EPM CONSULTANCY

Line of Balance

التخطيط لمشروعات الاسكان
والمشروعات ذات الطبيعة المتكررة

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Line Of Balance Method;

Construction of a house might reasonably be covered by a network from 30 to 60 activities (Possibly more if all material deliveries, estate road construction, sewers, electricity and other services are included)

However if the estate included 200 houses then the network would have six to twelve thousand activities.

There would be tremendous repetition on the network and it would be difficult to keep it updated.

It would not let anyone know management or employees, how work was proceeding and it is probable that the network would have little effect on the work.

Line of balance methods are particularly suited to repetitive work.

Illustration how progress today (week 20) can be seen at a glance from this progress chart for the construction of 50 houses.

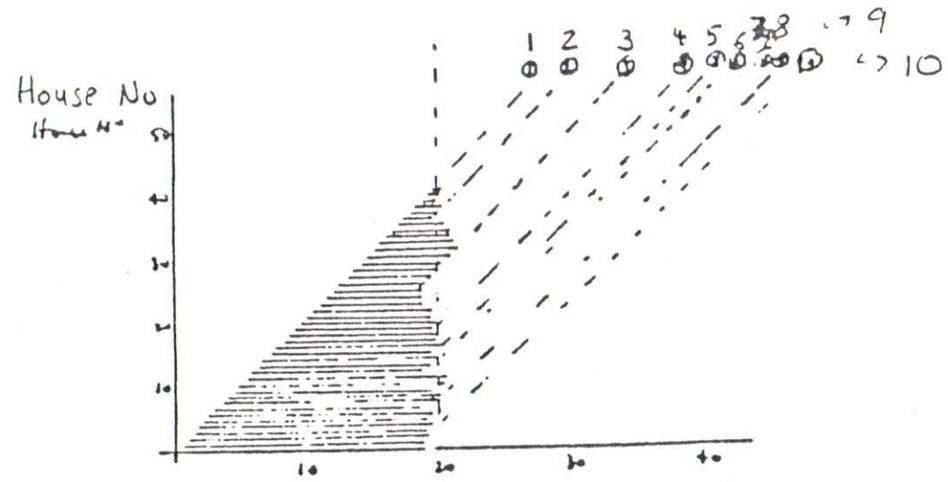


Fig-1

1-2 Substructure
2-3 Brickwork
3-4 Joinery
5-6 Glazing
6-7 Joinery finishing
6-9 Electrical
6-8 Plumbing
9-10 Painting

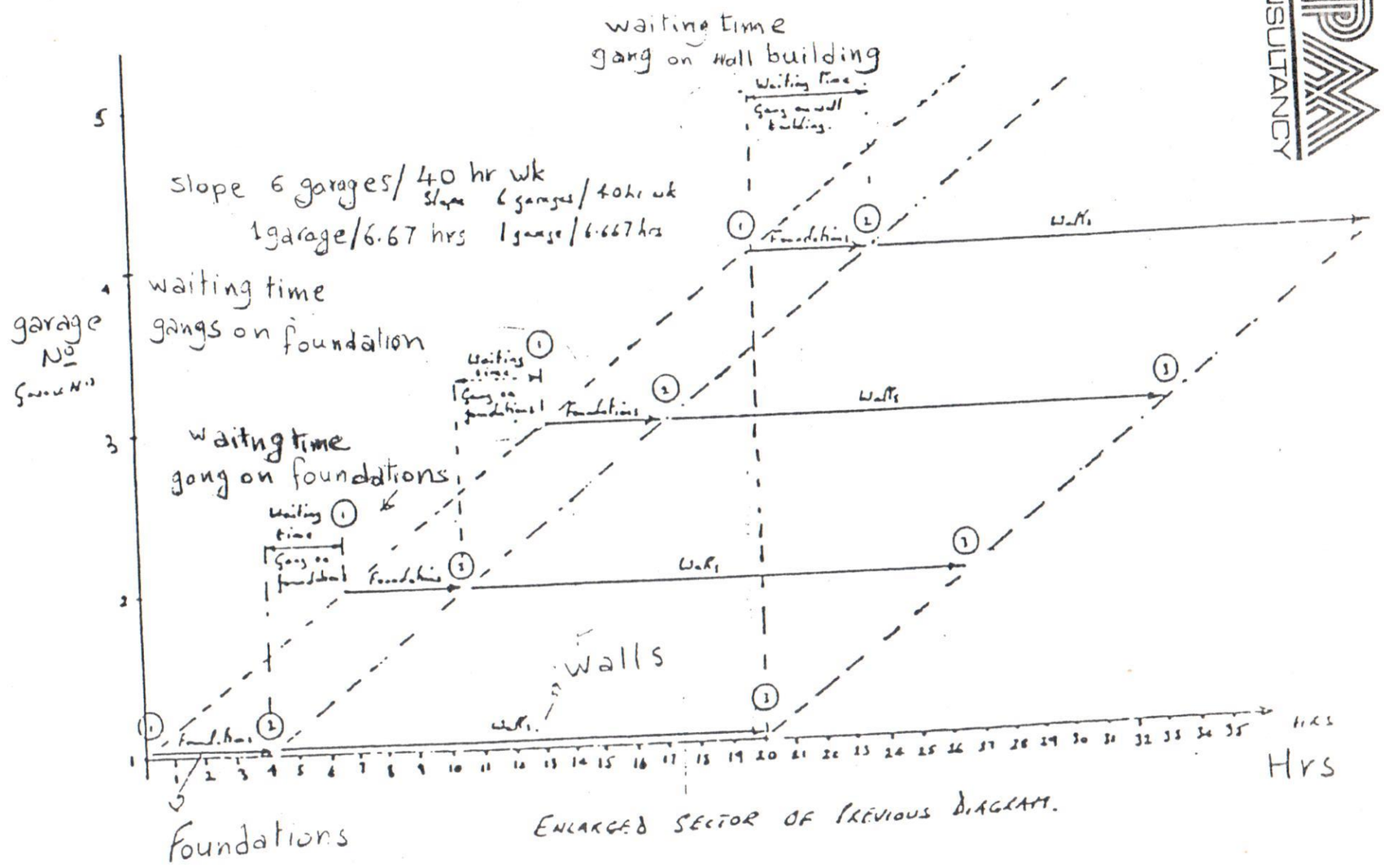

waiting time
gang on wall building
slope 6 garages/ 40 hr wk
1 garage/6.67 hrs
waiting time
gangs on foundation
garage No
waitng time
gang on foundations
walls
Foundations
Hrs
ENLARGED SECTOR OF PREVIOUS DIAGRAM.

Fig-2

Line of balance chart for construction of 6 garages every 40

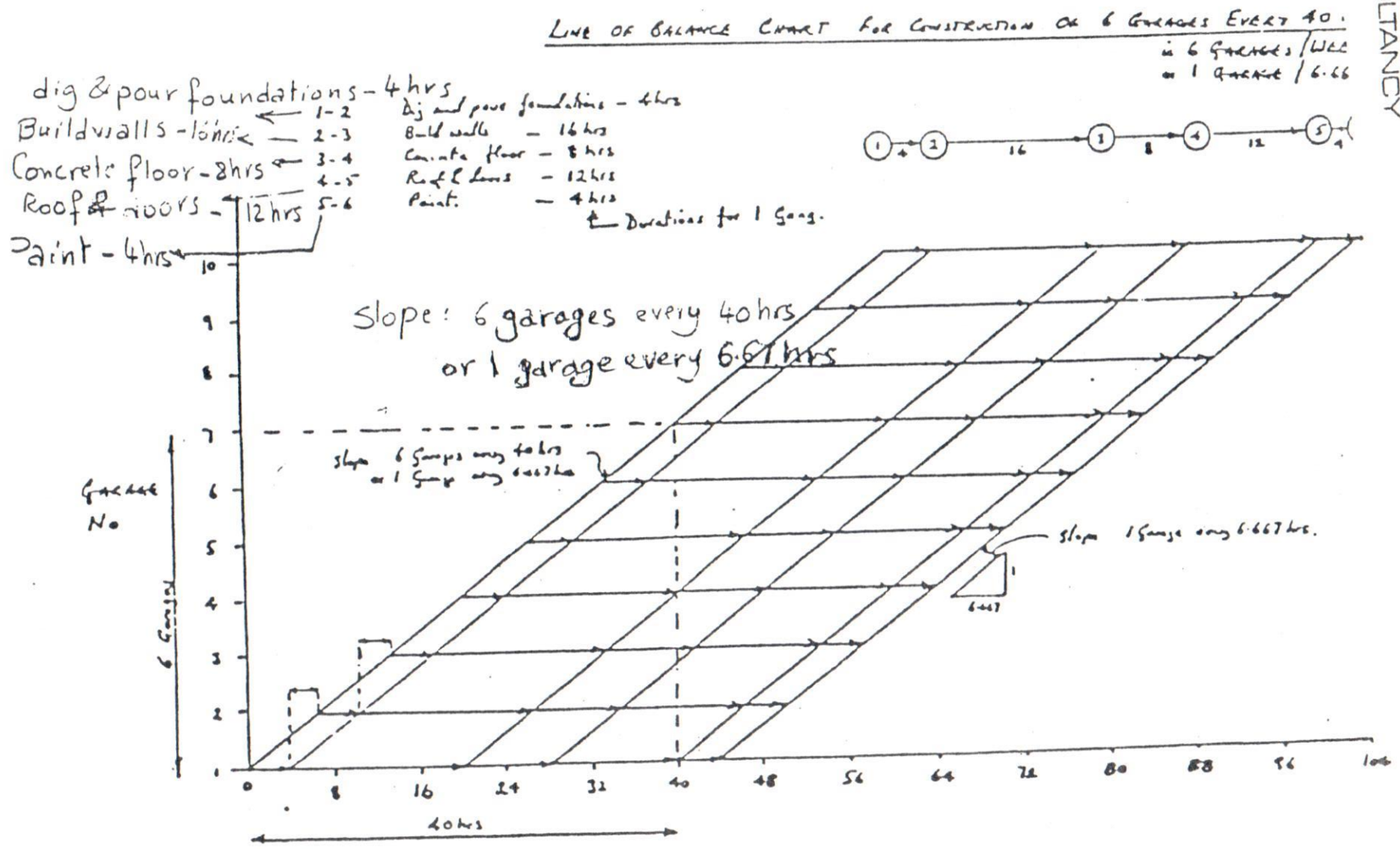


Fig-3

Resource Multiplication Factor

Resource utilization factor.

Activity	Duration		Waiting Time	Resource Utilization Factor
1-2 Dig pour foundations	4 hrs	1	6.667 − 4 = 2.667 hrs	$\frac{4}{4+2.667} = 0.6$
2-3 Build walls	16 hrs	3	4 + 3×6.667 − 20 = 4 hrs	$\frac{16}{16+4} = 0.8$
3-4 Concrete floors	8 hrs	2	20 + 2×6.667 − 28 = 5.333 hrs	$\frac{8}{8+5.333} = 0.6$
4-5 Roof and doors	12 hrs	2	28 + 2×6.667 − 40 = 1.333 hrs	$\frac{12}{12+1.333} = 0.9$
5-6 Paint.	4 hrs.	1	40 + 6.667 − 44 = 2.667 hrs	$\frac{4}{4+2.667} = 0.6$

ACTIVITY	DURATION	RESOURCE MULTIPLICATION FACTOR	OUTPUT FOR ACTIVITY IF NO WAITING
1-2 Dig and pour foundations	4 hrs	1	1 Every 4 hrs
2-3 Build walls	16 hrs	3	1 Every = 5.33 hrs
3-4 Concrete floors	8 hrs	2	1 Every = 4 hrs
4-5 Roof and doors	12 hrs	2	1 Every = 6 hrs
5-6 Paint	4 hrs	1	1 Every 4 hrs

NATURAL RHYTHM

Activity 1-2

Start on garage at 0 + (10-1)x 4 hrs and finish at 36 + 4 = 40 hrs

Activity 2-3

Start on garage No 1 at 4 hrs. Finish on garage No 1 at 20 hrs. Start on garage No 10 at 4 + (10-1)x 5.33 = 52 hrs. Finish on garage No 10 at 52 + 16 = 68 hrs.

Activity 3-4

Start on garage No 10 at 68 hrs. Start on garage No 1 at 68-(10-1)x 4 = 32 hrs. Finish on garage No 1 at 32 + 8 = 40 hrs.

ACTIVITIES OCCURRING AT THEIR NATURAL RHYTHM (OR MULTIPLE OF THEIR NATURAL RHYTHM)

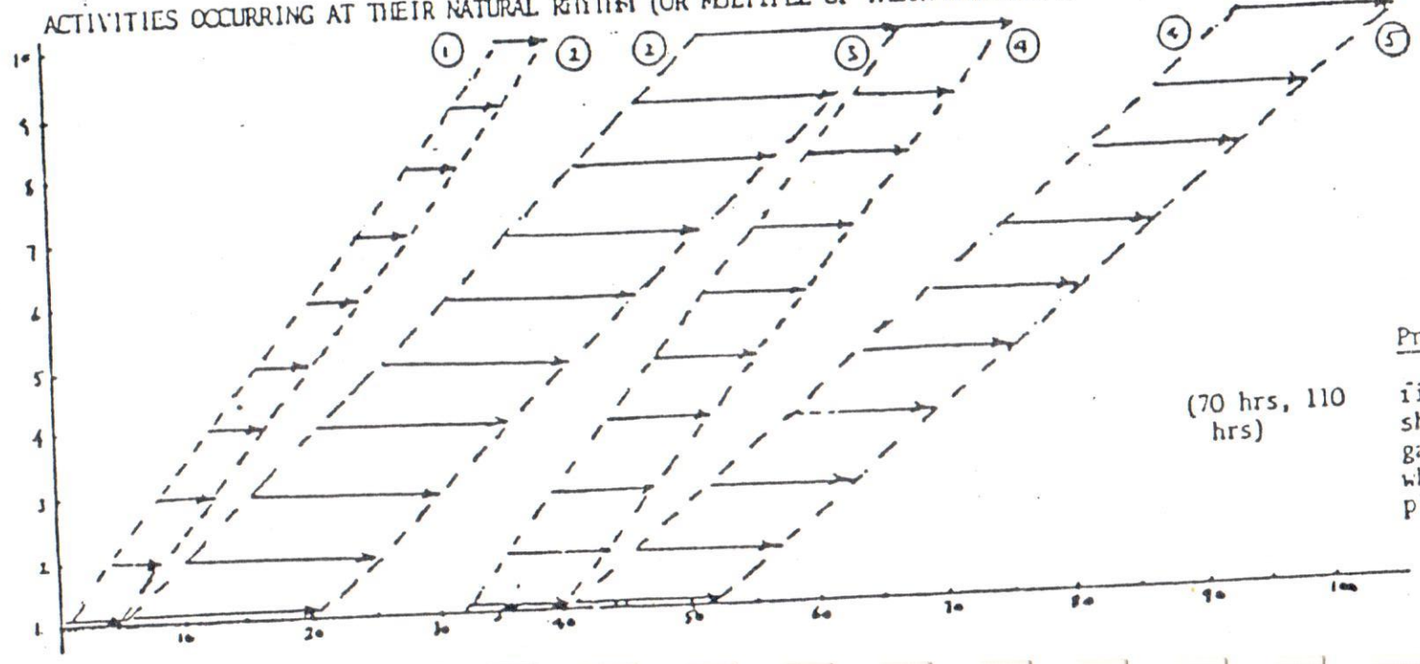


Fig-4

(70 hrs, 110 hrs)

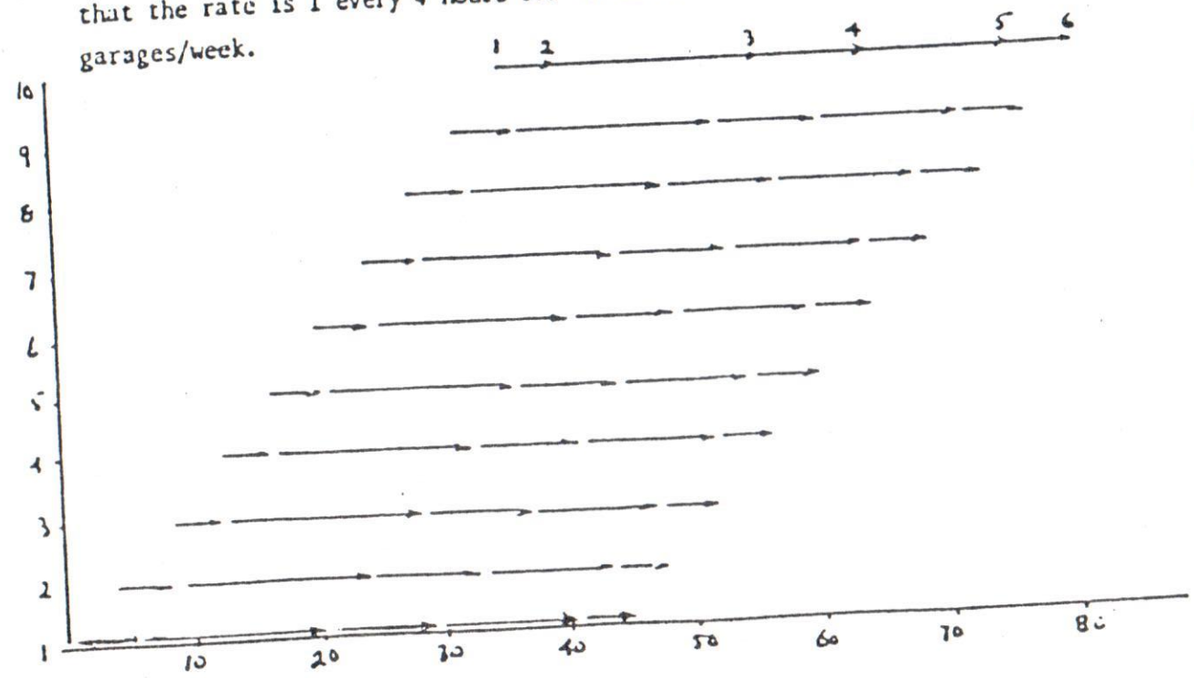
Problem 9

Find when painters should start on garage No 1 and when they will complete garage No 10.

FULLY BALANCED & PARTIALLY BALANCED ACTIVITY SEQUENCES.

Activity	Duration	Resource Multiplication factor	Output for activity if no waiting
1-2 Dig and pour foundations	4 hours	1	1 Every 4 hours
2-3 Build walls	16 hours	4	1 Every 4 hours
3-4 Concrete Floors	8 hours	2	1 Every 4 hours
4-5 Roof and Doors	12 hours	3	1 Every 4 hours
5-6 Paint	4 hours	1	1 Every 4 hours

By increasing resources it may be possible to obtain a partially balanced activity sequence or even (as in this case) a fully balanced activity sequence. Since each activity duration is a multiple of 4 hours by having 4 gangs for activity 2-3, 3 gangs for 4-5 a fully balanced activity sequence can be obtained. Note that the rate is 1 every 4 hours for all activities - ie. output = 10 garages per 40 working hours or 10 garages/week.



It is desirable to have production running at same rate for every item.

(a) avoids waiting time - more efficient less waste.
(b) easier management
(c) better labour relations
(d) better pricing
(e) better bonus scheme possible?

Fig-5

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Example of line of balance;

Your company has been awarded a contract to erect 124 pylons for the electricity board.

The Table shows the sequential operations involved in the construction of each pylon together with the estimated and required number of men per gang for each operation.

Table; Operation, manhours and number of men

Operation	Manhours	No. of men per operation per gang
A. Excavate	55	4
B. Concrete Foundations	64	4
C. Erect tower	145	8
D. Fix cantilever cable arms	90	8
E. Fix insulators	25	5

The handover rate specified is six pylons per week and this can be taken as the target rate of build.

Prepare a line of balance schedule assuming that each gang works at its natural rhythm. State clearly the contract duration. Assume a five-day week, eight hours per day, and a minimum buffer of two days.

The number of man-hours is

the number of men x the number of hours

ie. 5 menwoking for 11 hours is 55 man hours

Operation	Man-hrs/ pylon	Ideal gang size	Duration hrs	No of gangs to obtain output closest to every 6.667 hrs *	Time between start on first pylon and start on last
Excavate	55	4	13.75	2 when output = 1 every 6.875 hrs (= 0.859 days)	(124-1)x .859 = 105.7 days
Concrete foundations	64	4	16	2 when output = 1 every 8 hrs (= 1 day)	x 1 = 123
Erect tower	145	8	18.125	3 when output = 1 every 6.042 hrs (= 0.755 days)	x .755 = 92.9
Fix cantilever cable arms	90	8	11.25	2 when output = 1 every 5.625 hrs (= 0.703 days)	x .703 = 86.5
fix insulators	25	5	5	1 when output = 1 every 5 hrs (= 0.625)	x .625 = 76.9

* 6 pylons per week of 5 days of 8 hours = 1 pylon every 6.667 hours.

Excavation

Start at day 0 on first pylon and finish on day $\frac{13.75}{8} = 1.7$

Start at day 0+105.7 = 105.7 on pylon No 124 and finish on day $105.7 + \frac{13.75}{8} = 107.4$

(Note:- the accuracy of calculation is overdone in view of likely accuracy of input data - theoretically we have assumed that excavation gang 2 starts after 0.859 days - not a very sensible assumption but then the accuracy is being overdone. If gang 2 starts excavation at day 0 the answers will be only marginally affected.)

Concrete foundations

Start at day 1.7 + 2 (buffer) = 3.7 say day 4 and finish on day $4 + \frac{16}{8} = 6$ for pylon No 1

Start at day 4 + 123 = 127 on pylon No 124 and finish on day $127 + \frac{16}{8} = 129$

Erect towers

Start at day 129 + 2 (buffer) = 131 on pylon No 124 and finish on day $131 + \frac{18.125}{8} = 133.3$

Start at day 131 - 92.9 = 38.1 say 38 on pylon No 1 and finish on day $38 + \frac{18.125}{8} = 40.3$

Fix cantilever cable arms

Start at day 133.3 + 2 (buffer) = 135.3 say day 136 and finish on day 136 + $\frac{11.25}{8}$ = 137.4 for pylon No 124

Start at day 136 - 86.5 = 49.5 say day 49 on pylon No 1 and finish on day 49 + $\frac{11.25}{8}$ = 50.4

Fix insulators.

Start at day 137.4 + 2(buffer) = 139.4 say day 140 and finish on day 140 + 5/8 = 140.6 for pylon No 124

Start at day 140 - 76.9 = 63.1 say day 63 and finish on day 63 + 8 = 63.6 for pylon No 1

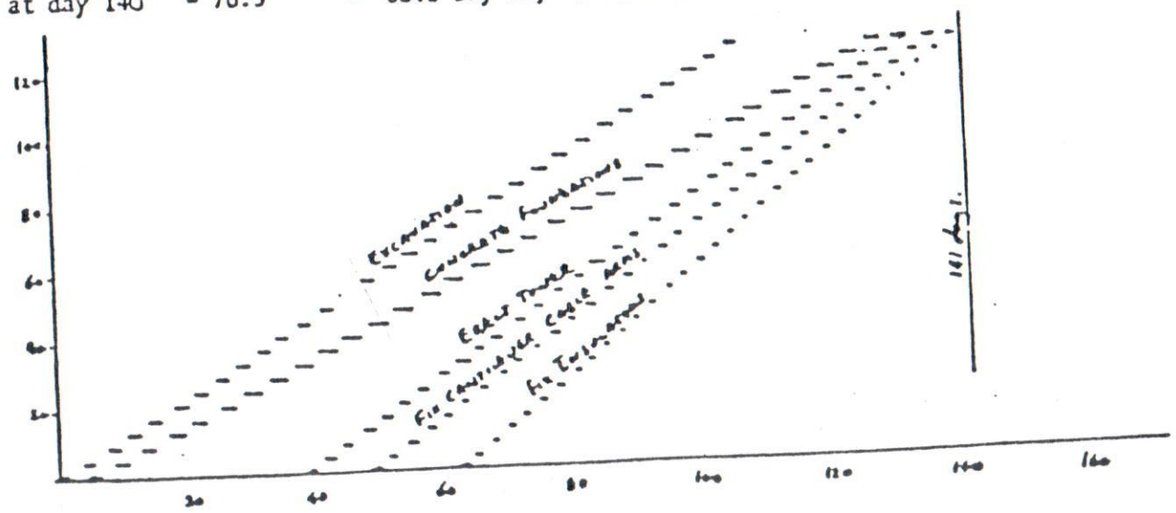
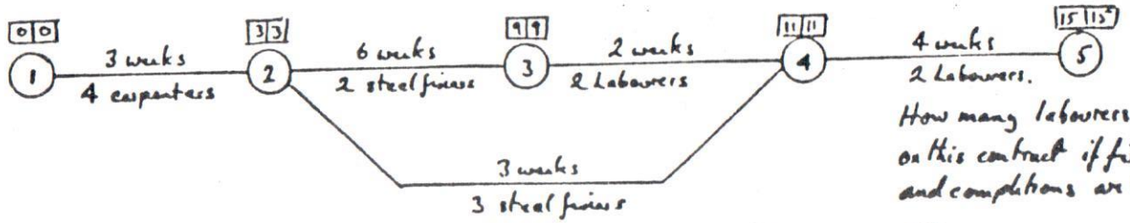


Fig-6



Example.

Construction of 15 piers

How many labourers, carpenters and steelfixers are required on this contract if first pier is to be complete after 15 weeks and completions are to be at the rate of 1/week thereafter?