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Research Article

Programming And Load Balancing For The Development Of The Multifamily Building - Lima, Peru 2020

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Abstract: The objective of this research is to show the production management in the construction of a multifamily building in Lima - Peru, it is worth mentioning that the main problem is that the companies do not adequately plan the optimal use of resources, the plan of attack of work, the sequence of activities through a correct design of production batch and sizing of crews, which are decisive during the execution of the work. The methodology used in this context is load and crew balancing. This allows us to manage resources and work scheduling, resulting in 100% efficiency. In conclusion, we can say that companies must maintain a correct control of their resources in order to achieve their schedules..

Keywords: y

1.Introduction

The construction sector has continuously been syndicated to imperfect performance. In general, the impression is that construction is a sector of low productivity and dubious quality given the lack of specialization of workers and professionals in the sector, many of the problems mentioned above are generated due to the lack of planning of the works, since the problems are solved as they appear. Although it is true that there are inconveniences that appear unexpectedly, many of the obstacles to the normal production of a task are predictable. Some professionals believe that the results of their design and construction management work had been completed within budget. However, these data are followed by those who completed their projects in the construction phase more than 3% over budget in the design phase, under 3%. In terms of time, this was not good in the construction phase, with most finishing less than 15 days behind schedule. [1].

Nowadays, construction companies not only offer lower cost works, but also quality, safety and time. Therefore, they seek to optimize their work times, generating efficiency and profit for the company. This uncontrolled number of projects has a main "defect" that comes to light and is incredibly costly: the waste or losses that are generated in the construction stage of these projects. [2]. These companies have been implementing the Lean Construction philosophy, achieving favorable results in terms of profit margins, productivity, labor efficiency and safety [3].

The traditional construction planning is based on making the work plan with scheduled dates, visualizing the duration of the items, as well as the total time of execution of the work. However, the optimal use of resources, the work attack plan, the sequence of activities through a correct design of production batch and sizing of crews, which are decisive during the execution of the work, are not adequately planned [4], which is why this article aims to show how production could be managed in the construction of a multifamily building in Lima - Peru. The essence of the system is to work to increase the reliability of the planning. The ultimate planner is the one who finally defines what will be done and who will do the work. The role of ultimate planner can be held by foremen, construction managers, supervisors, subcontractors, site managers and others. [5]

2.Method

Study area

The study was conducted in Peru, in the city of metropolitan Lima. (Figure 1).

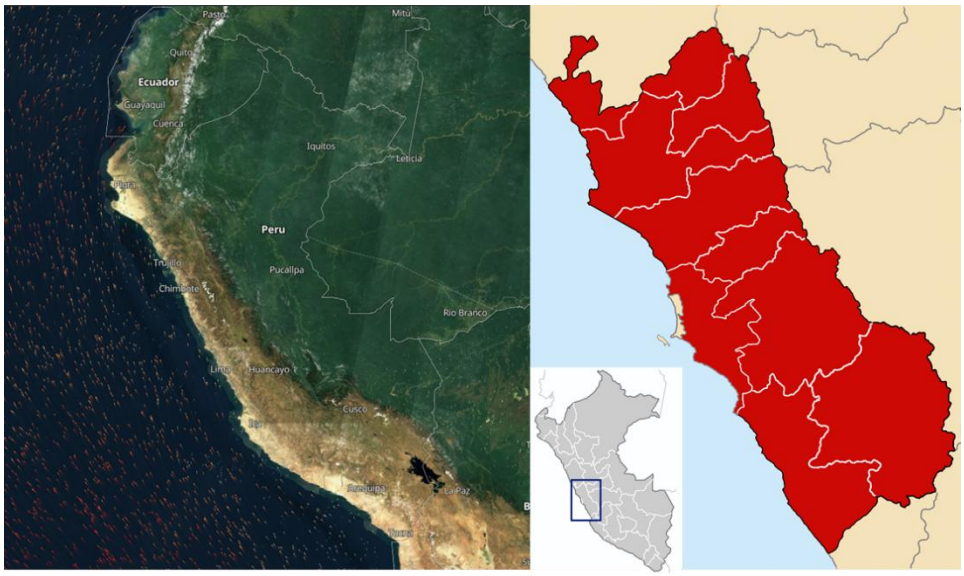

Figure 1. Localización de área de estudio.

Figure 1 shows the location of the study area, framed in the department of Lima

Type of research

The quantitative research will analyze the facts prior to and during the execution of the multifamily buildings, for this the experience must be taken into account and thus analyze correctly and concisely in our study. Likewise, the personnel resources to be used will be analyzed. From the information, the results will be obtained to make the corresponding decisions. [6

3.Procedure

Table N°1. Metrication per unit of element

METERING PER UNIT OF ELEMENT				
ELEMENT	NAME	STEEL (kg)	ENCOUNTERED (m2)	CONCRETE (m3)
Verticals	C1	1000.00	40.00	10.00
Verticals	C2	500.00	20.00	5.00
Verticals	C3	750.00	30.00	7.50
Horizontals	P1	1250.00	30.00	7.00
Horizontals	P2	1500.00	40.00	9.00
Horizontals	P3	1000.00	20.00	5.00

Table N°1 shows the corresponding metrics for the different elements used in the project.

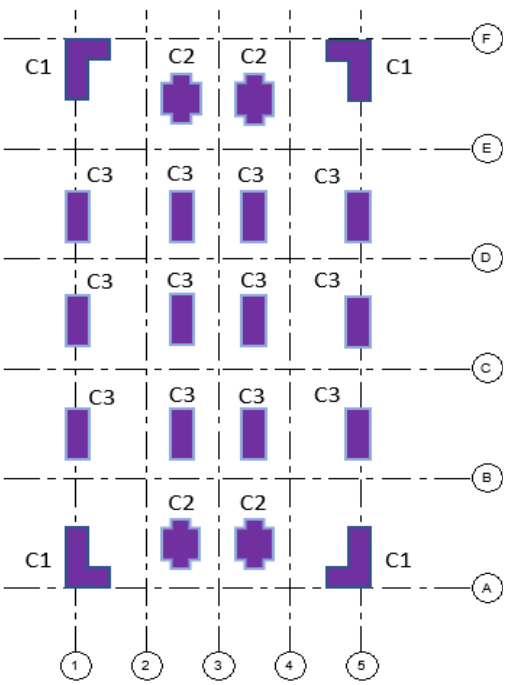

Figura 2. Verticals Plan

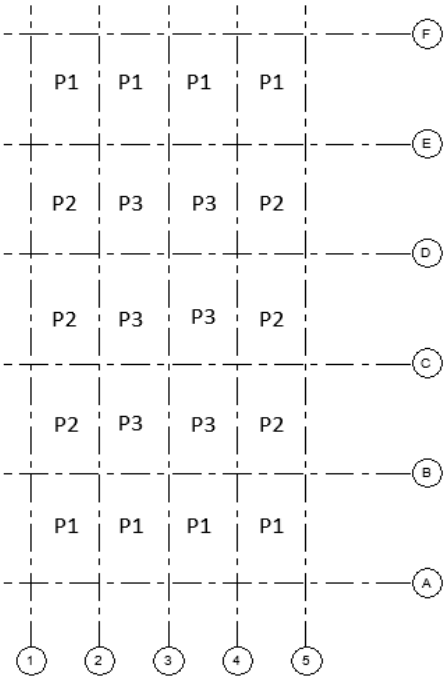

Figure 3. Horizontals Plan

For practical purposes, only the vertical and horizontal items will be taken as shown in Figure 2 and 3

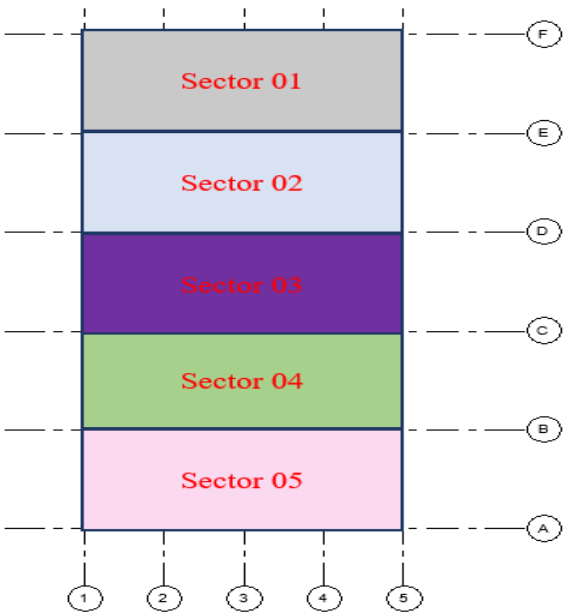

Figure 4. Vertical sectorization plan

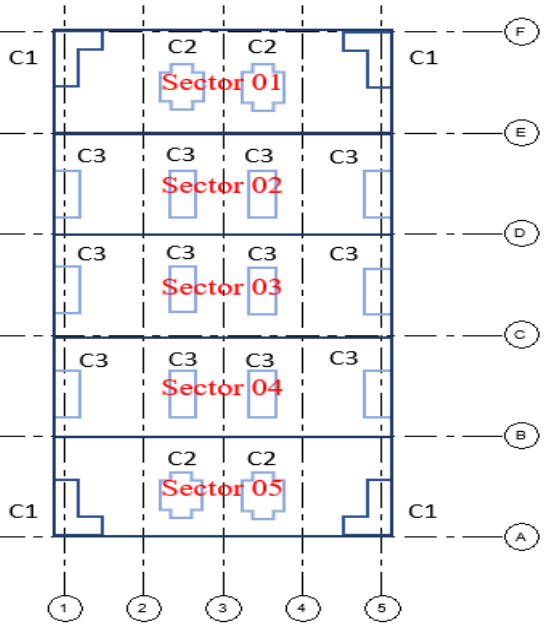

Figure 5. Horizontal sectorization pla

In Figure 4 and 5 shows the metrics, we proceed to sectorize the work area which consists of dividing a task or activity of the work in sectors, a small part of the total task should be included and in turn should include an approximately equal metric trying to balance the loads as shown. [7]

Sectoring in a correct way allows us to obtain greater efficiency, improve control and maximize production capacity.

Table N°2. Vertical metering

METRADO DE VERTICALES						
SECTOR	ELEMENT	NAME			TOTAL METER STEEL (Kg)	TOTAL FORMWORK LENGTH (m2)	TOTAL CONCRETE THICKNESS (m3)
		C	C	C			

		1	2	3			
Sector 01	Verticals	2.00	2.00	0.00	3000.00	120.00	30.00
Sector 02	Verticals	0.00	0.00	4.00	3000.00	120.00	30.00
Sector 03	Verticals	0.00	0.00	4.00	3000.00	120.00	30.00
Sector 04	Verticals	0.00	0.00	4.00	3000.00	120.00	30.00
Sector 05	Verticals	2.00	2.00	0.00	3000.00	120.00	30.00
TOTAL		4.00	4.00	12.00	15000.00	600.00	150.00

Table N°2 below shows the vertical element metrics according to the sectorization carried out.

Table N°3. Horizontal metering

METERING OF HORIZONTALS							
SECTOR	ELEMENT	NAME			TOTAL METER STEEL (Kg)	TOTAL FORMWORK LENGTH (m2)	TOTAL CONCRETE THICKNESS (m3)
		P1	P2	P3			
Sector 01	Horizontals	4.00	0.00	0.00	5000.00	120.00	28.00
Sector 02	Horizontals	0.00	2.00	2.00	5000.00	120.00	28.00
Sector 03	Horizontals	0.00	2.00	2.00	5000.00	120.00	28.00
Sector 04	Horizontals	0.00	2.00	2.00	5000.00	120.00	28.00
Sector 05	Horizontals	4.00	0.00	0.00	5000.00	120.00	28.00
TOTAL		8.00	6.00	6.00	25000.00	600.00	140.00

Table N° 3 shows the horizontal elements metrics according to the sectorization carried out.

Table N°4. Load balancing per sector unit

Carga Scale	8	hrs				
Activity	quantity	Unt	Rend	Unt	HH	crew
Vertical Steel	3000	kg	0.030	hh/kg	90	11.25
Vertical Formwork	120	m2	0.850	hh/m2	102	12.75
Vertical Concrete	30	m3	1.000	hh/m3	30	3.75
Horizontal Formwork	120	m2	1.200	hh/m2	144	18
Horizontal Steel	5000	kg	0.050	hh/kg	250	31.25
Horizontal Concrete	28	m3	1.000	hh/m3	28	3.5
Totals					644	80.5

Table N°04 shows the yield that would be obtained for each sector, we will take one and with the support of the Unit Price Analyses (APUS) we will determine the yield that would be obtained for each sector. [8]

Tabla N°5. General load balancing

Balance de Carga	8	hrs				
Activity	quantity	Unt	Rend	Unt	HH	crew
Vertical Steel	1500.00	kg	0.030	hh/kg	450	56.25
Vertical Formwork	600.00	m2	0.850	hh/m2	510	63.75
Vertical Concrete	150.00	m3	1.000	hh/m3	150	18.75
Horizontal Formwork	600.00	m2	1.200	hh/m2	720	90
Horizontal Steel	2500.00	kg	0.050	hh/kg	1250	156.25
Horizontal Concrete	140.00	m3	1.000	hh/m3	140	17.5
Totals					3220	402.5

Table 5 shows the load balancing for a sector and for the entire project. The load balancing should be according to the specific activity to be performed

Tabla N°6. LookAhead

	ACTIVITY SEQUENCE					
Activity	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**
Vertical Steel	X					
Vertical Formwork		X				
Vertical Concrete			X			
Horizontal Formwork				X		
Horizontal Steel					X	
Horizontal Concrete						X

Once this has been done, the lookAhead is prepared, as shown in Table N°6. The activities, necessary resources, definition of processes and detection of the restrictions of each activity that cannot yet be executed must be visualized. [9] All those involved in the work must participate in the planning, the objective is to determine the plan for future weeks in order to alert with the request for resources. By making the train of activities, the person in charge of the work will be able to know how much progress will be made each day. [10]

know how much progress will be made each day, forecast exactly how much progress will be made on a given day, know how much will be spent per day on the work, have greater control of expenses on the work and advance the work with a minimum of rework. [11]

The delay of one item causes the delay of all items, delaying the system as a whole. [12]

Table

Table N°7. Project LookAhead

PRODUCTION LOOKAHEAD														
ACTIVITY DESCRIPTION	QUADRILLA	**Week 1**						**Week 2**						
		L 01	**M** 02	**M** 03	**J** 04	**V** 05	**S** 06	**L** 08	**M** 09	**M** 10	**J** 11	**V** 12		
METERED VERTI														

CAL													
Steel	STEEL	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00							
Formwork	CONCRETE.		120.00	120.00	120.00	120.00	120.00						
Concrete	CONCRETE			30.00	30.00	30.00	30.00	30.00					
HORIZONT.													
Steel	STEEL						5,000.00	5,000.00	5,000.00	5,000.00	5,000.00		
Formwork	CONCRETE.							120.00	120.00	120.00	120.00	120.00	
Concrete	CONCRETE								28.00	28.00	28.00	28.00	28.00

In Table N°7, once the work sequence has been drawn up, we proceed to elaborate the sequence for activities balancing the loads of the project in question.

Table N°8. Staffing Schedule

		Week 1						Week 2					
	ITEM	**L**	**M**	**M**	**J**	**V**	**S**	**L**	**M**	**M**	**J**	**V**	**S**
EFFICIENCY		**01**	**02**	**03**	**04**	**05**	**06**	**08**	**09**	**10**	**11**	**12**	**13**
METRADO	STEEL	3,000	3,000	3,000	3,000	3,000	5,000	5,000	5,000	5,000	5,000	0	0
	FOUNDATION	0	120	120	120	120	120	120	120	120	120	120	0
	CONCRETE	0	0	30.0	30.0	30.0	30.0	30.0	28.0	28.0	28.0	28.0	28.0
EFFECTIVE PERSONNEL	STEEL	1	1	1	1	1	3	3	3	3	3	0	0
		1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	.00	.00
	FOUNDATION	0	1	1	1	1	1	1	1	1	1	1	0
		.00	2.75	2.75	2.75	2.75	2.75	8.00	8.00	8.00	8.00	8.00	.00
	CONCRETE	0	0	3	3	3	3	3	3	3	3	3	3
		.00	.00	.75	.75	.75	.75	.75	.50	.50	.50	.50	.50
	TOTAL	1	2	2	2	2	4	5	5	5	5	2	3
		1.25	4.00	7.75	7.75	7.75	7.75	3.00	2.75	2.75	2.75	1.50	.50
STAFF	STEEL	1	1	1	1	1	3	3	3	3	3	0	0
		1	1	1	1	1	1	1	1	1	1		
	FOUNDATION	0	1	1	1	1	1	1	1	1	1	1	0
			3	3	3	3	3	8	8	8	8	8	
	CONCRETE	0	0	4	4	4	4	4	4	4	4	4	4
	TOTAL	1	2	2	2	2	4	5	5	5	5	2	4
		1.00	4.00	8.00	8.00	8.00	8.00	3.00	3.00	3.00	3.00	2.00	.00

In table N°8, with the elaboration of the look ahead, according to the amount of meter to be performed, we proceed with the personnel schedule to maintain a correct rhythm of work without having to dismiss and then hire by days. [13]

Table N°9. Restriction analysis

Restriction analysis						WEEK 1							WEEK 2						
ITEM	WHERE IT COMES FROM	DESCRIPTION OF THE ACTIVITY	DESCRIPTION OF THE RESTRICTION	DATE	RESPONSABLE	01	02	03	04	05	06	07	08	09	10	11	12	13	14
1.01		VERTICAL																	
1.01.01	OC	Steel	Arrival of 25,000.00 kg of steel at the site	01	GP.	x													
1.01.02	Contract		Arrival of 11 Steel Operators	01	ADM.	x													
1.01.03	Contract		Safety talk to the 11 operators	01	PDR	x													
1.01.04	O/S	Formwork	Arrival of 120m2 of formwork	02	JOT.		x												
1.01.05	Contract		Arrival of 13 carpentry operators	02	ADM.		x												
1.01.06	Contract		Safety talk to the 13 operators	02	PDR		x												
1.01.08	Contract	Concrete	Arrival of 4 concrete workers	03	ADM.			x											
1.01.09	Contract		Safety talk to the 4 concrete workers	03	PDR			x											
1.01.10	O/C	Concrete	Arrival of the 30m3 of ready-mixed concrete	04	JOT.				x	x	x								
1.01.13	O/C	Concrete	Arrival of 30m3 of ready-mixed concrete	08	JOT.								x						
1.02		HORIZONTAL																	
1.02.01	O/C	Steel	Arrival of 15,000 kg of steel at site	08	JA.								x						

1.02.02	Contract		Arrival of 20 Steel Operators	08	ADM.								x									
1.02.03	Contract		Safety talk to the 20 operators	08	PDR																	
1.02.04	O/S	Formwork	Arrival of the 120m2 of formwork	08	JA.								x									
1.02.05	Contract		Arrival of 5 carpentry operators	08	ADM.								x									
1.02.06	Contract		Safety talk to the 5 operators	08	PDR								x									
1.01.10	O/C	Concrete	Arrival of the 28m3 of ready-mixed concrete	09	JOT.									x	x	x	x	x				
1.03		OFFICE																				
1.03.01	Contract	Administrative	Processing of the building permit	01	GP.	x																
1.03.02	Contract	Administrative	Processing of the work completion certificate	13	GP.														x			

In Table N° 9, once this is concluded, we proceed with the analysis of restrictions to avoid setbacks during the execution of the work.

4.Results

Table N°10. performance by sector

Activity	**Quadrilla**	**HH**
Vertical Steel	56.00	448.00
Vertical Formwork	64.00	512.00
Vertical Concrete	19.00	152.00
Horizontal Formwork	90.00	720.00
Horizontal Steel	156.00	1248.00
Horizontal Concrete	18.00	144.00
Totals	403.00	3224.00
Efficiency		***100 %***

Table N°11. overall performance

Activity	Quadrilla	HH
Vertical Steel	11.00	88.00
Vertical Formwork	13.00	104.00
Vertical Concrete	3.00	24.00
Horizontal Formwork	18.00	144.00
Horizontal Steel	31.00	248.00
Horizontal Concrete	4.00	32.00
Totals	80.00	640.00
Efficiency		***99 %***

Table N°10 and N°11 show that an efficiency of 100% will be obtained by using the calculated crew in accordance with the yields. [14]

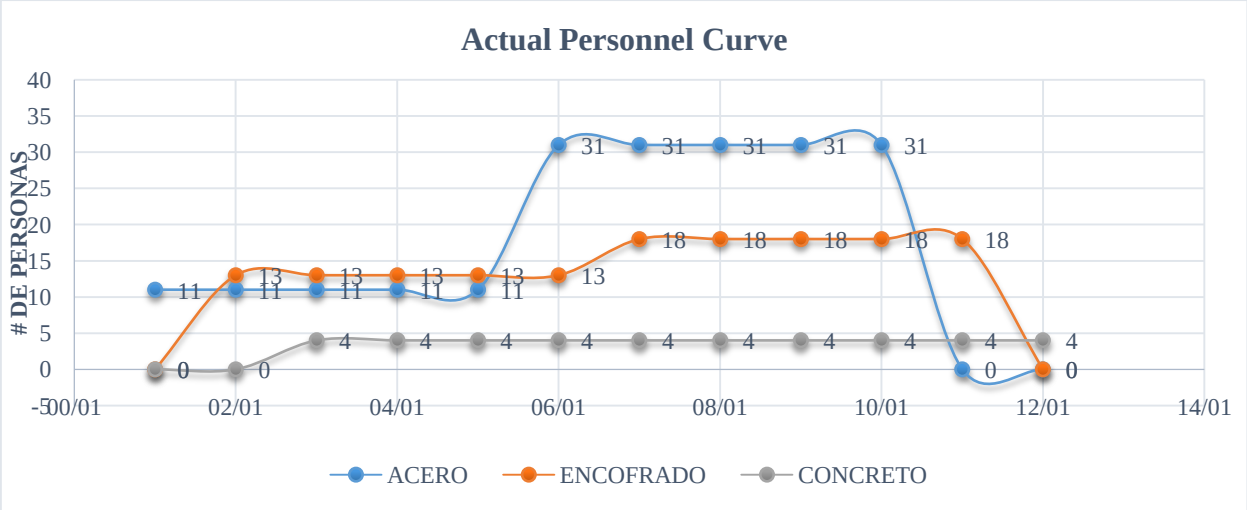

Figure 6. performance by sector

Figure 6, after performing the lookAhead, shows the actual personnel curve according to the distribution in time and deadlines in order to meet the needs: manpower, equipment, consumables, critical materials, subcontracting and others. [15]

Tabla N°12. performance by sector

CONSTRAINT ANALYSIS		
	WEEK 1	WEEK 2
TOTAL NO. OF RESTRICTIONS	12	13
% OF RESTRICTIONS PER WEEK	48%	52%

After analyzing the restrictions, we can see that during the execution of the work, during the first week there will be a total of 48% of the restrictions and for the second week there will be 52%.

5.Conclusions

In order to maintain a correct personnel curve, it is necessary to try to balance the curves so as not to have paralyzed personnel during the execution of the work.It is possible to try to reduce the sectorization in order to minimize the work areas, but it would increase the workloads causing the increase of crews.

The sectorization helps to optimize the production of workers through repetitive work, also helps to have greater control over the items allowing to reduce the time of the process.Perform the Loos Ahead in order to create a "shield" 3 to 5 weeks in advance.

This allows us to foresee what is needed so that future activities can be carried out.For the constraint analysis it should be done formally (meeting and minutes of agreements), concrete action should be taken on the identified constraints, in addition to always assign responsible for each constraint, set deadlines and follow u

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