

# FAÇADE CLEANING PROCESS ANALYSIS AND EVALUATION FOR THE DEVELOPMENT OF AN INTELLIGENT ROBOTIC SYSTEM FOR HIGH-RISE BUILDING MAINTENANCE

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**ABSTRACT:** As residents and building owners demand maintenance that is required to achieve sustainable building performance, efficient building management methods are required. Even though the demand for maintenance systems is increasing, current maintenance work for high-rise buildings mostly uses conventional ropes and gondolas that pose a high risk of accidents and exhibit poor performance and efficiency. Thus, there is an urgent need to develop an automation robot system that can reduce accidents and improve the maintenance efficiency of the conventional high-rise building façade maintenance system. As a preceding work for the development of an automation robot system, this study classified and analyzed the work processes of actual construction sites and proposed basic techniques for the work mechanisms of the robot system by investigating the motions of cleaning workers.

**Keywords:** *High-rise Building Facade Maintenance System, Robot System, Motion Research, Work Mechanism, Cleaning Work Analysis, Basic Techniques*

## 1. INTRODUCTION

While the number of high-rise buildings is increasing, façade-related processes are functionally degrading due to such problems as aging technicians and lack of new workers, which result in rising labor cost, lower work quality, delayed work, increasing work cost, and higher risk of accidents at construction sites. The construction industry, which is becoming more and more advanced, complex, and luxurious, urgently needs high-value-added technologies and requires active consideration of automation via construction robots.

This study categorized and analyzed the work processes at actual construction sites and proposed basic techniques for the work mechanism of the robot system, by investigating the motions of cleaning workers.

This study investigated the motions of workers for domestic high-rise building façade maintenance. To analyze the basic techniques needed for the development of a maintenance robot system, façade cleaning work at a construction site was demonstrated.

The motions of categorized work processes were evaluated based on such factors as workability, contamination level, water and detergent usage, and rubbing count. Then

methods to apply them to robot technologies were examined.

## 2. THEORETICAL CONSIDERATION [1]

A motion study was started to find the best method of performing a given task through motion analysis.

Whereas time study aims to determine the standard time of a task, motion study aims to derive task improvement measures.

The purposes of a motion and time study are to i) develop a better system, ii) develop new systems and methods based on the existing methods, iii) set the time for completing a task when a skilled worker performs it at normal speed, and iv) quantitatively measure the volumes of water and detergent required for different cleaning methods.

## 3. WORKING ANALYSIS

The wet task progressed in the following sequence :

detergent cleaning → water cleaning → squeegee work; the semi-dry task, sponge cleaning → squeegee work; and the dry task was performed by wiping windows with a diatomite paste cloth

Table 1. Quantitative analysis of glass surface cleaning

Division	Dry Method			Semi-dry Method			Wet Method		
	at completion	More than 5 years	More than 10 years	at completion	More than 5 years	More than 10 years	at completion	More than 5 years	More than 10 years
Contamination level									
Water usage g/m <sup>2</sup>	-	-	-	5.3	5.3	5.3	142.5	213.7	356.1
Detergent Usage g/m <sup>2</sup>	0.2	0.2	0.2	-	1.8	3.6	-	1.8	3.6
Rubbing Count times/m <sup>2</sup>	63	76	95	13	16	20	8	9	12

#### 4. QUANTITATIVE ANALYSIS

The contamination levels were divided into that upon the completion of construction and 5 and 10 years after the completion. The usage was divided differently for the wet, semi-dry, and dry methods.

Further studies should be conducted on expanding the robot application technologies for building façade maintenance, including for defect monitoring and painting.

Table 2. Quantitative analysis of stone surface cleaning

Division	Wet Method		
	at completion	More than 5 years	More than 10 years
Contamination level			
Water usage g/m <sup>2</sup>	-	-	-
Detergent usage g/m <sup>2</sup>	-	3.6	7.1
Rubbing count times/m <sup>2</sup>	8	10	13

The usages were also divided based on cleaning surface such as stone, aluminum, and glass surfaces.

#### 5. CONCLUSIONS

This study analyzed the basic techniques related to cleaning, which is a component of maintenance, as a preceding study for the development of building façade maintenance robots. The basic techniques for applying unit motions to actual robots were technically and quantitatively analyzed.

The results of this study will contribute to the production of robots that are equipped with the basic techniques required for application.

Table 3. Quantitative analysis of aluminum panels

Division	Wet Method		
	at completion	More than 5 years	More than 10 years
Contamination level			
Water usage g/m <sup>2</sup>	99.7	119.7	149.6
Detergent usage g/m <sup>2</sup>	-	3.6	7.1
Rubbing count times/m <sup>2</sup>	12	14	18

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#### REFERENCE

[1] Hun-Hee Cho, *A Study on the Working Analysis of Domestic Rebar Work*, Korea University Graduate School, Master's Thesis, Feb. 1997.