

Automation and Robotics in Construction in Japan - State of the Art -

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Abstract

Construction industry is one of major industries in Japan. Although Japanese economy is severe condition in these days, research and development for automation and robotics in construction is still active. Automated building construction systems are developed and applied to actual projects. Many types of automated systems are developed for tunneling. New types of construction management systems are developed based on information and telecommunication technology.

1. Introduction

Construction market size in Japan in 1995 was 86.7 trillion-yen. This value is larger than that of US (67.0 trillion yen) and 15 major European countries (82.1 trillion yen). The number of construction industry employees in 1996 is 6.7 million, which are about 10% of all industries. Thus construction industry is very important in Japan. But, there are some problems. For example, number of death of workers in construction industry in 1996 is 1001, and that number in all industries is 2363. Which means that the number in construction industry is almost half of number in all industries. Labor shortage is not a serious problem in these days. But, aging of construction worker is a problem. Average age of workers in construction site is 44 and this is higher than the average age of all industries. Basic needs for automation and robotics in construction still exist.

Japanese economy was damaged by the burst of bubble economy. Many banks, insurance companies and stock companies are bankrupt recently in Japan. Construction companies are also in severe condition because of the recession and reduction of construction investment in private and public sector. Construction companies are trying to restructure their company to improve profit.

Research and development for automation and robotics in construction is not a boom but still active in Japan. Only large general contractors were involved in this activity at beginning, but middle classed general contractors are also involved in this area recently.

State of the art in automation and robotics in construction is discussed in this paper. Following two symposiums are major source for the data

- 1) The 6th Symposium on Construction Robotics in Japan (July, 1997)
- 2) 12th Construction Robot Symposium (January, 1998)

Symposium 1) includes wide area of automation and robotics systems in construction. Symposium 2) is limited in building construction field.

2. Research and Development in building construction

2.1 Automated Building Construction

Research and development related to automate building construction is very active in Japan. There are 9 systems developed by 8 companies. It can be said that this is like a boom for automated building construction system development. Some systems are already used more than two sites.

The SMART system, which is developed by Shimizu Coporation, was applied to RC Yokohama building as second project. Shimizu developed other type of all weather construction system and applied it to middle sized building.

Big Canopy which is developed by Ohbayasi Corp. was used three projects, and will be used in overseas project this year.

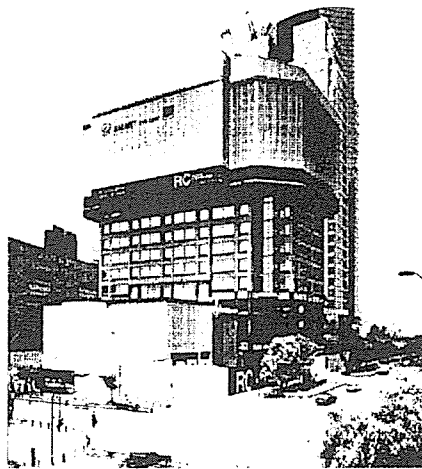


Fig.1 SMART system

2.2 Automation and Robotics in other area

Special features can not be found in stand-alone type robotic systems in building construction. Some companies developed steel column erection assisting machine. Those systems are consists of surveying equipment for measuring accuracy of the position of the column and actuators for adjusting the position of the column.

Special hoist for curtain wall installation is developed to reduce installation time. The machine is hanged by tower crane with wall panel and transported to installation point. The machine is set to the building temporally and installs panel.

Material handling systems for inside the building is developed. Automatic guided vehicle, which is navigated by signboard without guide tape. Personal interior finishing robot is developed to reduce physical exhaustion. Material handling is essential work in building construction, so that development in this area will continue in future.

3. Research and Development in Civil Works

Japanese government decided to reduce construction investment for public works. Big project like "Trans-Tokyo Bay Highway" was completed. It can be said that the construction boom was over in Japan. Nevertheless, many types of automated systems are developed for civil works project.

3.1 Tunneling

Development of automated systems for tunneling is very active. In shield tunneling, automatic drive system, segment installation robot and automatic segment carrier are developed. Subsurface radar for monitoring obstacles of shield machine is also developed.

Besides shield tunnel, automated excavator (Road-Header) and hard rock tunneler are developed. Basic study of the development of a robot for loading explosives started.

3.2 Other Works

Automatic crane control systems for dam construction are developed. Dam concrete surface treatment (Green-Cutting) machines are also developed.

Tele-operated systems are developed for hazardous work such as pneumatic caisson and deep shaft excavation.

Regarding maintenance of structures, bridge repainting robot and water-jet concrete removal system are studied.

4. Research in Elemental Technologies

Elemental technologies for automation and robotics in construction are studied. Basic study for a robot with integrated locomotion and manipulation is carried out. Many types of mobile robot are studied.

"Friendly Network Robotics (FNR)" project, which is planned by MITI, is in the stage of feasibility study, and will start from fiscal year 1998. The project aims at developing human friendly robots. Construction work is considered to be one of the application areas of FNR.

The committee of the Japan Society of Mechanical Engineers carries out development of rescue robot. The purpose of this project is to study rescue robot for disaster like the Kobe Earthquake.

IMS project is international corroborating project for intelligent manufacturing system. IF7 project is one of the IMS projects which covers automated assembly of large-scale structures. Japan, Europe and Canada participated this project, and will study the new concept of production system for housing.

5. Research and Development in Construction Management

In the area of construction management, various systems, which use advance information and telecommunication technologies, are developed. With popularization of Internet, many companies developed in-house network by Intranet system. What they do is to make technical information database for assisting engineers on site. And they developed document production assisting system. Document forms or templates are stored in the database, and engineers can shorten the time to write a document. By using technical

information database, engineers on site can shorten the time to make the plan of construction operation.

Data conversion from design drawing CAD to construction drawing CAD is necessary to reduce time and error. Some companies developed those systems.

3D CAD system is used for construction process simulation. 3D CAD is not only used for production process simulation but for disassembling of temporally frame of automated building construction system. Fig.2 shows simulation of disassembling process by 3D CAD.

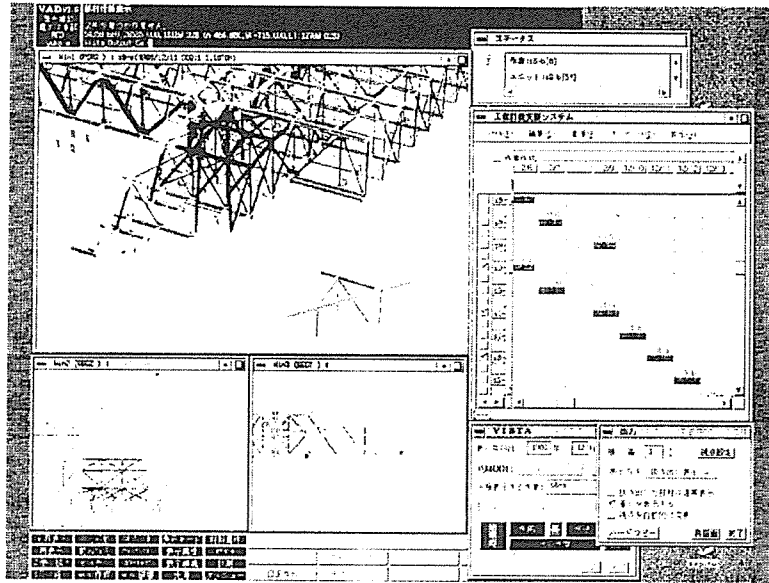


Fig.2 SMART system disassemble simulation

6. Conclusion

Research and development of automation and robotics in construction started early 1980's in Japan. Through R&D experience until now, we recognized what is effective and what can we do technically. Fully automated (worker-less) construction site, which was a dream of construction engineers, seems not to be feasible in the near future. But, to make impossible thing to possible is the aim of research and development. Computer is a good example, computer used to be less ability compared to its price. Now, new personal computer has much more power than old main frame computer.

Of course construction robot is not same as personal computer, but the performance will go up and the price will go down. We have to keep challenging mind to realize our dream.

References

1. Proceedings of the 6th Symposium on Construction Robotics in Japan (Japanese), July, 1997.
2. Proceedings of the 12th Construction Robot Symposium (Japanese), January 1998.