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Reinforced-Concrete Works Productivity Analysis on Nuclear-Power-Plant Project

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Abstract: Both the importance and process of estimating Nuclear-power plant construction time and cost have increased in significance as energy user costs themselves have become more significant. In estimating construction time, few parameters are more significant than work item production rates and factors significantly affecting the rates. A standardized data collection tool was used to acquire a total of 401 data points from a S Nuclear-power plant project, for selected critical works: form-work, rebar-work, and concrete-pouring. With the data, several hypothesized drivers of the man-hour production rates and crew-day production rates were also analyzed. Findings from this study will enable industry professionals to enhance accuracy of time and cost estimation for nuclear power plant construction.

Keywords: Productivity, Productivity Factor, Nuclear Power Plant, Reinforced Concrete work.

I. INTRODUCTION

Constructing a new nuclear power plant always takes many years and costs an astronomical sums of money, that makes schedule and cost management inevitable. Despite its distinguishable characteristic, however, management of labor productivity has little attention as material and equipment cost is relatively much higher than labor for the plant project. This study has collected and analyzed field-production rate data of reinforced concrete works, namely form-work, rebar-work, and concrete-pouring, from a nuclear power plant project in Korea and found factors driving the production rates.

II. RESEARCH METHOD

A. Data Collection

A data collection tool was developed and used based on industry input to facilitate the data collection process, enhance the accuracy of data, and enable analyses of drivers. The construction of the S nuclear power plant project studied for the research began in September 2007 and expected to be finished 2015. Site visits were conducted on a weekly basis to collect data on production rates. Site personnel, mostly foremen responsible for each work item, explained daily variations in production during the site visits.

B. Production Rate Definition and Candidate Drivers

1) Production Rate Definition: Production rates of selected activities were calculated based on the formula of 'total output/total work hours' for Man-hour production rate and 'total output/total crew workdays' for Crew-production rate'.
The output value represents the quantity of work completed during a certain number of workdays and was measured in '㎡,' 'ton,' and '㎥' for the activities of form-work, rebar-work, and concrete-pouring, respectively.

A 'work hours' simply means the sum of total work hours performed by all the manpower, and 'crew workday' was assessed based on a rule called the half-day rule. If, in a given day, the delay effect caused by any of factors amounted to less than 2 hours, the day was considered one workday. When the delay was less than or equal to 5 hours but greater than 2, the day was counted as a half-workday.

Based on many observations and experts interviews during the research, each form-work crew, rebar-work crew, and concrete-pouring crew is defined as 11, 11, and 8 people respectively and 'One workday' of a work crew refers to 1 workday in general, but if there is a night work, then it should be considered as 1.2 workdays.

2) Candidate Drivers: From a literature review and consultation meetings with specialists in the project, possible factors driving the productivity were carefully selected(Table 1).

Ⅲ. ANALYSIS RESULT OF PRODUCTION RATE

A. Production Rate

Several outliers were deleted and the production Rate of both Man-hour and Crew-day were calculated. The average Man-hour production rate of Form-work is 0.54, and 0.06 for Rebar-work and 1.98 for Concrete-pouring. The number of data included in the calculation for the activities, namely Form-work, Rebar-work, and Concrete-pouring, respectively 169, 179, 53.
In the case of the Crew-day production rate, the average of Form-work is 45.64, and 2.93 for Rebar-work and 110.25 for Concrete-pouring.

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TABLE 1. Definition OF Candidate Drivers

Candidate Drivers		Definition
Weather	Data from Meteorological Administration	Cloud amount is above 6 and below 6
	Weather data from the site work report	Clean day, cloudy day and rain day
Day of the Week		Divided by week, from Monday to Sunday
Overtime		Divided by whether there is a night duty or not according to the work report
No. of Worker		Number of total workers per unit day
No. of Crew		Number of total crews per unit day
Work Amount		Total work amount (Ton or m2) per unit day
Work Zone	Accessibility	Accessibility of Work Zone (Easy, Common, Difficulty)
	Congestion	Complexity of Work Space (Quiet, Common, Complexity)
Work Complexity		Degree of Difficulty of Work

The number of data included in the calculation for the activities, Form-work, Rebar-work, and Concrete-pouring, was respectively 197, 182, 52.

B. Production Rate Drivers

Candidate drivers were identified by visually inspecting scatter-plots. Then, analysis of variance ANOVA and simple regression were employed to test the statistical significance of candidate drivers' relationships with production rates. The significance level used in this study was 0.05. Drivers found from the analysis were summarized in the Table 2. Total of four drivers affecting the Man-hour production rates and five for Crew-day production rate were identified.

TABLE 2. Drivers of Production Rate

Candidate Drivers		Definition						Statistical Method Employed
		Form-work		Rebar-work		Concrete-pouring		
		Man-hour	Crew-day	Man	Crew	Man	Crew	
Weather	Data from Meteorological Administration	X	X	X	X	X	X	ANOVA
	Weather data from the site work report	X	X	X	X	X	X	ANOVA
Day of the Week		◎	X	X	X	X	X	ANOVA
Overtime		◎	◎	◎	◎	◎	◎	ANOVA
No. of Worker		-	○	X	○	X	X	Regression Analysis
No. of Crew		X	X	X	X	X	X	Regression Analysis
Work Amount		X	◎	X	◎	○	○	Regression Analysis
Work Zone	Accessibility	X	X	X	X	-	-	ANOVA
	Congestion	◎	◎	◎	X	-	-	ANOVA
Work Complexity		◎	◎	◎	◎	-	-	ANOVA

◎ : Statistically is significant
○ : Affect to a certain extent
X : Not affect

Ⅳ. CONCLUSION

For selected activities, namely Form-work, Rebar-work, Concrete pouring, over 400 data points were collected and production rates were computed from the on-going nuclear power plant project in Korea.

The man-hour production rate of Form-work, Rebar-work and Concrete pouring is 0.54(㎡/man·hour), 0.06(ton /man· hour), 1.98(㎥/·man hour), respectively. And among the selected ten candidate drivers, 'Day of the Week', 'Overtime', 'Work Zone Congestion', 'Work Complexity' were found to be drivers of form-work productivity. Moreover, those of Rebar-work and Concrete pouring activities are affected statistically by 'Overtime', Work Zone Congestion', 'Work Complexity', and 'Overtime', 'Concrete amount poured', respectively.

In the case of Crew-day production rate, the average rate of Form-work, Rebar-work and Concrete pouring is 45.64(㎡/crew·day), 2.93(ton/crew·day), 110.25(㎥/ crew·day), respectively.

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Furthermore, it was revealed that 'WZ(Work Zone) congestion can reduce man-hour production rate as high as 71% for form-work and 83% for rebar-work. It was also found that 'Work complexity' could affect the productivity of form-work and rebar-work as low as 78% and 81%, respectively.

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