ANALYSIS OF OPERATION EFFICIENCY OF TOWER CRANE IN FORM WORK CONSTRUCTION FOR MULTI-FAMILY HOUSING

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ABSTRACT: High-rise apartment projects in Korea have been built up to twenty stories with three to fifteen hundred multi-family units. When these projects are under construction, operation of lifting equipment such as tower cranes substantially influences project costs and scheduling. In other words, the operation of an appropriate crane based on its lifting load is highly related to the execution of construction projects. Although many researchers have attempted to examine the optimal site selection for a tower crane, thus far, operation efficiency analysis of tower cranes has been fairly limited. The objective of this study is to analyze operation efficiency of tower cranes used for multi-family housing construction in Korea. The data were collected by measuring operation time and lifting load. The findings of this study will help project managers to make better informed decisions when they are planning to use tower cranes for multi-family housing. Additionally, the results will provide essential information to assess lifting capacity for additional loads by applying new construction methods.

***Keywords**: Tower Cranes, Operation Efficiency, Multi-family Housing*

1. IMPLEMENTATION OF TOWER CRANES IN MULTI-FAMILY HOUSING

Multi-family housing projects in Korea are usually built as a single project of 300-1500 units with over 20 stories. In this circumstance, efficiency of operating tower cranes is significantly important to cut project costs and scheduling. However, frequently lifting plans are not properly managed because tower crane lifting plans are mostly implemented based on the daily work lists kept by tower crane operators (Lee et al. 2002). In addition, despite the fact that high monthly lease costs for tower cranes significantly impact project costs and scheduling, studies of tower crane operations in Korean multi-family housing projects have rarely been conducted. In this respect, to provide reference for basic analysis to improve the efficiency of tower cranes in multi-family housing projects, this study has measured operation time and lifting load of tower cranes for three days in the concrete structural frame work which accounts for the largest portion of project costs and scheduling.

2. WORK EFFICIENCY FOR TOWER CRANES

Most research on the lifting plan of tower crane has been based on selection of optimal equipment and location and tower crane installation plans (Al-Hussein et al. 2005; Gray and Little 1985; Tam et al. 2001). In order to estimate the efficient operation time for the existing lifting work of tower cranes, Lee J. R. determined the factors that were not considered in estimating the time for existing lifting operations. Based on these results, a multiple regression analysis for the lifting time required for tower crane operation was used to predict lifting time. (Lee J. R. et al. 2004). In addition, Lee J. H., using GPS technology, conducted an analysis on tower crane operation conditions required for construction and the time spent for lifting work (Lee J. H. et al. 2002). However, studies on ways tower cranes can be efficiently utilized in construction have not been conducted. In this respect, the data collected from the site of this study can be used as basic data for the analysis of tower crane efficiency in multi-family housing projects.

3. CASE STUDY FOR EFFICIENCY OF TOWER CRANES

This study was conducted through measuring and analyzing the video clips of tower crane operations taken from a local multi-family housing project site (D company, site; Gwang Gyo, Suwon, Kyunggi-do, RC structure system) for three days (Dec. 8, 9, 12-2010)(See Table 1). The tower crane chosen for analysis is a rope buying lateral-support type which operated the lifting work for two buildings (4 lines in a story, each line with two units, one unit sized 100~110m^2). In this study, the data were collected from one unit of tower crane which seized the gang forms for two buildings. According to the daily work lists as shown in Table 1, the operations carried out over three days included gang form load, masonry construction and drain piping, but did not include casting of concrete or seizing of steel bar. Thus, the lifting time measured in this study is the time spent for loading a gang form.

Table 1. Daily work lists

Unit	12/ 8/2010	12/9/2010	12/12/2010
501	9F: Load gang form	1F,2F: Masonry	9 F: Finish gang form 1F,2F: masonry
502	7F: Load gang form Drain piping	7F: Finish gang form Drain piping	Drain piping

In order to measure the time, this study took pictures of the tower crane from the top floor of a neighboring building and analyzed the data. The collected data are shown in Table 2. As shown in Table 2, all operation times and details of the work were taken on a minute basis for three days.

Table 2. Data collected for efficiency analysis

Dec. 8. 2010		Work		
Start (h:m:s)	Finish (h:m:s)	Lifting time (m:s)	Activity	Up/ Down
8:51:46	8:53:13	01:27	Prepare	
8:53:13	8:55:00	01:47	Load	Down
8:55:00	8:57:20	02:20	Prepare	Up
8:57:20	8:59:21	02:01	Load	Down
8:59:21	9:02:49	03:28	Prepare	
9:02:49	9:04:11	01:22	Load	Down
9:04:11	9:08:30	04:19	Prepare	Up
9:08:30	9:25:02	16:32	Load	Waiting
9:25:02	9:28:13	03:11	Rearrange	

4. DATA ANALYSIS

According to the collected data, gang form lifting work was carried out in two buildings over three days and the total work time was 10 hours and 43 minutes as shown in Table 3. In addition, tower crane efficiency rate during the measuring period was 58.41% on the first day (8th), 57.57% on the second day (9th) and 24.90% on the last day (12th) when partial gang form work was done in the afternoon. Therefore, on average, efficiency over three days was 46.96%.

Table 3. Work efficiency

Date	Operating time	Work time	Efficiency (%)
12/8/2010	6:29	3:47	58.41
12/9/2010	7:55	4:33	57.57
12/12/2010	9:32	2:23	24.90

In addition, time spent over the three days to install the gang forms for the two buildings was 6 hours and 34 minutes as shown in Fig.1. Time spent to transport various materials such as molds for installation was 4 hours and 8 minutes. Meanwhile, idle time caused by an unavailable operator and waiting time was 13 hours and 17 minutes. In this case study, the gap between idle time of the tower crane and working time is around 10%.

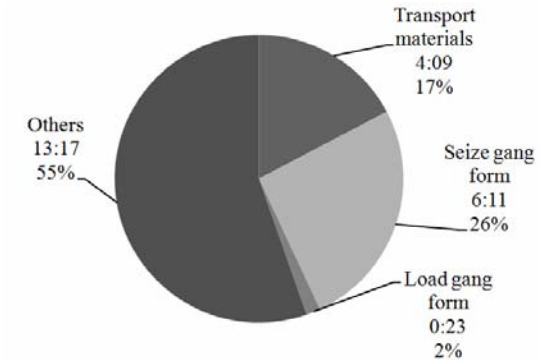

Fig. 1 The time required for each task

5. CONCLUSION

Korean multi-family housing projects are usually built as a single project of 300-1500 units with 20 stories. In such large-scale housing projects, tower cranes are used for about 12~14 months with significant costs for monthly equipment rentals. Due to these characteristics, the operation of tower cranes substantially affects project costs

and scheduling. However, operation efficiency analysis of tower cranes has been fairly limited thus far since there has been little research on these operations in Korean multi-family housing projects. In this respect, this study analyzed the operation efficiency of tower cranes by measuring the lifting time during gang form work. As a result of data analysis, daily tower crane operation efficiency was calculated at 47% on average during gang form work. In addition, tower crane operation time was analyzed on a minute basis during the measuring period. As a result, 55% of total operating time was found to be idle time. In this regard, the lifting capacity for the structural frame work plan and additional load can be improved by up to 40% from the current lifting plan. The result of this study can be utilized as a basic reference to suggest a plan to improve efficiency of tower crane operation for new structural frame work or development of new form work methods. As a further study, the problems caused by wasted operation time will be analyzed and plans will be suggested to improve tower crane operation efficiency in multi-family housing projects.

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