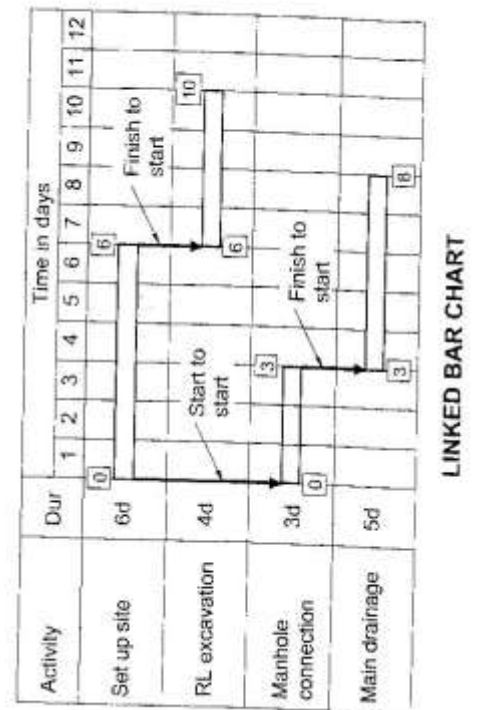
START-TO-START RELATIONSHIPS



ARROW DIAGRAM

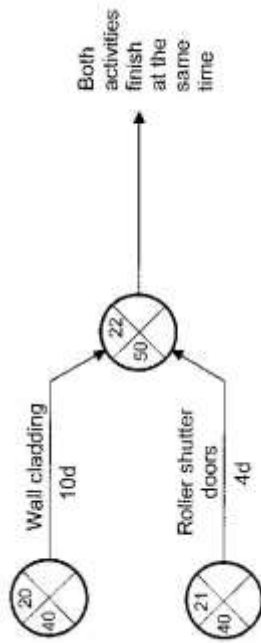


PRECEDENCE BOX

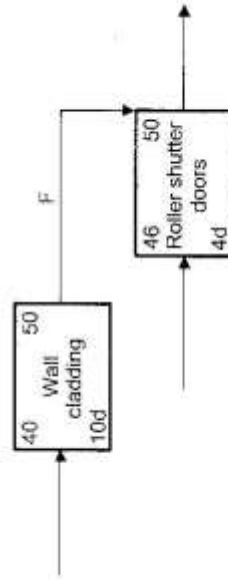


LINKED BAR CHART

FINISH-TO-FINISH RELATIONSHIPS



ARROW DIAGRAM

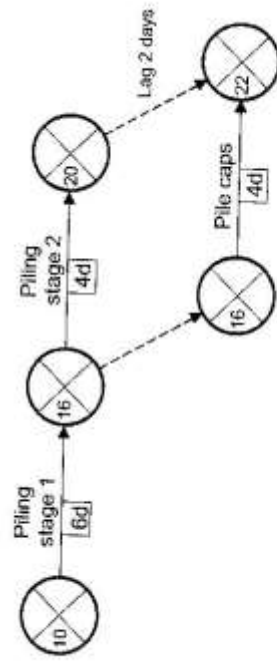


PRECEDENCE BOX

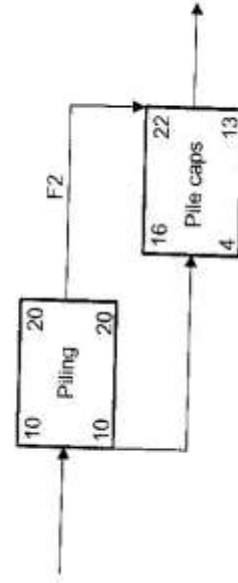
Activity	Dur	Time in days											
		40	41	42	43	44	45	46	47	48	49	50	51
Wall cladding	10d												
Roller shutter doors	4d												

LINKED BAR CHART

START-TO-FINISH RELATIONSHIPS



ARROW DIAGRAM



PRECEDENCE BOX

Ref	Operation	Dur	Time in days													
			8	9	10	11	12	13	14	15	16	17	18	19	20	21
12	Piling	10d														
13	Pile caps	4d														

LINKED BAR CHART

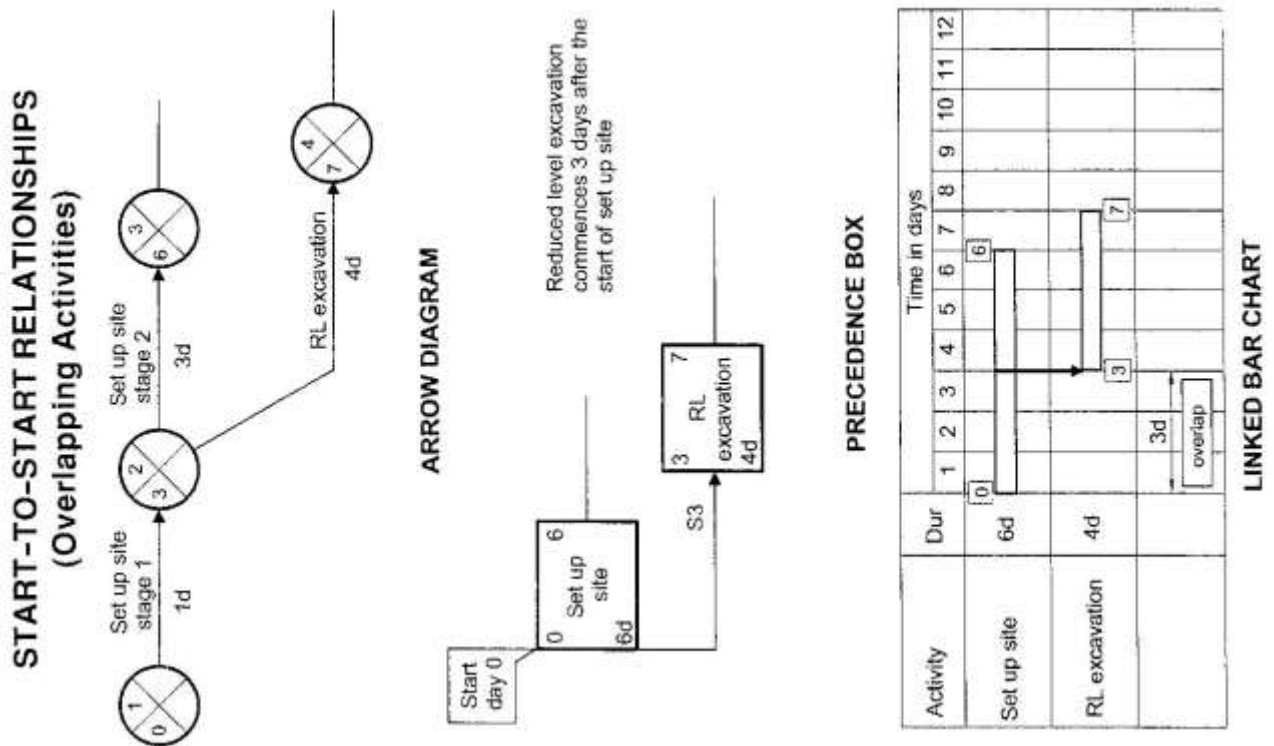


Figure 3. (Cooke et al, 2009).

1.5 Line-of-balance diagram

A line-of-balance diagram comprises a series of inclined lines which represent the rate of working between repetitive operations in a construction sequence. Many types of projects contain repeated blocks of activities (i.e. road or high-rise construction). In these types of projects there is a set of tasks repeated across many work areas. The Line-of-Balance (also known as the Vertical Production Method) is a graphical technique that can be used in conjunction with Arrow or Precedence Diagrams.

Developing a line-of-balance diagram

In the Line-of-Balance diagram, the x-axis represents (as in the bar chart) the timeline of the project. The y-axis identifies the work areas that define the project. The blank chart below is the starting point for the Line-of-Balance schedule.

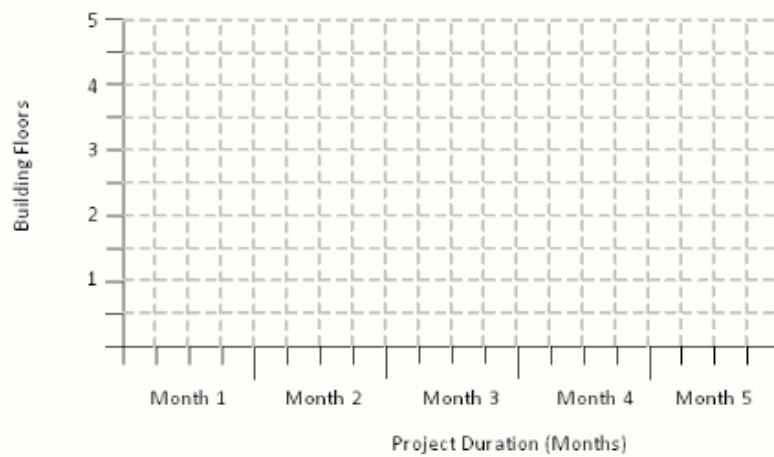


Figure 4. (www.cpm-tutor.com).

As crews arrive on the project, they begin at the first work area and move through the project. In the figure below, Activity A has a total duration of 10 weeks. Spread across each of the work areas the productivity of Activity A can be shown to be 2 weeks per floor.

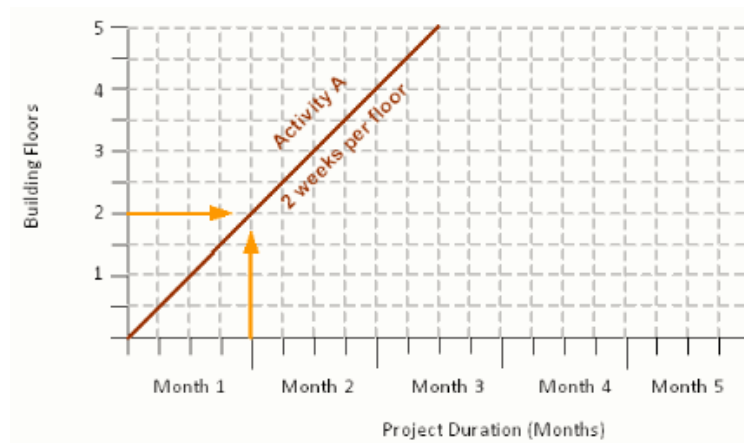


Figure 5. (www.cpm-tutor.com).

Now consider the implication of an Activity B that has a productivity of one week per floor. If we try to start Activity B as soon as possible, then the start of activity B on the first floor can occur at the end of week 2.

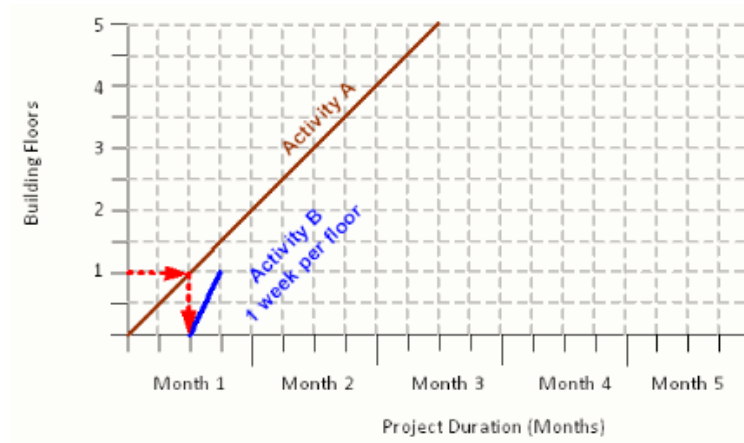


Figure 6. (www.cpmmtutor.com).

As we continue to add Activity B throughout the remaining work areas we can see that Activity B starts on the second floor, at the end of week 4; on the third floor, at the end of week 6 and so on; as shown in the diagram below.

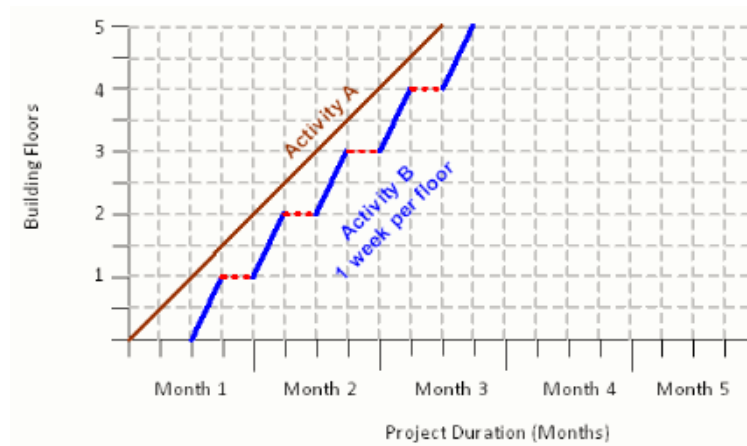


Figure 7. (www.cpmmtutor.com).

The breaks in the Activity B line, shown as red dashed lines above, are significant. This gap means that the crew is waiting around for Activity A to clear out before it can start. In the case of the project above, starting work as soon as you can will result in a lost productivity of 4 crew weeks.

The diagram below shows that you should delay starting Activity B for four weeks. If you do that, then you will keep the crew productive for their entire stay on your project. If you were running a real project, you might include a bit extra time in case things backup.

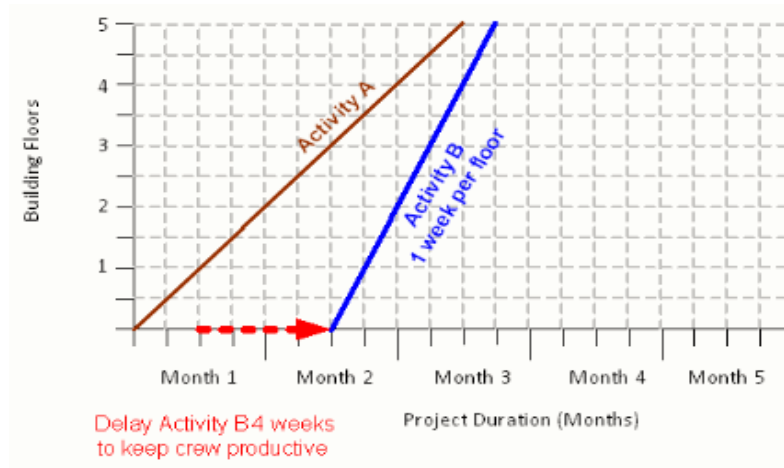


Figure 8. (www.cpm-tutor.com).

1.6 Time-chainage diagrams

This form of presentation enables the time dependencies between activities to be shown, together with their order and direction of progress along the job. These diagrams are most usefully employed as a planning tool on projects such as motorways and major highway works, pipelines, railway track work, tunnelling, etc.

These projects can be viewed as mainly linear in nature. In other words, construction starts at one point and proceeds in an orderly fashion towards another location. This would be typified on a highway project by activities such as fencing, drainage, road surfacing and road markings. Most operations take place on a forward travel basis with the gang starting at one point or chainage and moving along the job. As one activity leaves a particular location, other activities can take its place.

Most of the lines on the time-chainage diagram have no appreciable thickness. This is because the time spent by each gang at a particular location is relatively small and the gang moves along the site quite quickly.

Basically, the diagram comprises two axes, time and distance, with the various activities shown as lines or bars on the chart. Linear activities are represented with a line or bar which is positioned on the chart to show its commencing and completion chainages, and is inclined in the direction of progress at an angle consistent with the anticipated duration of the operation. A static activity (i.e. a bridge) is represented by a vertical line or thin bar at a particular location, and the duration is expressed by its length. Activity labels are annotated on the respective line or bar to distinguish one operation from another.

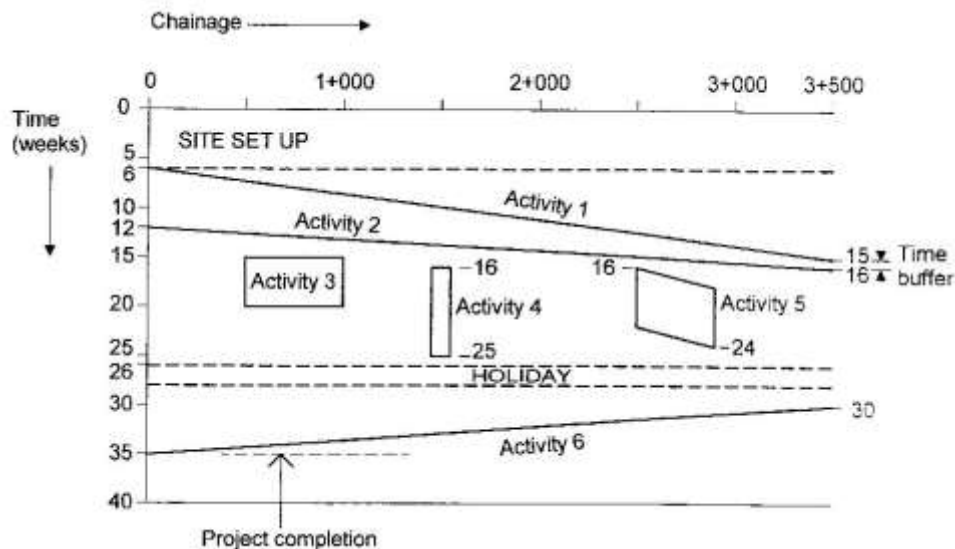


Figure 9. (Cooke et al, 2009).

Developing a time-chainage diagram

The steps are as follows:

1. Consult the project drawings and note the chainage positions. Main chainages on a highway project are at 1000 m intervals.
2. Draw an outline time-chainage diagram with time along one axis and distance or chainage along the other, using either the horizontal or the vertical format (add main holiday periods as needed).
3. List main programme activities or operations in approximate construction sequence. Include activities for site set-up mobilisation and clear site at the end. Estimate the duration of each programme activity in weeks.
4. Fill in the site “set-up” and “clear site” activities on the time-chainage diagram. Using your preferred format, plot the appropriate number of weeks over the entire length (chainage) of the project.
5. Decide in turn where and when each activity will take place. For linear activities, start at the appropriate location and week number and draw a line for the correct distance (chainage) and time. For static activities, draw a thin box at the appropriate chainage with a length representing the activity duration.
6. Complete all activities on the list. It is sometimes helpful to produce an outline bar chart programme to help clarify the correct time-chainage display.

REFERENCES

Cooke, B., Williams, P. (2009) Construction, Planning, Programming and Control. 3rd Ed. Oxford: Wiley-Blackwell.

CPM Tutor. www.cpm-tutor.com.

