

# THE RESEARCH OF AUTOMATIC CONCRETE PLACING

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Abstract: Construction is a dynamic process that is becoming increasingly complex. Today's construction industry is a highly diversified operating in a complex society. Concrete placing is one the most laboring activities in each construction job-site. How to improve the placing productivity with automatic technique will be an effective study. This paper is trying to present a study result, based on a three years' research relating with automatic concrete placing. The final suggestion of this research, which will be presented in this paper still needs to keep forward for its real application.

This paper will introduce the following topics: the research approach and initial condition of this study, the investigation and analysis of concrete productivity, the original concept of automatic concrete placing, the suggestion and conclusion of this study. The purpose of this paper's presentation is trying to motivate more and more people involve to the research and development (R&D) domain of construction automation.

Keywords: Concrete placing, Construction job-site, Placing productivity, Automatic concrete placing, Construction automation.

## 1. PREFACE

### *1.1 The research Background*

The improvement of productivity at construction job-sites represents one of issues in the construction industry today. Construction engineering is a dynamic process it is combining with complexity activities [1,2]. Concrete placing is one of most complexity activity in each construction job-site [3]. In Taiwan, there are lots of concrete workers working in the placing area once the rebar and formwork activities were finished and the concrete was need to be placed in the floor as shown in figure1. During the placing operation, the concrete crew always needs to move the front part of concrete transportation pipe to place the concrete in each specific formwork. As shown in figure 2 and 3. During the placing process, every concrete worker needs to spend his personal power to present his role. Therefore concrete placing is one of the most laboring activities in each construction job-site [4,5]. This research is searching to improve the concrete placing productivity with automatic technique.

### *1.2 Investigation of placing productivity*

In general, the concrete activity works as a cycling operation as shown in figure 4. This study

spent 2 years to investigate and analyze the motion and productivity of concrete placing activity. The final productivity data were collected and analyzed based on sixteen times investigations within six construction job-sites.



Figure 1. Concrete Placing Activity



Figure 2. Front Part of Concrete Transportation Pipe



Figure 3. Pipe Moving

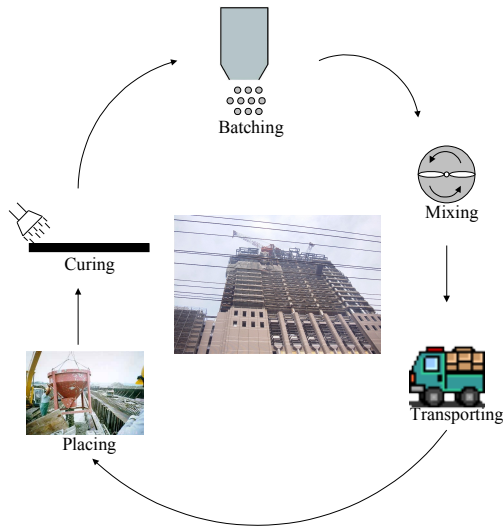


Figure 4. Cycling Operation of Ready Mixed Activity

## 2.Motion and Productivity analysis

This research uses camera and Video to collect concrete placing pictures for productivity analysis [6,7]. Figure 5 shows an example of continuous pictures with 10 seconds lap. After the statistic analysis, the placing productivity of front part of concrete transportation pipe is shown in figure 6. Detail motion is shown in figure 7 and table 1. Surfacing worker's productivity is shown in figure 8. Figure 9 is another concrete worker's productivity. Figure 10 is the vibrator's productivity.



(A) Placing



(B) Move Right



(C) Move Backward



(D) Move Forward



(E) Move Left

Figure 5. Continuous Pictures with 10 Seconds Lap

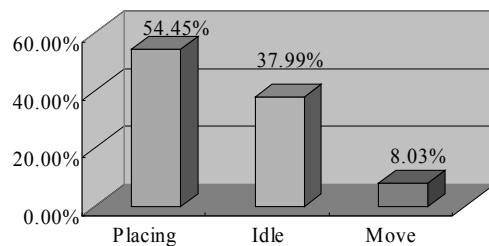


Figure 6. Productivity of Front Part of concrete Transportation Pipe

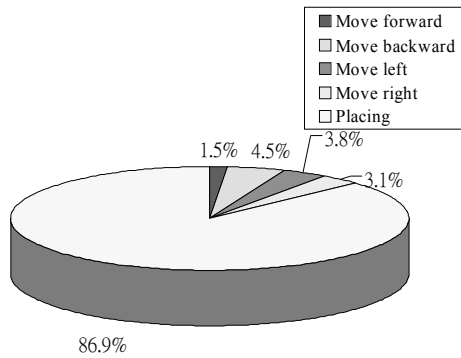


Figure 7. Detail motion of Front Part of Concrete Transportation Pipe

Table 1. Record of Front Part Detail Motion

Motion	Times	Total working time (seconds)	%
Move forward	5	59	1.5
Move backward	23	187	4.5
Move left	32	149	3.8
Move right	19	124	3.1
Placing	-	3457	86.9

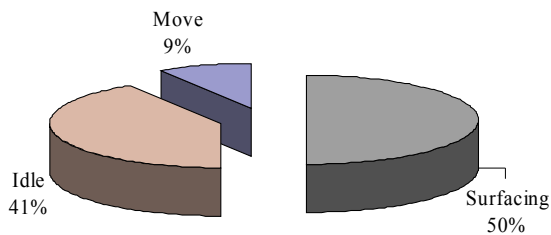


Figure 8. Surfacing Worker's Productivity

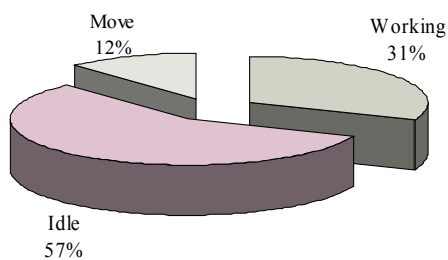


Figure 9. Concrete Worker's Productivity

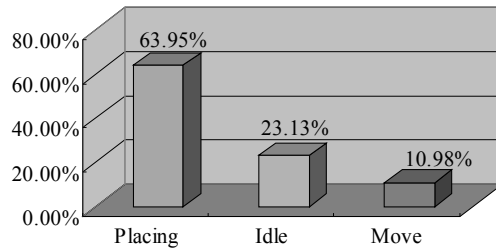


Figure 10. Vibrator's Productivity

From the investigation can realize that the procedure of concrete placement in each job-site is using air compressor (refer to figure 11-(A)) to supply pressure first and uses transportation pipe to transfer concrete to the front part (refer to figure 11-(B)). Then the operations of placing, moving, vibrating and surfacing are held to finish the concrete placement activity (refer to figures 11-(C), (D) and (E)). The whole process can be shown in figure 11.

Based on the investigation and analysis, there are several disadvantages of productivity during the concrete working process:

- (1) The exchange process of ready mixed concrete truck will make the whole placing activity idle and reduce the efficiency of productivity.
- (2) The front part of concrete transportation pipe is the critical operation, once its' action is stop, then all the other action will idle.
- (3) The exchange and movement of transportation pipe will also postpone the placing activity.
- (4) Any equipment break down or pipe stock always causes the whole activity stop.
- (5) The inappropriate distribution of worker and labor's loading also will reduce the placing productivity.

To solve the problems and increase the concrete placing productivity, thinking to improve the front part of concrete transportation pipe works as an automatic robot will be an effective study.



(A)



(B)



(C)



(D)



(E)

Figure 11. Working Process of Concrete

### 3. SUGGESTION AND CONCLUSION

Based on the study, this research contributes three kind of suggestions relating with automation to improve the front part's operation :

- (1) Robot arm: uses robot arm to replace front part of transportation pipe. The robot arm can be designed similar with figure 12 but mechanic considerations must be involved.
- (2) Remote control: adds several movable facilities to make front part of concrete transportation pipe removable. The first type can use wheel to let the front part works as a remote car. The second type is seeking to make the front part can walk on the floor as shown in figure13.
- (3) Suspension: uses facilities to make front part of transportation pipe as a suspending pipe. This idea is shown as in figure 14 and is a little similar with groove arm of concrete transportation pipe (refer to figure 15).

The purpose of this paper is trying to motivate more and more people involve to the research and development (R&D) domain of construction automation.

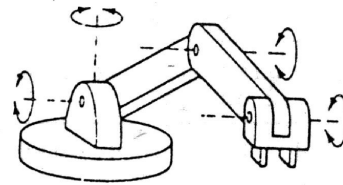
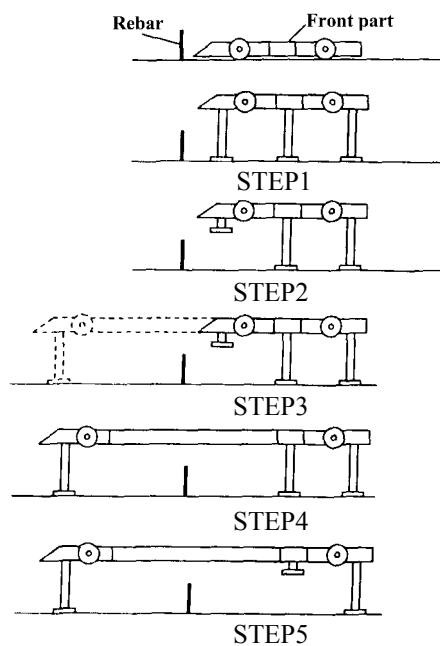


Figure 12. Robot Arm [8]



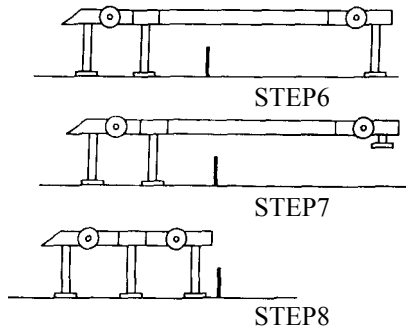


Figure 13. Concept of Walk Robot

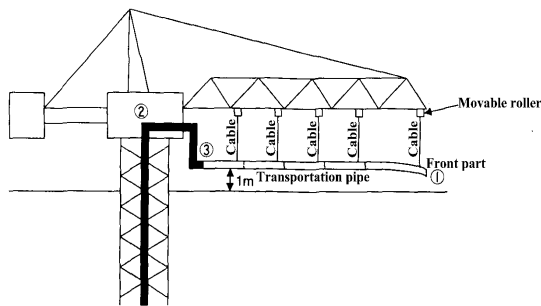


Figure 14. Concept of Suspension



Figure 15. Groove Arm

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