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Implementation of work study in construction project

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Abstract
Work study has always been an important tool in improving the plant layout in manufacturing industries by capturing the flow of materials and workers. Work study techniques are not very widely used in construction sites due to complex and dynamic nature of construction projects. The present study is based on implementation of work study in a congested residential construction project. The study incorporated various method study charts to capture the flow of men and materials at the construction site. Relationship diagram was drawn using the method study charts to show the closeness among the facilities. Site layouts were drawn for possible relocation of facilities. Recommendations were suggested to effectively use the construction space.

Keywords: work study, method study, site layout, relationship diagram

1. Introduction
Construction site is complex and dynamic in nature. Every construction project has different space, facilities and nature of work. The facilities required at the project also change with the time. For construction site, it is utmost important to utilize the space effectively. Effective utilization of space reduces the material handling and movement of workers. This results in increase of productivity at the site.

Previous studies were dedicated to understand the factors responsible for reduction in construction site productivity. Kaming *et al*. (1998) [2] observed that factor responsible for loss of productivity at the construction site is space constraint due to poor site management. In other study, Sanders *et al*. (1989) [4] showed that due to congested workplace and restricted access the efficiency at the site decreases by 58% and 65% respectively.

The dynamic nature of the construction project requires effective site management. Activities required at the site change with time and so do the facilities involved with them. The site layout models must be able to show the dynamism of the site. Many researchers had tried to optimize the construction site space using various models. Li and Love (1998) [3] optimized their objective function for temporary facilities using genetic algorithm method. Andayesh and Sadeghpour (2014) [1] showed that construction site space can be reused using dynamic models.

To show the dynamic nature of site in the layouts, it is important to understand the flow of men, machine and materials at the site. Work study has always been seen as an important tool to record the flow of information. Work Study concepts and techniques have been used for improvement in plant layout in manufacturing industries. The recording techniques used in the charts help in finding the flow of men, material and equipment. Systematic layout planning uses the concept of flow of materials, men and equipment for locating the space for facilities. Wiyaratn and Watanapa (2010) [7] incorporated systematic layout planning (SLP) for improving the productivity of iron manufacturing plant. They used operation process chart and travel chart to analyze the flow of materials and equipment. These recording charts helped in finding bottleneck and suggesting improved plant layout. Shewale *et al*. (2012) [6] conducted a research on study of compressor plant based on systematic layout planning (SLP) for increased productivity. The proposed layout reduced the material handling distance. Shah and Joshi (2013) [5] had shown the use of operation process chart for identifying the flow of materials.

Work study has been frequently used in manufacturing plants for recording the flow of information. The implementation of work study and its recording techniques have not been done frequently. The paper is focused on implementation of method study techniques to understand the flow of materials and workers in a congested construction space. The flow of materials and workers is used to understand the dynamism of the construction space.

2. Methodology
The construction project was divided into various phases on the basis of the facilities required at the site for entire duration of the projects. The facilities were classified into fixed and moveable facilities. Initial site layout was drawn to scale using AutoCAD. The method study techniques were implemented at the construction project to understand the flow of men and materials. Travel chart and frequency charts were used to record the distances and frequency of travel among the facilities. Based on the flow of information, a relationship chart was drawn to show the closeness among the facilities. All the information collected were used to provide the recommendations to the construction site to effectively use the construction space.

3. Case Study and Findings
A case study of congested residential construction project was taken. The project was of 26 months duration. The scope of work for contractor was to build the towers including all finishing activities.

3.1 Facilities identification and classification
The whole construction process was divided into 3 phases by the construction planners. Three towers were identified

to be constructed. The construction stages were divided in following phases:

- Phase 1 – Construction of tower A (up to ground level)
- Phase 2 – Construction of towers B & C (up to ground level)
- Phase 3 – Construction of area above ground level.

The facilities were identified and classified into various categories. Due to congested space, most of the facilities in this construction site are related to the movements of workers and staffs. Fewer material handling facilities were installed at the site. Facilities like batching plants were shifted off-site due to lack of space at site. Table 1 depicts the facilities installed at the site and their classification.

Table 1: Facilities identification and classification

S. No.	Facility	Phase 1	Phase 2	Phase 3
1	Tower A	Fixed	Fixed	Fixed
2	Tower B	Fixed	Fixed	Fixed
3	Tower C	Fixed	Fixed	Fixed
4	Material stockyard 1	Moveable	Moveable	Moveable
5	Material stockyard 2	Moveable	Moveable	Moveable
6	Office	Moveable	Moveable	Moveable
7	Store	Moveable	Moveable	Moveable
8	Time Office	Moveable	Moveable	Moveable
9	EHS	Moveable	Moveable	Moveable
10	First Aid	Moveable	Moveable	Moveable
11	Worker Rest Room	Moveable	Moveable	Moveable
12	Worker Canteen	Moveable	Moveable	Moveable
13	Worker Induction Room	Moveable	Moveable	Moveable

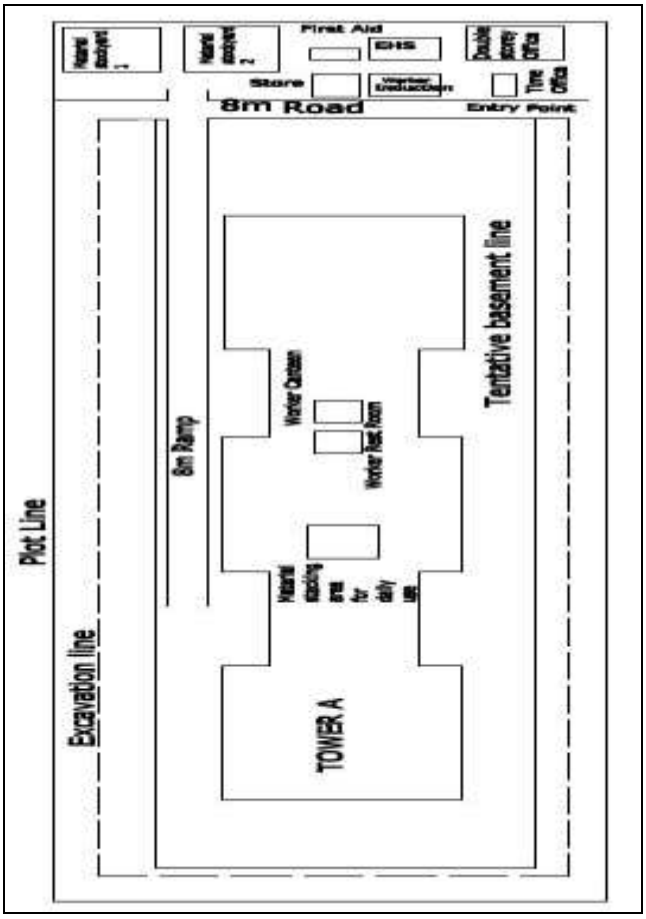

Fig 1: Site layout of the construction project during phase 1

Figure 1 shows the site layout of construction project during phase 1. Since facilities associated with movement of materials like batching plant and reinforcement yard were shifted off-site, the facilities left at the site were mostly associated with movement of workers and staffs such as worker canteen, worker rest room, EHS, office etc.

3.2 Implementation of work study

The method study along with its various charts were implemented at the construction site. The idea was to capture the flow of materials and workers at the site to show the dynamism of the construction project. The schedule of the activities suggested that almost all the facilities

represented in the site layout would be present during entire duration of project. The flow charts of concrete process and worker movement were drawn. Table 2 and table 3 depict the flow charts of concrete and workers respectively.

Table 2: Material flow chart of concrete

	Chart: Material Flow Diagram						
	Material: Concrete						
Step No.	**Activities**	**Operation**	**Transportation**	**Inspection**	**Delay**	**Storage**	**Distance Covered (m)**
1	Arrival of ready-mix concrete at the entry point of site.		x				
2	Collection of batch sheet from the driver				x		
3	Permission to enter the construction site				x		
4	Transportation of concrete from entry point to site through ramp		x				260
5	Discharge of concrete	x					
	Total						260

Table 3: Worker flow diagram

	Chart: Worker Flow Diagram						
	Worker/Staff: Worker						
Step No.	**Activities**	**Operation**	**Transportation**	**Inspection**	**Delay**	**Storage**	**Distance Covered (m)**
1	Arrival of worker at entry point		x				
2	Arrival of worker at worker induction room		x				21
3	Safety induction by safety officer			x			
4	Movement of worker from induction room to work site		x				260
5	Job description by the site engineer to worker				x		
6	Job performed by worker	x					
7	Return of worker to worker rest room		x				6
8	Movement of worker from worker rest room to worker canteen		x				15
	Total						302

The travel chart shown in table 4 is found to be symmetric as same routes for both directions were followed during the time of investigation. The travel chart also suggests that most of the facilities are closely spaced and located close to each other. Travel chart also suggests that the site is very congested as it was also observed during the time of investigation.

Table Error! No text of specified style in document.**:** Travel chart (Distances are in metres)

From/To	**Material Stockyard**	**Office**	**Store**	**Time Office**	**EHS**	**First Aid**	**Worker Rest Room**	**Worker Canteen**	**Worker Induction**
Material stockyard	0	58	37	76	35	20	178	163	51
Office		0	52	18	23	38	236	221	37
Store			0	37	30	14	215	200	14
Time Office				0	41	56	254	239	21
EHS					0	15	213	198	16
First Aid						0	198	183	31
Worker Rest Room							0	15	127
Worker Canteen								0	112
Worker Induction									0

Table 5 shows the frequency chart for the site. The materials were stacked at the work site for daily use and no such facilities were made to stack the rugged materials. In frequency chart shown in table 5, stacking area is treated as a facility to record movements. Relationship diagram is drawn using the help of travel chart and frequency chart.

Table 5: Frequency chart

From/To	**Material Stockyard**	**Office**	**Store**	**Time Office**	**EHS**	**First Aid**	**Worker Rest Room**	**Worker Canteen**	**Worker Induction**	**Material stacking (at site)**
Material stockyard										2
Office										4
Store									1	
Time Office		10	2		2	2				
EHS						2				2
First Aid										
Worker Rest Room								15		
Worker Canteen										15
Worker Induction										15
Material stacking (At site)										

Wiyaratn and Watanapa (2010) [7] gave ratings and their values for relationship chart shown in table 6. The same ratings and their values have been used in the relationship chart. Table 7 shows the relationship diagram which is drawn using the travel chart and frequency chart. The relationship diagram showed the closeness among the facilities at the construction site. The site layout of phase 2 was drawn using the AutoCAD software.

Table 6: Relationship chart with ratings and values (Wiyaratn and Watanapa 2010) [7]

Values/Ratings	Closeness
A	Absolutely essential
E	Especially important
I	Important
O	Ordinary closeness
U	Unimportant
X	Not desirable

Table 7: Relationship chart

	Material Stockyard	Office	Store	Time Office	EHS	First Aid	Worker Rest Room	Worker Canteen	Worker Induction	Material stacking area (at site)
Material stockyard		U	U	U	U	U	O	O	U	I
Office			I	O	O	O	U	U	U	U
Store				O	U	U	U	U	I	U
Time Office					O	O	U	U	O	U
EHS						E	U	U	E	U
First Aid							U	U	O	U
Worker Rest Room								A	O	A
Worker Canteen									O	A
Worker Induction										U
Material Stacking Area (at site)										

4. Analysis

Various charts of the method study were used to understand the flow of materials and workers at the construction site. The travel chart of the case study suggested that most of the facilities were closely spaced and located close to each other. Also, the facilities identified at the construction site were mostly related to staff/workers movements. Phase 2 of the project involved the construction of tower B and C. During that period there would be shortage of space for facilities. As the project enters the phase 3, many new activities would start resulting in addition of new facilities. Figure 2 shows the layout of site during phase 2.

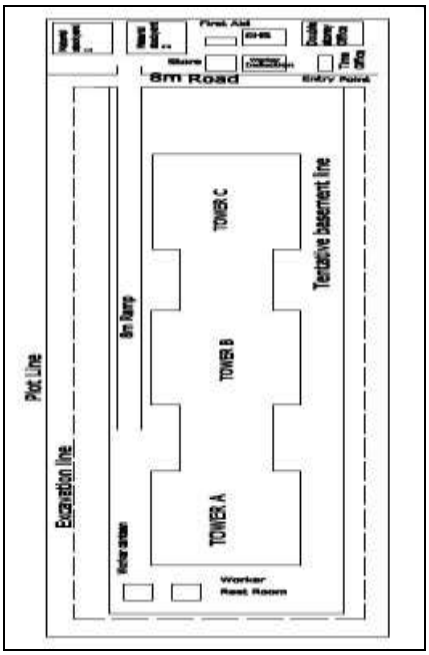

Fig 2: Site layout for phase 2

The travel chart showed that the site was very congested. Further, the facilities like batching plant, reinforcement yard, quality lab etc. were kept off-site. Therefore, most of the facilities related to material handling were not at the site except the material stockyard. The frequency chart showed that most of the movements were around the staff or workers facilities.

The site layout of phase 2 shown in figure 2 showed that once the tower B and C would start, the space gets reduced. As it was evident from the travel chart that site was very congested, it would create serious problems for contractor to allocate space to incoming facilities. So keeping in view of future scenario, few options can be implemented to reduce congestion at site. During the phase 2 and phase 3 construction stages, facilities like worker canteen and worker rest room would be relocated. Since these facilities are of very small areas, they can be adjusted anywhere. But since many other activities would start, even these small facilities can make the site more congested.

Site layout of phase 2 suggested the relocation of worker canteen and worker rest room. The relocation was suggested in the basement during the phase 3. The reason behind this was to decongest the site. Since these facilities are mostly mobile and can be relocated easily, they can be given space in semi constructed buildings. In congested site the fixed facilities can be utilized by giving space to worker canteen or office.

5. Conclusion

Work study techniques were implemented at the construction project. Material and worker flow charts were used to understand the flow of materials and movement of workers. These charts break down the activities into simpler activities which helped in understanding the critical activities. The travel chart and frequency chart showed the important facilities at the sites. Based on travel and frequency chart, relationship chart was drawn. Travel chart and frequency chart showed that mostly facilities related to workers movement were present at the site. On the basis of the flow of material and movement of worker, site layout for the phase 2 was drawn where relocation of worker canteen and worker rest room were suggested. The present study incorporated the use of method study techniques in a congested construction project. The methodology can be

implemented in complex construction project to show the dynamic nature of the construction project.

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