Current Status and Key Issues for Construction Automation and Robotics in Japan

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Abstract

At first, the current status of automation and robotics in Japan is introduced. Since the end of 1970`s much efforts have been devoted to automation and robotization of construction works. As the result, many types of robot have been introduced into the industry for improving labor conditions, productivity and quality levels. However, in spite of earnest effort of Japanese people, the number of automated machinery and robots is very small compared with robots which are utilized in manufacturing industry because of difficult conditions such as high R&D cost, narrow market, and so forth. For a breakthrough of this thick wall of hazard the author proposes promotion of international co-operation through IAARC and ISARC activities.

1. Introduction

In Japan, about 6,7 million people are involved in construction industry, and approximately 90 trillion yen is invested in a year for constructing airports, dams, highways, bridges, tunnels, harbors, office buildings, factories, homes, and so forth. The industry has been contributing to social infrastructures and economy of the nation. Even so adding value per employee of the industry is not enough, and working conditions are not comfortable like those of the advanced type of industries. Robot and advanced automation technology have been incubated in modern factories since 1950th. The technology has grown up in manufacturing industry and spilt out from the factory buildings and advanced technology of robotics has been transferred to the outdoor type application field.

2. Nation wide promotion activities

The first IAARC in Japan(the 5th ISARC) was held in 1988 in Tokyo. The symposium was held with 500 participants and it was very successful with contribution of many overseas guests. The symposium gave big impact to the Japanese society and it was the first experience of tight co-operation with the people in building and heavy structure construction and robotics field. In the following year a nation wide league of construction R&D co-operation named " Council for Construction Robot Research" was founded. The council was organized by six construction robot research organizations, such as Japan society of Civil Engineers(JSCE), Architectural Institute of Japan(AIJ), Robotics Society of Japan(RSJ), Advanced Construction Technology Center(ACTEC), Japan

Construction Mechanization Association(JCMA) and Japan Robot Association(KARA). The council has been holding yearly construction robotics symposia(five domestic and one international), and widely promoting construction robotization. Another important role of the council is supporting IAARC and ISARC. For such a purpose, CCRR has been sending delegates of each ISARC held in foreign countries. In 1995 the council made a survey of construction robot research and diffusion activities in each member organization, and reported on the proceeding of the 5th Symposium for Construction Robotics which was held in 1995.

3. Challenging big projects in construction automation fields

Beside R&D of each construction robot, some larger projects are going on. Some of them are introduced as follows:

1) Tele-earth work system at foot of Mt.Unzen-Fugen.
Several years ago, Mt.Unzen-Fugen volcano in Kyusyu Island made big eruptions and hundred millions of tons of hot soil and rocks have flown down, many houses were damaged and some people were killed. The volcano is active even today, and the Ministry of Construction asked general constructors to restore disaster area with introducing wireless remote control construction machinery and operate them from separated safe places. Fig.1 shows a scene of earth work with remote controlled unmanned earthwork machineries.

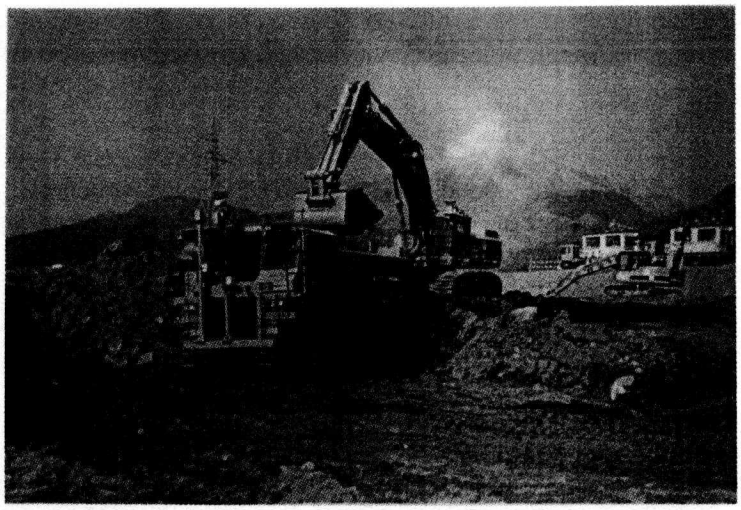

Fig.1 Tele-earth Work System at Foot of Mt. Unzen-Fugen
(Courtesy: Kumagaigumi Corp.)

2) Automated weather-unaffected building construction system
This epoch-making integrated building construction system for easiness to applying construction robots was invented about 10 years ago in Japan. The upper floor is assembled first and becomes a building production plant and a roof for protecting operators from snow and rain. The roof like plant is sliding up after assembly of the under floor is finished. By introducing this type of the system. They can raise labor productivity, working conditions, shorten construction period of time, reduce construction waste, and so forth. This method has been introduced by several leading

general contractors, and it is anticipated to become a new wave of building construction. Fig.2 shows an example of this system.

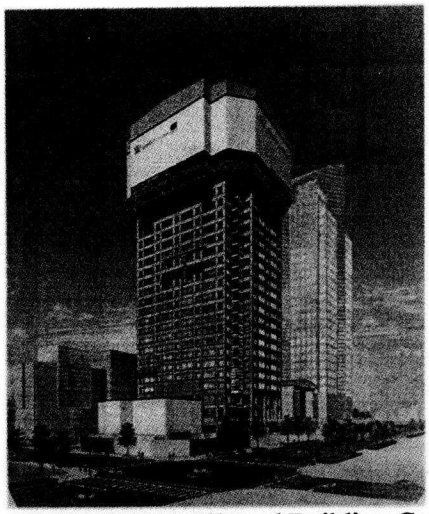

Fig.2 Automated Weather-Unaffected Building Construction System
(Courtesy: Shimizu Corp.)

3) Automated tunnel construction system
Recently many tunnel construction projects are going on in our country.
Fig.3 shows the world biggest size under sea bottom tunnel construction system which is composed of 14.14m diameter shield machine and automated segment handling and assembly system. With this automated construction system several hundreds of pieces of heavy segments(10t/piece) are automatically assembled for lining inside wall of the tunnel.

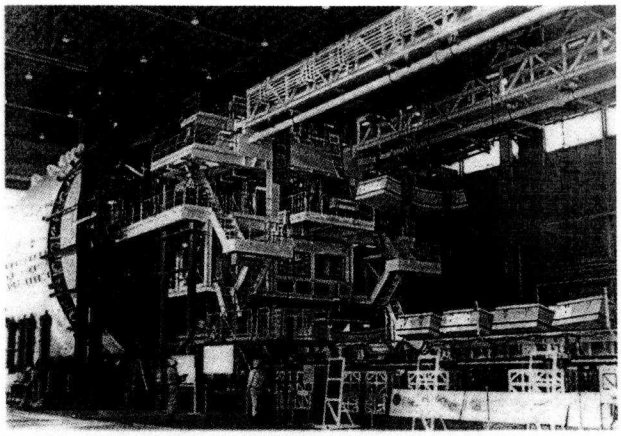

Fig.3 Automated Under Sea Bottom Tunnel Construction System
(Courtesy: Trans Tokyo Bay Highway Ukishima-South Office)

4) Innovative intelligent field factory international co-operative research program
The purpose of this research program is transferring innovative intelligent automation technology from in door factories to the field factories by international research co-

operation.
Fig.4 shows an image of the developed intelligent field factory, and utilization of innovative technologies such as cyber space, virtual reality, intelligent robotics, and so forth are considered. The project is sponsored by the Japanese government, and we are looking for overseas participating organizations earnestly.

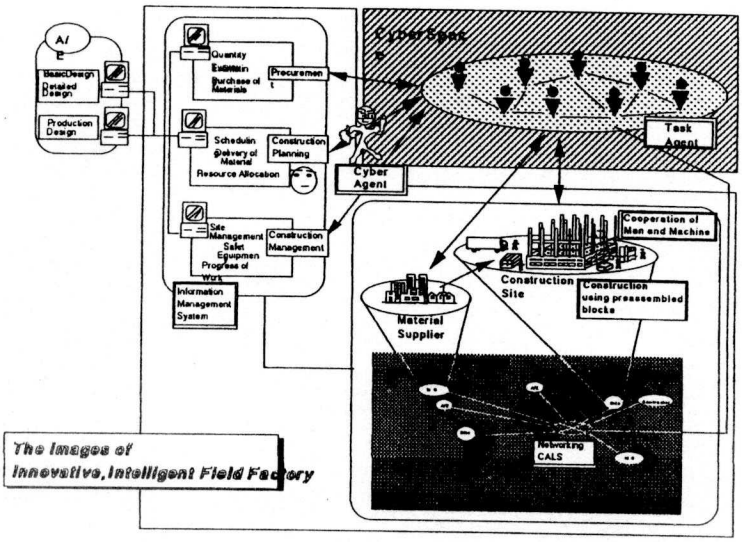

Fig.4 Image of Innovative Intelligent Field Factory
(Courtesy:IMS Center)

4. Automated construction technologies and construction robots are diffusing into Japanese construction industry

The automation committee of Japan Construction Mechanization Association has been making a questionnaire survey of construction automation and robotization every two years. Some topics of the newest survey is introduced as follows:

1) Purpose of construction automation and robotization. The following items were answered.

Table 1 Purpose of Automation and Robotization

Purpose	Share	Accomplishment ratio
a. Working condition improvement	15%	58%
b. Easiness of operation	12%	43%
c. Safety promotion	16%	62%
d. Cost saving	5%	20%
e. Performance improvement	14%	75%
f. Quality improvement	12%	49%
g. Labor saving	18%	50%
i. Unmanned operation	8%	69%

2) Expense of R&D

Maximum expense for one machine was ¥500M(a tunnel machine) and more than ¥100M was 42 items. The average expense per item was ¥75M.

3) Diffusion level of automated construction machines and construction robots.

Most diffused items and actually operated numbers are as follows:

Table 2 Popular robots and their working numbers

Item	Working number
a. Wireless controlled steel beam assemble manipulator	460
b. Mortal splaying robot	265
c. Automated road surface cutting system	113
d. Remote control panel handling manipulator	105
e. Automate snow removing glader	94
f. Concrete floor finishing robot	30
g. Automated dam wall concrete form	26
h. Heavy duty remote control manipulator	20
i. Steel beam welding robot	10
j. Steel piller uprightness measuring system	10

They reported that the number of machines which are working more than 10 pieces are 38 items. From these figures we can understand that we are already getting in the construction robotics age.

5. Necessity of international co-operation for coping with difficulty of construction

Today about 400,000 robots are used in our manufacturing industry. It means that the people who are involved in manufacturing industry are fully enjoying the fruit of automatization and robotization for improving their working environments, shortening working hours, raising salaries, and so forth. In construction industry, in spite of earnest effort of the people, we have not reached the state of enjoying result of automation and robotization R&D effort. The author understands that it comes from the following difficult conditions in construction industry.

1) More R&D cost and difficult research themes

The result of the above mentioned survey shows that R&D of heavy, big construction robots need more R&D funds, and also we need to cover particular R&D themes of construction robots. For promoting our research activities, we need to find research funds internationally and put together for the same purpose.

2) Small market and few robot sales

The author feels the market size of construction robot is very small compare with the manufacturing industry. Therefore we must consider to standardize the robot, exchange the R&D results and also get together the opportunity of the robot application.

3) Restructuring the industrial structure of construction for meeting the robot age
The construction industry is consisted of multi layer structure of general contractors, sub-contractors, construction machinery manufactures, engineering design office, and so forth. We need to re-organize the structure of the industry from the standpoint of easier utilization of advanced construction technologies.

4) International information exchange as the activities of IAARC
International exchange of the information of construction robotics through IAARC will much encourage the people in this field.

5) Recruiting young earnest people into this field
International exchange of educational knowhows, and attracting young people, is very important for the future of construction robotization in the next century.

6. Conclusion

The working conditions of manufacturing people has been dramatically improved since a half century ago by introducing and utilizing advanced automation technologies. It is not easy and will take longer time for modernization of construction industry than expected. Even so, by tight international co-operation, we shall be able to make the industry more attractive with fruits of automation and robotization.

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