

"CUTTING EDGE" OF THE STATE OF THE ART OF
CONSTRUCTION ROBOTIZATION IN JAPAN

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ABSTRACT

The newest status of robotization in Japanese construction industry is reported based on Construction Industry Institute classification. And the recent result of a questionnaire survey for promoting automatization and robotization of construction industry by Ministry of Construction is introduced. Finally the author discusses strong necessity of international co-operation for break-throughing difficult conditions of robotization.

1. Introduction

On the developing process of construction robots for the full enjoyment of their merit in construction industry, we have to solve many obstacles such as complexity, mobility, bigger size, heavier weight, less repetitive and so forth compared with cases in manufacturing industry. Figure 1 shows the productivity increment trend comparison in construction and manufacturing industry in our country.

Today we have serious problems of labor shortage, high cost, construction schedule delay, worse working conditions, young workers spinout, and so forth. Without exception, labor productivity increment in construction industry was none or very little in many countries in the world. This serious fact means the difficulty of the theme to develop the robotized construction system in each country.

On the other hand, the history of robot development is telling us even in the case of robot development for manufacturing industry it takes almost two decades from the beginning to the full commercialization of the developed robots. In the construction field, we have only one decade of history in the development in our country. Nevertheless the author would like to introduce the recent status of the development by earnest companies and institutions.

2. Present Status of the Construction Robot Development in Japan Based on CII Classification

Table 1 shows the newest status of construction robot development and utilization which is based on Construction Industries Institutes classification. From the table, in Japan, the construction robot development has been mainly being done in the civil engineering field and not yet much activities in mechanics field. But, in our country, some technological transfer from the following parallelly running robot research projects can be expected.

- 1) Robot Development Project for Hostile Environment
(Sponsored by MITI)
 - a. Atomic Power Development Robots
 - b. Ocean Development Robots
 - c. Fire Rescuing Robots
- 2) Space Development Robot Project (Sponsored by NASDA)
 - a. Space Laboratory Construction Robots
 - b. Space Base Construction Robots

Also, as special characteristics of construction robots, many of them have more sophisticated functions than those in manufacturing such as mobile, remote control, heavy duty, intelligent and so forth.

3. A Questionnaire Survey for the Future of Robotization of Construction in Japan

In 1988 and 1989 Ministry of Construction made a nation-wide survey for the future robotization of construction under tight co-operation among companies which are involved in construction work. The author would like to introduce a part of them.

3.1 Robotization needs in construction industry by the type of operations

Figure 2 shows the priority of robotization needs in heavy structure construction field by frequency of answers. In such area the construction of dams, tunnels, bridges, roads, piers and so forth are included. From the figure we can understand that the weight of tunneling work is far bigger than other field and it comes from geographical character of our land.

Figure 3 shows the priority in building construction field. The reason why the mechanics work is not included is that those kinds of work are not mainly done by general contractors themselves in our country but most of them are being done by facility suppliers and sub-contractors, and this tendency is also found in table 1.

3.2 Expected automatization level

Figure 4 shows the expected automatization level by the type and histogram of answers. In spite of the appearances of many fully automated un-manned factories and CIM systems in manufacturing industry in our country, the main part of automatization level targets are remained as partial automation, mechanization and remote control. Those results are considered to show difficulty of the robotization in construction industry.

4. Opportunities for Economic Benefits

Even in construction robotization, the trend of robot diffusion might take the same pattern from simple and low cost to sophisticated and high cost which can be seen in robotization in manufacturing industry. The construction robots such as concrete floor finishing, window cleaning, floor sweeping, and radio controlled devices for steel beam clamp release have reached the commercially feasible stage even today.

As we have learned from the history of robot introduction into manufacturing industry, however, we shall not be able to enjoy big fruits of construction robotization until we take the system merit by utilizing a fleet of robots in the construction sites. This is not an easy target to us, and we shall have to solve many technical, management and structural themes which will particularly be needed in construction industry.

5. Conclusion

The present status of the construction industry compared with ten years ago is as follows. The industry has been non-attractive to the young working people. Especially in some dirty and tedious jobs, we can recruit no young workers today. We are facing big and serious needs to make a revolutionary modernization of the industry by introducing advanced robot technologies.

For conquering many hazardous items such as bigger robot development cost and smaller market for them, we need to have tighter international co-operation. This symposium is one of the most important opportunities to discuss this issue.

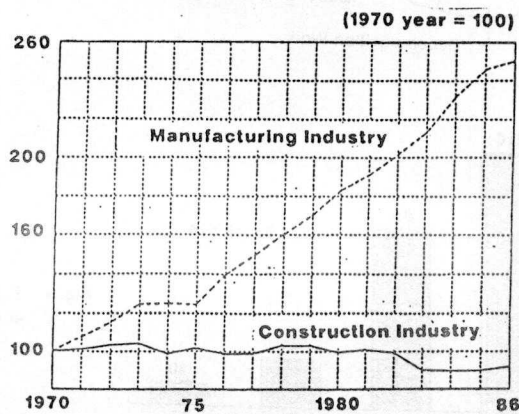
References:

1. "A Report of Survey for Promotion of Automatization and Robotization of Construction Industry", Ministry of Construction, 1989 (Japanese)
2. Y. Hasegawa, "Technologies to be Developed for Successful Introduction of Robots into Building Construction Industry", Proc. 5th ISIR, Tokyo 1988

TABLE 1. PRESENT STATUS OF CONSTRUCTION ROBOT DEVELOPMENT AND UTILIZATION IN JAPAN.

Application Area of Automation & Robotics		No Progress	Technical Success	Economic Application.
Civil	Earth Work		<ul style="list-style-type: none"> (1) Automated system capable of controlling compactors (2) Automated construction vehicles navigation system (3) Automated construction vehicles collision avoiding system 	<ul style="list-style-type: none"> (1) Shield Method Automation System: Shield excavation. (2) Measuring and Controlling System for Shared Ground and its Peripheral subsoils: The control of underground construction. (3) Radio Controlled Loader (4) Automatic hydraulic back hoe (5) Giant substructure system
	Foundations		(1) Concrete block laying robot	(1) Excavator for deep slurry wall (OHBAYASHI)
	Structure		<ul style="list-style-type: none"> (1) On site Welding Robot:Automated steel welding operation at construction site. (2) Robot for Arranging Heavy Bars: The playback type robot carries 30 bars (A bar weighs 100 kg and requires 5 to 7 workers to carry) at a time and automatically places them. (3) Shot-erecting Robot (4) Dam Concrete Transporting Vehicle (5) Remote assembly manipulator for steel beams (6) Automated Crane for Re-bar Arrangement (7) Concrete Floor Screeding Robot (8) Automated Material Transportation System (9) Bracing Crane 	<ul style="list-style-type: none"> (1) Climbing Robot Jack System: The climbing method for bridge piers (2) Concrete Slab Finishing Robot:This trackless self-driven robot does slab finishing by travelling along the automatically programmed courses over a predetermined area. (3) PC Board Setting Robot: PC board positioning (4) Shield-segment Erection Robot:For shield tunneling work (5) Auto Rock Drilling Machine:For dynamite and rock supporting bolts (6) Auto clamp for steel erection (7) Radio control auto release clamp (8) Concrete floor plastering robot (9) Auto setting form for dam (10) Assembly Line for Reinforcement Bar units (11) Horizontal Concrete Distributor (12) Concrete Distributing Crane (13) Concrete Surface Finishing Robot
	Enclosure Skin		(1) Automated Coating Delamination Robot	(1) Self Climbing Wall Inspector
	Interior Finishes		<ul style="list-style-type: none"> (1) Concrete Chipping Robot:By using water-jet technology (2) Ceiling panel positioning robot (3) Multi-purpose travelling vehicle for concrete floor processing and cleaning 	(1) Wall Board Manipulator: The wall board manipulator was developed to reduce time and labour involved in the transportation and affixing of boards.
Mechanics	Roofing	X		
	Piping	X		
	Plumbing	X		
	Vessels	X		
Others	EVAC	X		
	Mechanical Equipment	X		
	Special Equipment Installation	X		
	Electrical	X		
	Instrumentation		(1) Automatic position measuring system	

Application Area of Automation & Robotics	No Progress	Technical Success	Economic Application
Insulation	X		
Others	Coatings and Painting	(1) Painting and Finishing Robot for Wall Surface : By spraying and shot-blasting (2) Automated Coating Robot for External Wall	(1) Tower Interior Surface Coating Robot: Painting (2) Automatic sprayer for exterior wall painting (3) Automatic silo lining system (4) High Rised Building Exterior Wall Painting Robot: The robot is suspended by cable from the roof car (the hoisting unit for a gondola) installed on the roof of a building descends along the guiderails provided on the exterior wall surface
	Fire Proofing/ Protection		(1) Fire Proofing spray robot
	Inspection		(1) Clean Room Environment Investigator: Vacuum Investigation robot in industrial clean room. (2) Inspection Robot for External Tile Wall: The robot ascends and descends the chain suspended from the rooftop parapet, continuously tap tiles and the resultant sound in analyzed. (3) Self climbing wall inspection robot
	Others		(1) Water Jet Cutter: Concrete cutting (2) Automated Steel Pipe Inspection/Acceptance System: Repairment, classification and transactions of steel pipes.



Source: National Economic Agency

Fig. 1 Productivity Increment Trend Comparison in Construction and Manufacturing Industry

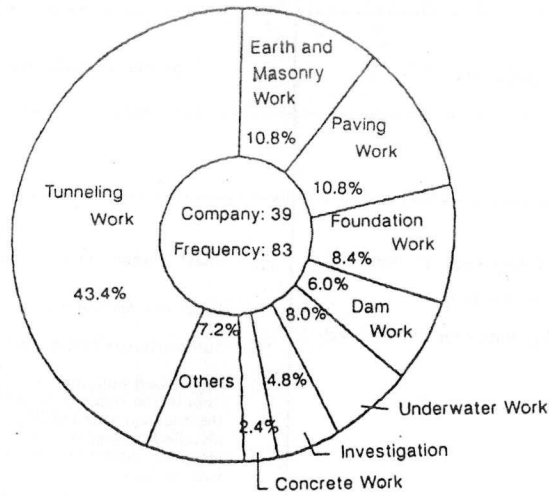


Fig. 2 Robotigation Needs in Construction Industry (Heavy Structure Construction)

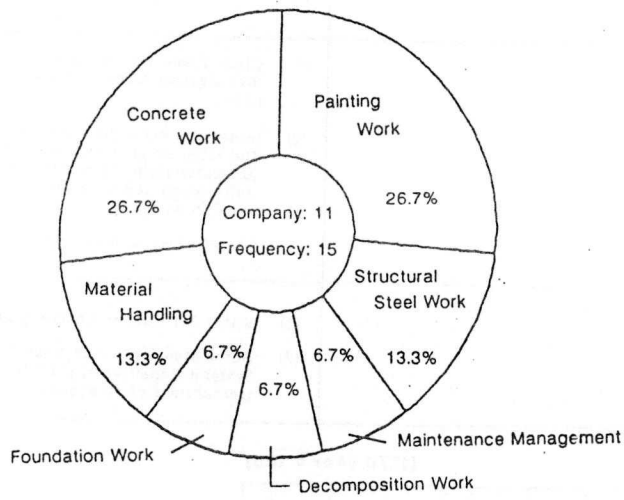


Fig. 3 Robotigation Needs in Construction Industry (Building Construction)

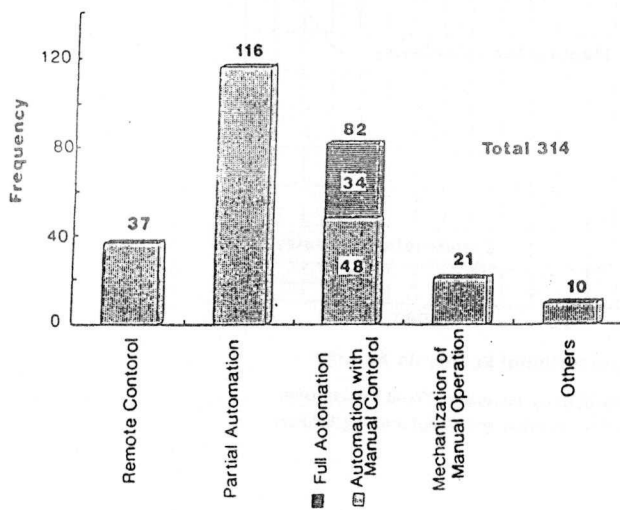


Fig. 4 Expected Automatization Level in Construction Industry.