Zeitschrift: IABSE journal = Journal AIPC = IVBH Journal
Band: 14 (1990)
Heft: J-40: Introduction of construction robotics in Japan

Artikel: Introduction of construction robotics in Japan
Autor: Hisatomi, Yo
DOI: https://doi.org/10.5169/seals-31666

Introduction of Construction Robotics in Japan

Introduction de la robotique dans la construction au Japon

Einführung von Baurobotertechnik in Japan

Yo HISATOMI
Gen. Mgr.
Shimizu Corporation
Tokyo, Japan

Yo Hisatomi, born 1931. Graduated in Building Engineering from the Tokyo Institute of Technology in 1954, and has been working for Shimizu Corporation for 35 years: 10 years on construction sites, 10 years at the firm's research institute, 10 years in its technology development division, 3 years in its international division, and 2 years in its corporate planning division.

SUMMARY

This report describes construction robots for building works, developed and manufactured by Japanese general construction companies. The background of this development, application fields, purposes and the future orientation of the researcher are introduced.

RÉSUMÉ

Ce rapport décrit des robots utilisés dans des travaux de construction. Ils ont été développés et fabriqués par de grandes entreprises de construction japonaises. L'article traite de l'origine de ces développements, des domaines d'application, des objectifs et de l'orientation future de la recherche.

ZUSAMMENFASSUNG

Dieser Bericht beschreibt Bauroboter im Hochbau, die von grossen japanischen Bauunternehmen entwickelt und hergestellt werden. Aufgezeigt werden der Hintergrund dieser Entwicklung, Anwendungsgebiete, Ziele und künftige Ausrichtung der Forschung.

This report draws partially on an article by Mr. M. Yamada of Takenaka Komuten in the JACIC Journal, published in July 1989, Vol.4, No.3 pp. 26-30. The list of Japanese construction robots and their photos were taken from the article; however, the following comments and analysis are my own.

1. BACKGROUND

Until the end of the 70s in Japan, mass-production industries like automobile manufacturing firms had developed several manufacturing robots with the aid of robot makers, and had utilized them in their production lines. Automated material handling and welding have been the main functions of these robots, which took the place of the traditional human workforce.

In the construction industry, the application of robots to its 'production line', that is, the construction site, was not launched until the end of the 70s. The reasons for this were:

1) The work conditions of the construction site were not suitable for the application of robots. In particular, the mobility of robots on construction sites is essential.
2) Robot makers were busy supplying robots to mass-production industries, and did not show interest in the construction industry.
3) The application of robots would not achieve economical advantages comparable to traditional working methods.

In the early 80s, large Japanese general contractors who had in-house R&D organizations started trials for the application of robots to the construction site. They limited the functions performed and working specifications and placed orders with the robot makers. In the beginning, some of the robots used were only standard models with devices added to make them suitable for construction work.

2. ROBOTS DEVELOPED IN JAPAN

Robots that have been developed are listed separately. They can be categorized by purpose as follows:

1) To eliminate hazardous work for human workers:
   - Fire-proofing material spray robot.
   - Concrete slab finishing robot after concrete has been poured.
2) To eliminate heavy work for human workers:
   - Re-bar bending and handling robot.
   - Concrete pouring robot. (In parallel, prevention of damage of the arranged re-bars during the concrete pour.)
3) To eliminate dangerous work for human workers:
   - Steel structure erection robot.
4) To increase productivity:
   - Re-bar bending device.
5) To eliminate temporary scaffolding:
   - External wall painting robot.
   - External wall inspection robot.

- Interior finishing robot.

6) To eliminate human contamination in clean rooms:

- Environmental contamination detection robot in clean rooms.

It is interesting to see that their primary expectation was not to increase productivity or profit, but to improve human-related working conditions. It can be explained that at that time no one was confident about the economical advantages of using robots.

As is always the case in Japan, all the competing construction companies followed each other: similar robots with similar purposes were developed and applied to sites by all the large general contractors.

2.1 Bar Handling Robots

At nuclear plant works, a large quantity of heavy re-bars are used, and the placement of them at precise positions requires a specific device. For this purpose, two robots, one with an automated spacing device and the other with an automated positioning device were developed (photos 1, 2). More improvement is said to be necessary for practical use of the latter.

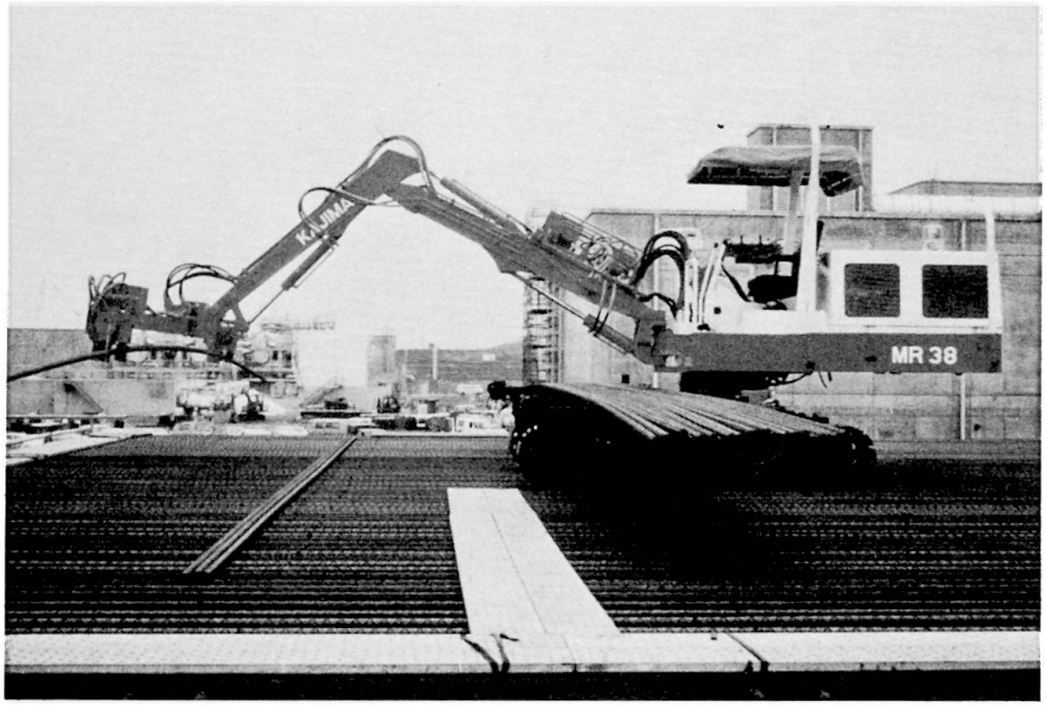


Photo 1 Heavy bar assembling robot

2.2 Concrete Work Robots

For delivery and pouring of concrete, remote-controlled pouring pipes are the main developments (photos 3, 4, 5).

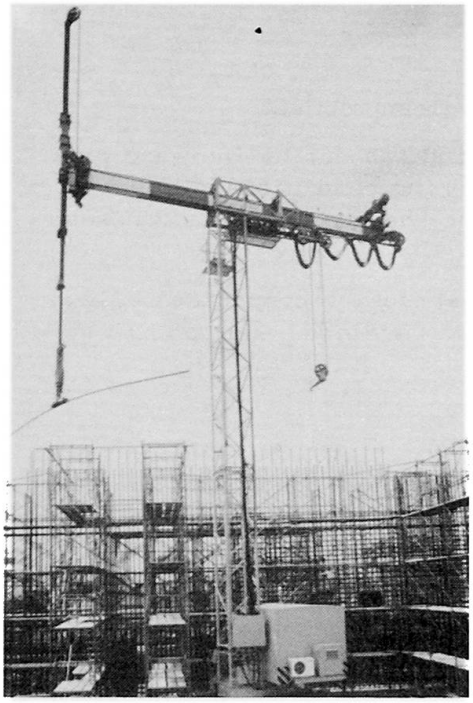


Photo 2 Heavy bar assembling crane

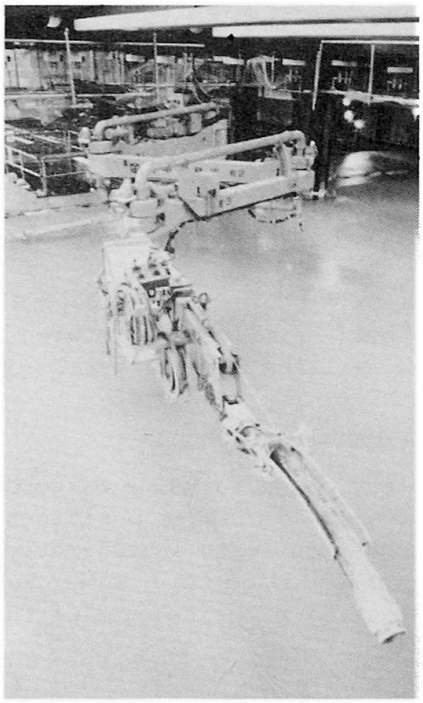


Photo 3 Horizontal distributor

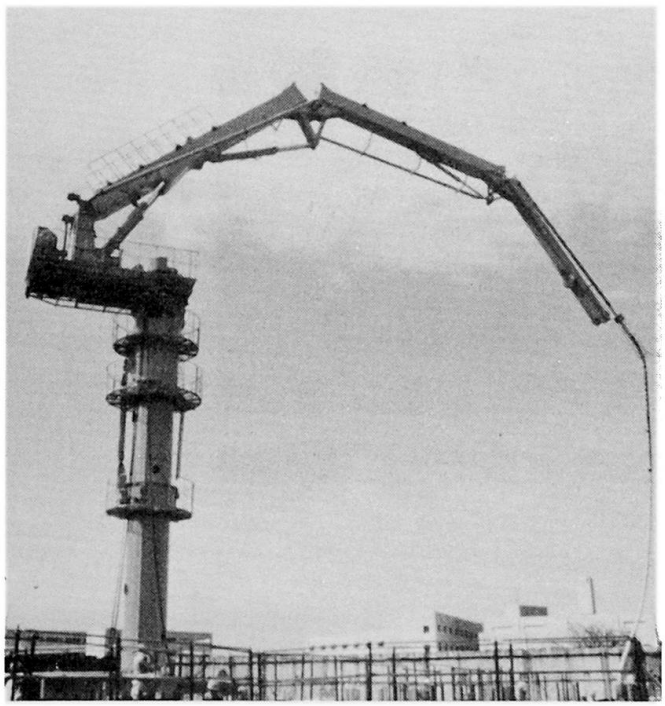


Photo 4 Con-disk crane

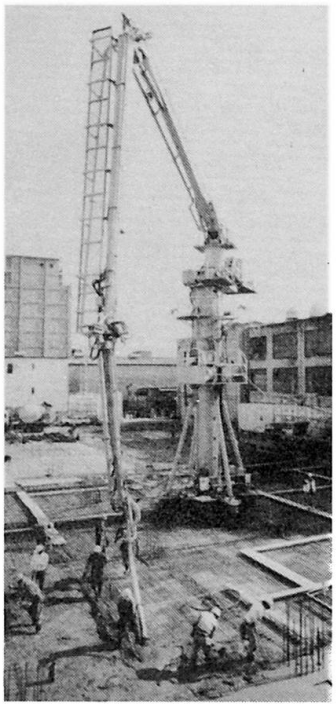


Photo 5 Placing crane

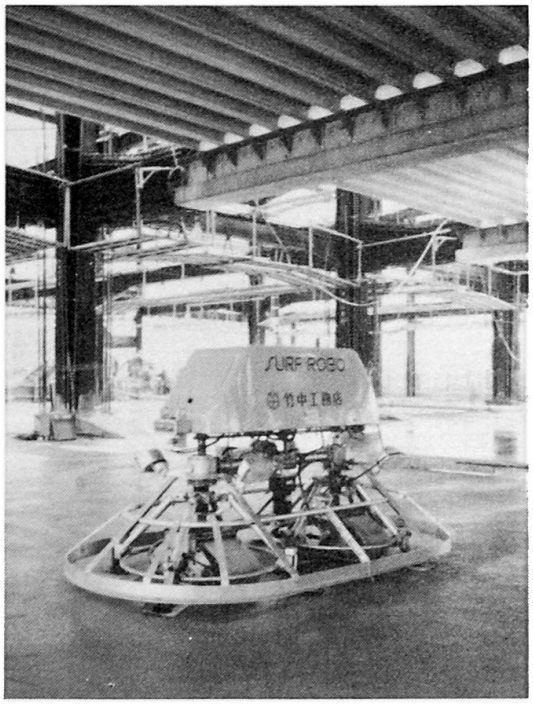
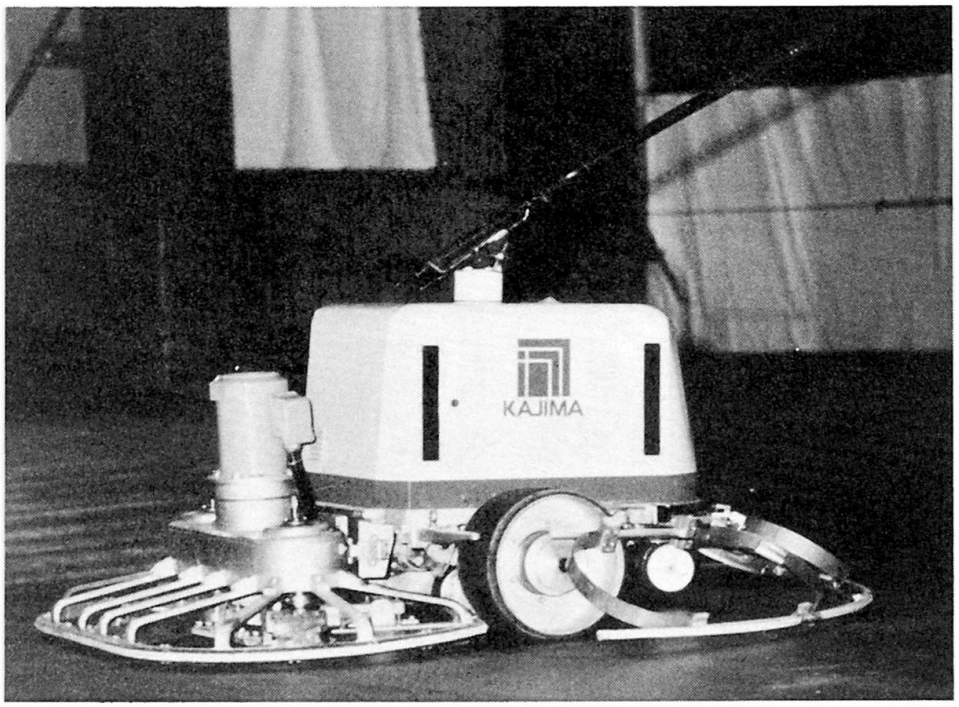


Photo 6 Surf robot

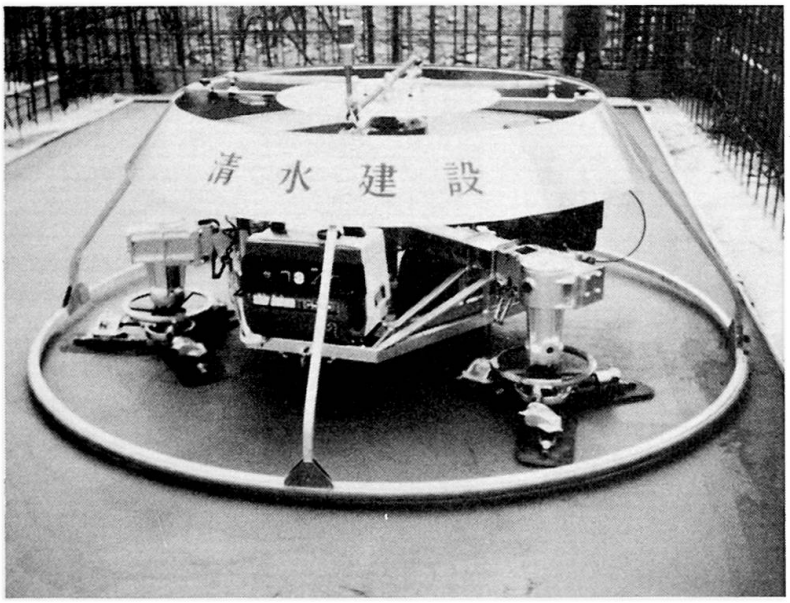
Photo 7 Concrete finishing robot



For the finishing of concrete after a slab pour, the remote-controlled motor-trowel was developed and improved to be equipped with automated sensing devices for operation. This application area is thought to be economically feasible (photos 6,7,8,9).

Photo 8 Automated finishing robot

Photo 9 Robot plaster



2.3 Steel Structure Work Robots

There are a series of fire-proofing material (rock wool) spray robots. At present, Model 3 is in undergoing testing. A newer model, which is equipped with sensors to detect the position of the spray nozzle and the location of the robot, has achieved good results with automated operation based upon input data to the robot's computer (photo 10).

Erection robots have wider applications, from simple remote-controlled slinging devices to beam-setters equipped with adjustment devices for measuring the distance between two columns (photos 11, 12).

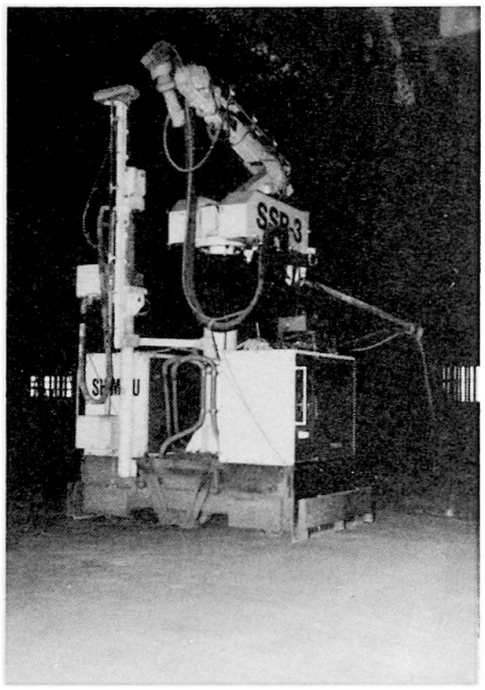


Photo 10 Fire-protection spray robot

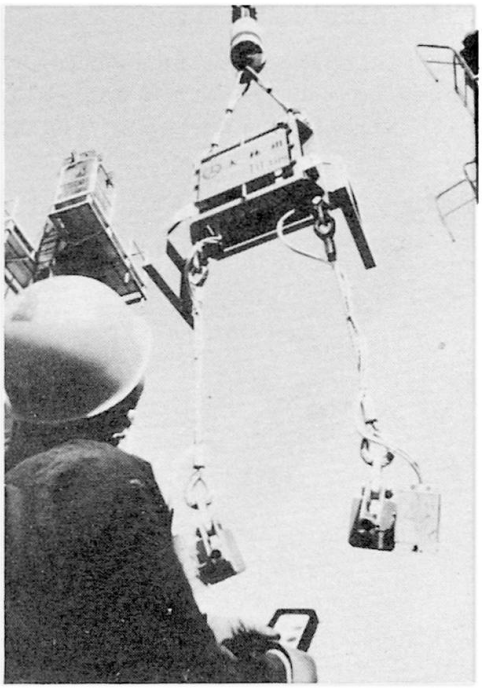


Photo 11 Auto clamp

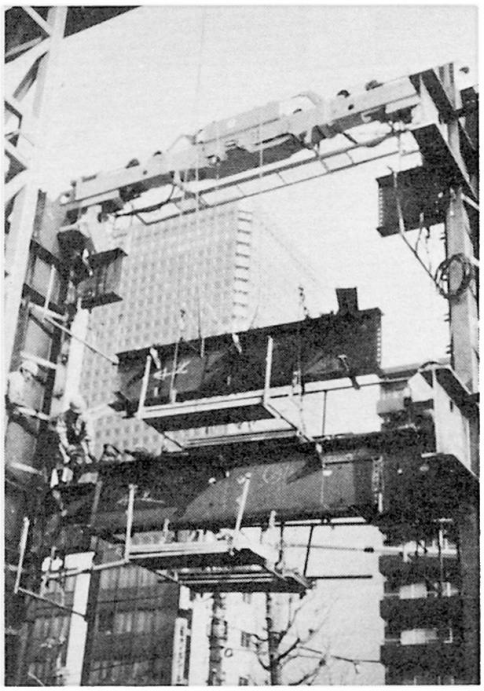


Photo 12 Mighty jack

2.4 Finishing Robots

For finishing external walls, various devices have been developed. Some are paint-spraying robots with a self-climbing function (photos 13, 14), and some are hung with wire from the top of the wall (photo 15).

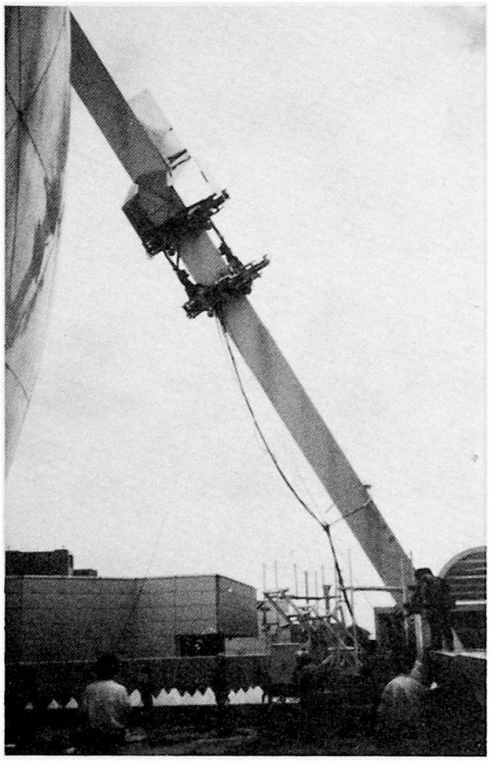


Photo 13 Long column painting robot

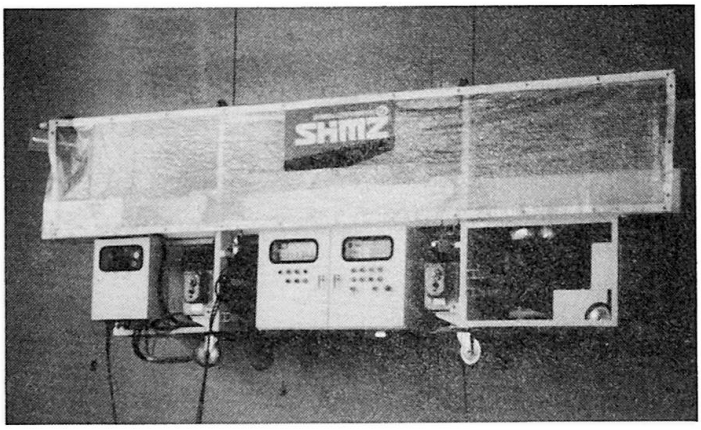


Photo 15 Auto spray machine

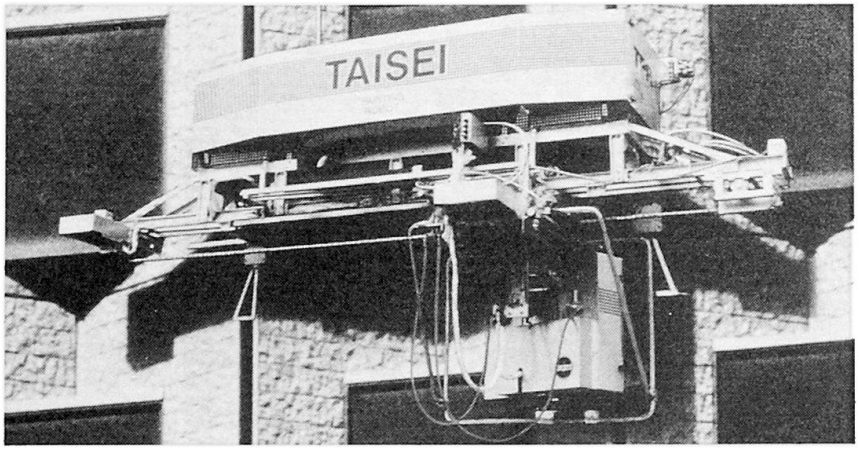


Photo 14 Painting robot

To remove existing paint from walls, an automated device with a water jet nozzle was developed (photo 16).

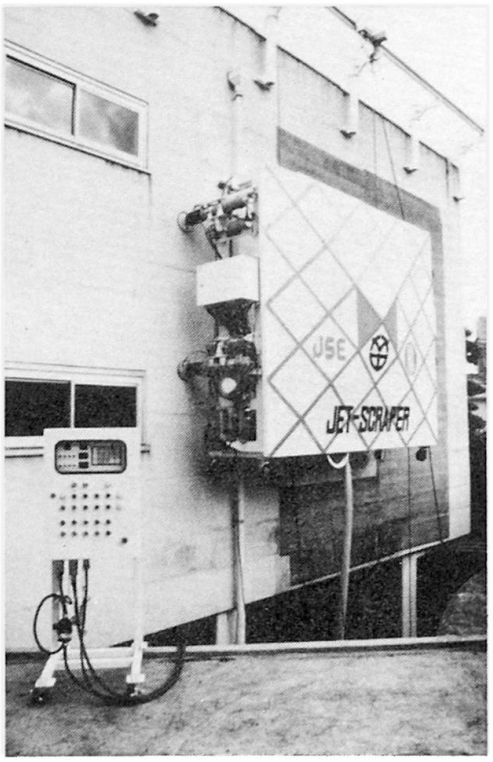


Photo 16a Jet scraper

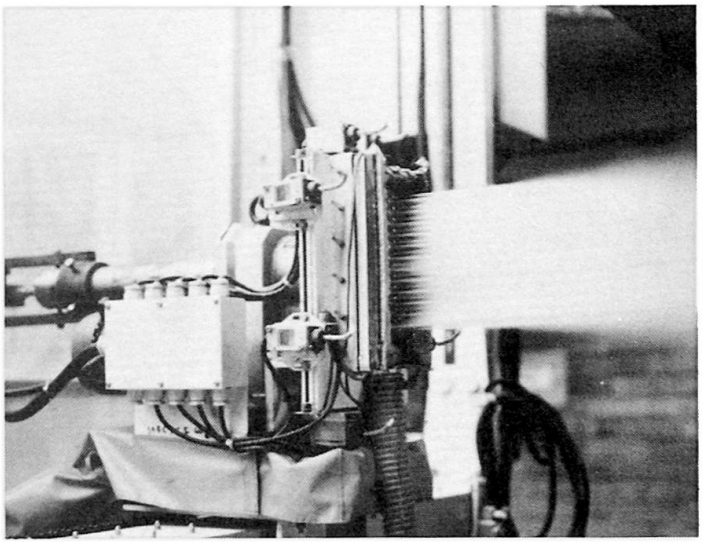


Photo 16b Jet scraper

For interior finishing, handling devices for applying building board to partition walls and ceilings have been developed (photos 17, 18).

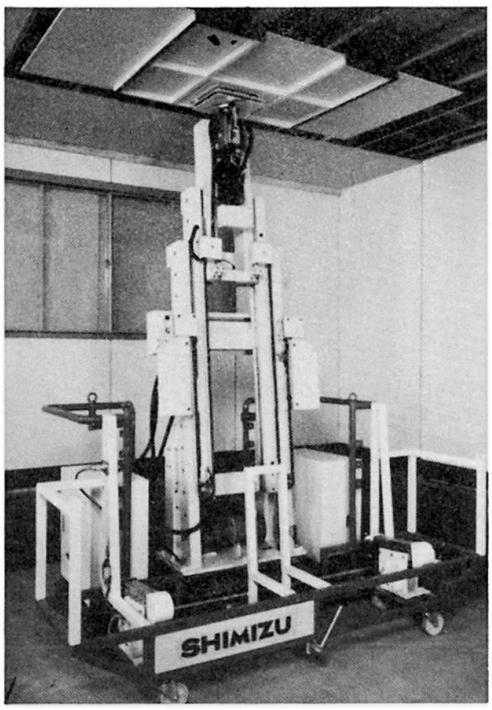


Photo 17 Ceiling fixing robot

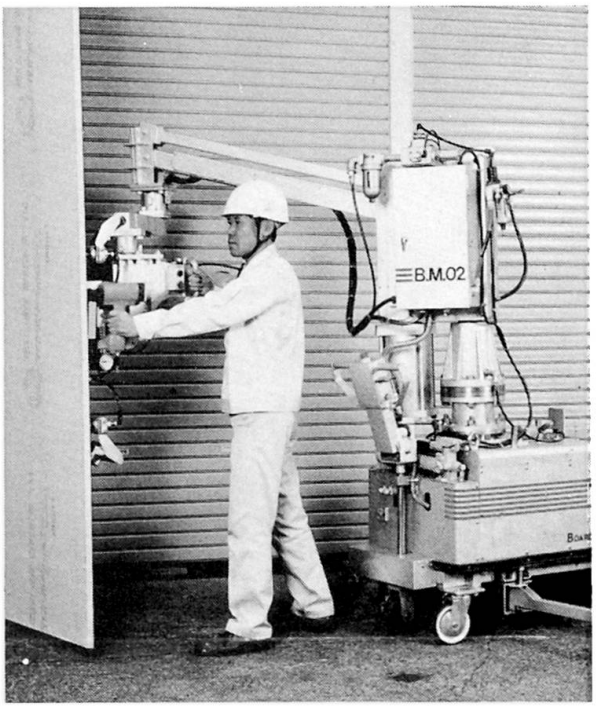
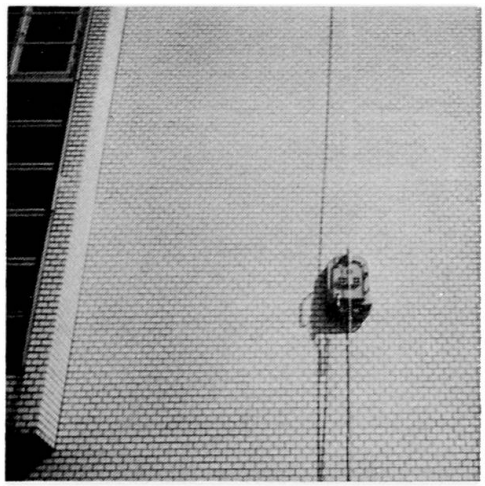


Photo 18 Board manipulator

2.5 Work Inspection Robots

For the inspection of tile and plaster finishes of external walls, self-mobile detecting devices equipped with sensors and recorders have been developed (photos 19, 20, 21, 22).



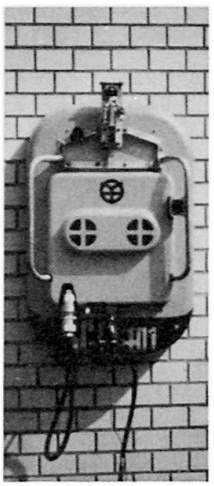


Photo 19a Inspection robot

Photo 19b Inspection robot

Photo 20 Tile inspection robot

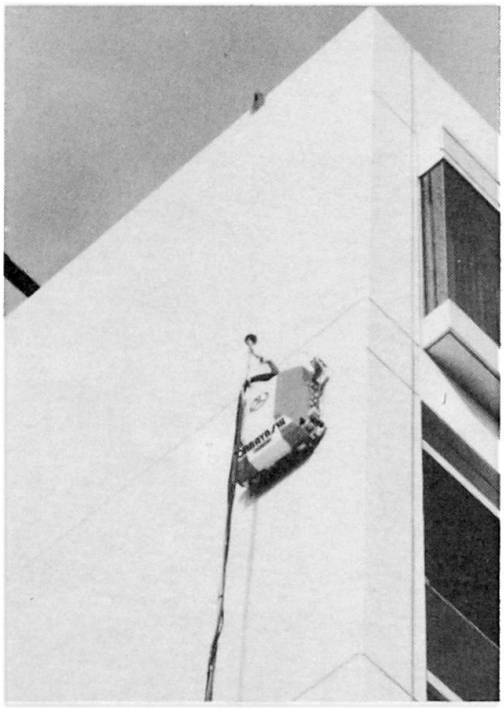


Photo 21 Wall inspection robot

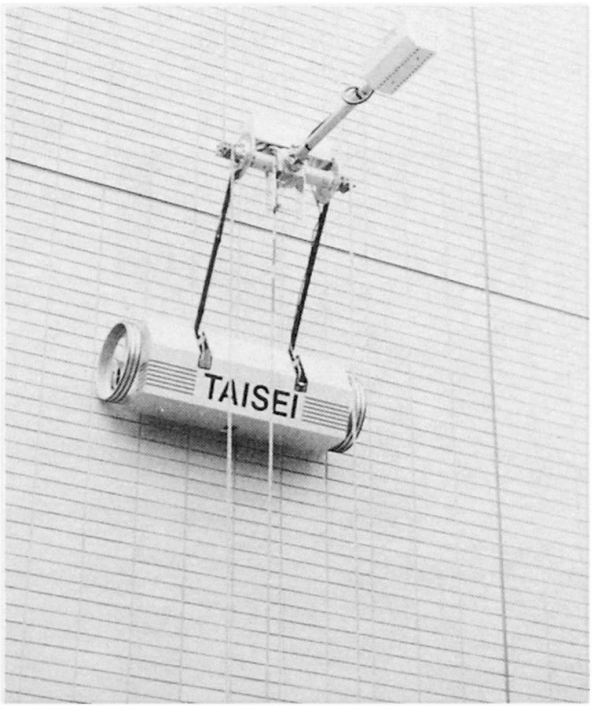


Photo 22 Tile inspection robot

To detect particulate contamination in clean rooms, automated mobile platforms with sensors have been developed, which can minimize the additional particles often generated by human inspectors.

3. PRESENT SITUATION AND THE FUTURE

As reported above, many devices have been developed that are being referred to as construction robots. Some of these are merely remote-controlled machinery, while some are equipped with sensors and self-controlled devices and thus qualify to be called robots.

Yet, all of these robots are still undergoing testing. Further R&D activities may improve their mechanical and electronic functions to reach expected operational levels in the near future. Regarding the economical feasibility of their use, right now it is difficult to gain visible advantages over traditional work methods. At the moment, researchers are approaching building researchers to work together to envisage a building system that will be suitable for building robots, rather than trying to adapt robots to suit the present building system.

4. HEAVY CIVIL ROBOTS

This report describes only the building construction discipline. For heavy civil construction, some robots or automated control devices have been developed and placed in use: tunnel shield machine control, concrete spray control and so on. In general, historically heavy civil construction has been carried out utilizing heavy machinery, and the application of automated control is much more apparent than in the more complicated and manpower-intensive building construction field.

5. ACKNOWLEDGEMENTS

The author would like to thank the JACIC Journal which allowed the partial use of its article. The author is also grateful to Mr. M. Yamada of the Takenaka Komuten for allowing the use of the list of Japanese construction robots. Finally, the staff of the Kajima Corporation, Ohbayashi Gumi, Taisei Corporation, and Takenaka Komuten were most helpful in the preparation of the photos.

FUNCTION	NAME	PHOTO NO.	OUTLINE
Welding & Bar bending	Stud welding robot		Welder of stud bolts
	Unit bar assembly line		Bending & assembling of large diameter re-bar
	Automated bar assembling system		
Transportation	Material handling system		Automated loading device for vertical lifting
Bar fixing	Heavy bar assembling robot	*1	Bar handling for nuclear plant works (base mat)
	Heavy bar assembly crane	*2	Bar handling for nuclear plant works (wall)
Concreting			
Placing	Horizontal distributor	*3	Attached to steel column
	Con-disk crane	*4	Not necessary to attach to steel column
	Placing crane	*5	
Leveling	Concrete leveling robot		Leveling of wet concrete
Finishing	Surf R080	*6	
	Concrete finishing robot	*7	
	Automated finishing robot	*8	Final finishing of placed concrete
	Robot plaster	*9	
Steel erection			
	Fire protection spray robot	*10	Spray fireproofing material on steel structure
	Auto clamp	*11	Remote-controlled lifting clamp
	"Mighty Shackle"		
	Auto setter		Remote-controlled beam fixing machine
	"Mighty Jack"	*12	
	Auto claw		Remote-controlled lifting clamp
	Welding robot		In-situ welding robot
Finishing			
Exterior wall	Long column painting robot	*13	
	Veranda wall painting robot	*14	
	Auto spray machine	*15	Spray robot
	Auto spray machine		
	Jet scraper	*16	Paint scraper
	Panel fixing robot		PC panel (0.5 ton) fixer
Interior	Ceiling fixing robot	*17	Gypsum board fixer
	Board manipulator	*18	Wall board fixer
	Floor cleaning robot		Multi-purpose cleaning
Inspection			
Exterior wall	Inspection robot	*19	
	Tile inspection robot	*20	Inspection robot for wall tile and finishes
	Wall inspection robot	*21	
	Tile inspection robot	*22	
Clean room	Crimro		Environmental monitor on movable wheel deck
	Clean watcher		
	Inspection robot		

Table 1 **Robotization of the construction site in Japan**

JACIC Journal VOL.4, NO.3 1989