A NEW WAVE OF CONSTRUCTION AUTOMATION AND ROBOTICS IN JAPAN

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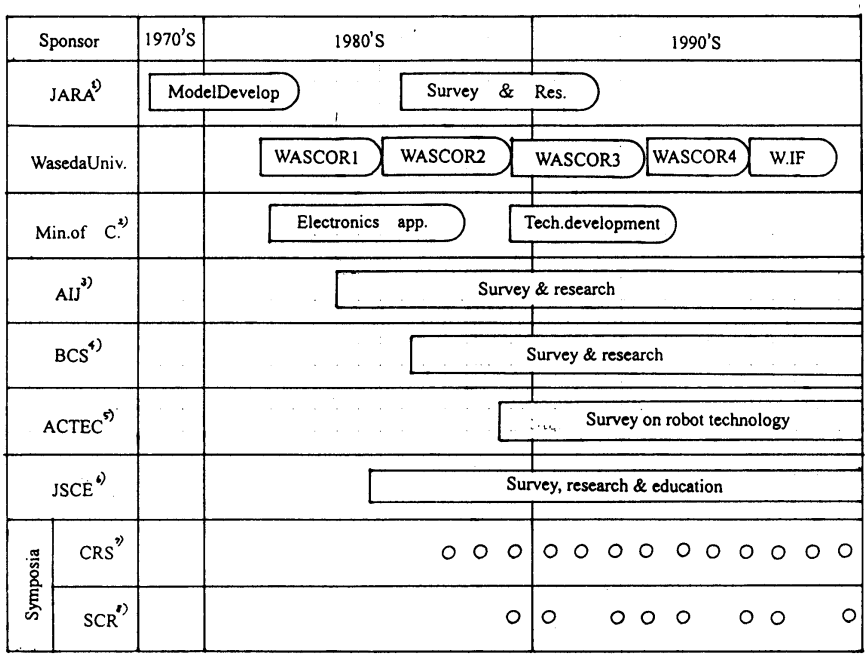
Abstract: In Japanese manufacturing industry, research and introduction of automation and robotization was started in 1950's. In 1970's they were enjoying fruits of their efforts and labor productivity and labor conditions were much improved. Following that of manufacturing industry the research in construction industry was started around in 1980's The nationwide research activities and the research results are introduced. Also challenging activities to the future is discussed.

Keywords: automation, robotics, construction, research projects, wireless control, new Concept, computer simulation



1) Japan Robot Association 2) Ministry of Construction 3) Architecual Institute Japan
4) Advanced Construction Technology Center 6) Japan Society of Civil Engineers
7) Construction Robot Symposium 8) Symposium on Construction Robotics

Fig. 1 Trend of Construction Automation & Robotics R & D in Japan

1. INTRODUCTION

In Japan, over 6 million people are involved in construction industry, which is about 10% of the working population and they are constructing airports, harbors, dams, highways, railroads, factories, schools, office buildings, homes, and so forth.

The industry has been contributing to the enrichment of social infrastructures of the country. However, adding value per employee of the industry is not enough, and working conditions are not comfortable compared with that of the advanced type of manufacturing industries. Robots and advanced automation have been incubated and introduced into manufacturing factories since 1950's. As the result, labor productivity in the industry dramatically increased and the working conditions of the people in the industry were much improved.

The advanced automation and robot technologies were started to spill out from the factory buildings and gradually transferred to outdoor type construction industry.

2. NATIONWIDE PROMOTION ACTIVITIES

The first construction robot Co-operative Research was started in 1978. The research project was sponsored by Japan Industrial Robot Association, and developed the robotized building construction systems by the research project team composed of specialists from universities, robot manufacturers and general contractors. The research projects took a role of trigger which started construction robot research in the country. Since around 1980 many general contractors rushed into the construction robot research. Fig. 1 shows construction robot research activities in the country and many new robots and automation systems were developed.

3. CHALLENGING RESEARCH PROJECTS IN AUTOMATION AND ROBOTICS IN CONSTRUCTION

3.1 Automated weather-unaffected building construction system

About 15 years ago, an original idea was invented by a university-company co-operated research group members. The purpose was to concentrate the place of robot working on one floor , and save the waste time to carry the robots to different floors. Instead, push up the completed floor. The upper floor is completed first and becomes a building production plant and a roof for protecting operators from snow and rain. Next when a roof- like floor plant is finished the underneath floor becomes construction plant, and after completion the floor is pushed up. By introducing this type of construction systems they can raise labor productivity, improve working conditions, save construction waste, and so forth. Today this method is introduced into about ten leading general contractors and it is anticipated to become a new wave of building construction.

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Fig. 2 A case of automated and weather- anaffected building contraction system

No.	System name	Application start year	Bldg. size(㎡)	Developer
1	Roof push up	1990	11,880	Takenaka
2	SMART	1992	20,657	Shimizu
3	T.up	1993	110,918	Taisei
4	MCC	1993	6,614	Maeda
5	ABCS	1993	10,190	Ohbayashi
6	Akatuki 21	1993	13,065	Fujita
7	Big Canopy	1995	23,469	Ohbayashi
8	AMRAD	1993	3,408	Kajima
9	FECS	1993	34,867	Goyo
10	RoofROBO	1993	8,624	Toda

Table 1. Cases of automated weather-Unaffected building construction system

Also Table 1 shows the cases of this new-building construction system.

3.2 Unmanned Tele-earthwork system

About 10 years ago Mt. Unzen-Fugen volcano in Kyushu Island burst into big eruptions and hundreds of millions tons of hot soil and rocks flew down, and many houses were damaged and some people were killed.
The volcano is active even today, and the Ministry of Construction requested general contractors to restore the disaster area with introducing wireless remote control construction machines and operation team from separated safe places.

Fig. 3 shows a scene of the earth work with remote controlled unmanned earthwork machineries. Today,

the volcanoes in Hokkaido and Izu Islands are active, and the application of the systems is being considered again.

Fig3. A case of remote controlled *un-manned earth work*

3.3Automated tunnel Construction System

Recently many tunnel construction projects are going on in our country. New underground railways, highways and sewerage systems are being constructed. Fig. 4 shows the sea-bottom tunnel construction system which is composed of shield machine and automated segment handling and assembly systems. This system is contributing to increasing productivity and shortening construction period of time of tunnel construction work. The similar system was successfully applied to the construction of the Dover Tunnel.

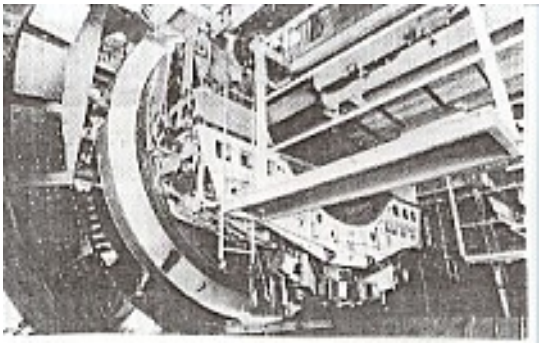

Fig.4Automated tunnel construction system (courtesy: Kawasaki Heavy Industries)

4. DEVELOPED AND COMMERCIALLY USED CONSTRUCTION ROBOTS

Since the start of R & D of construction robots about two decades have passed. As the result of continuous effort of the dedicated people, some of them are commercially used in construction sites.

Fig. 5 shows the radio controlled steel beam handling robot for the steel beam assembly work. Byintroducing this robot, the workers are released from dangerous, highly elevated operations.These robots are commercially supplied more than 400 pieces today.

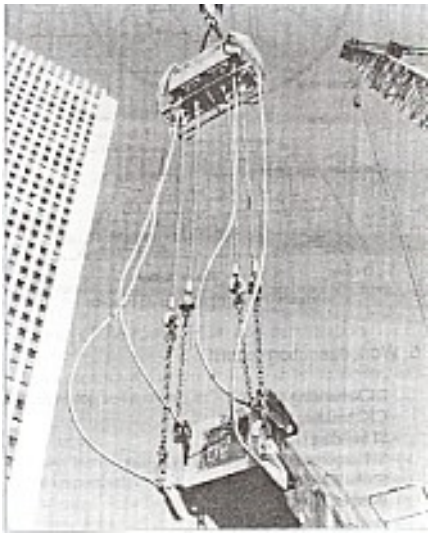

Fig. 5 Radio controlled steel beam handling robot (courtesy: Shimizu Corp.)

Fig.6 shows the concrete floor finishing robot. The robot was developed in comparatively early time and it does 3 operators' work of concrete floor surface finishing. Now over 30 robots are being used in many construction sites.

Fig. 6 Concrete floor finishing robot (courtesy: Kajima Corp.)

According to the survey of IAARC, more than 100 types of construction robot prototypes are tentatively used in many Japanese construction sites. Those new robots will be gradually but really utilized and commercialized by continuous efforts of the people in this industry.

5.CHALLENGING TO THE FUTURE

Since 1980's people who are involved in automatization of construction work have eagerly been devoting their efforts. Because of the difficulty of the research theme, w have not yet reached the stage to fully enjoy fruits, but we feel some new tiding wave to solve the problem as follows:

5.1 Conceptual change of construction work

Until today the people in construction industry have generally understood that the main construction operations should be carried out in the construction

sites. Therefore most of the tools are portable, and fabricating and assembly work is done outdoors, and design function and construction function were not yet integrated. The recent efforts of rationalizing the industry reached the point to integrate planning, design, fabricating and assembly process like manufacturing industry.

Very recently, the design information is immediately transferred to construction process planning department and the design specification is carefully studied and refined from the standpoint of automated member fabrication and assembly.
By this consideration, previously separated these functions are combined and integrated as the big construction system. That conceptual progress is considered as the trigger of construction automitization.

5.2 *Rationalization of the construction Industrial structure*

Until today the structure of construction industry was much complicated. Under one general contractor there were many multi layer sub and sub-sub contractors. Most of them are small enterprises and they have no capacity to make technological progress. To simplify the structure of the industry and give an opportunity to let them utilize the technical specialty is important.

5.3 *Full scale utilization of new advanced technologies*

The Recent rapid progress of information technology gives a big merit to construction industry. For instance, quick diffusion of portable telephone and internet systems are solving the handicap of construction industry, because the construction sites are located distant places to each other and relocate often times. Also the progress of GPS enables to set an exact position in the outdoor environment. By applying laser technology, we can measure far more accurate distance today. By introducing CAD and computer aided simulation technology it is possible to make the plan of construction work down to more detailed points. Fig. 7 shows the flow of advanced construction technologies..

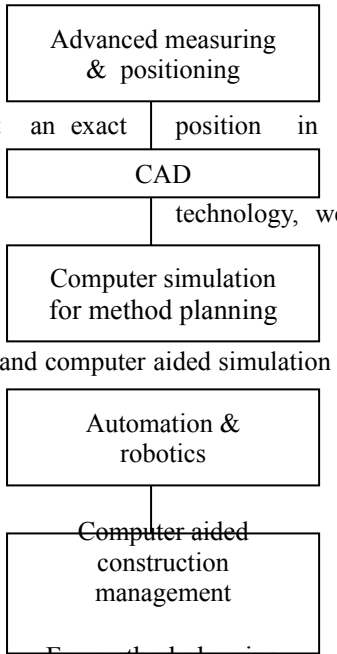

Fig.7 Flow of advanced Construction technology

6. CONCLUSION

In the 21st century the construction industry will make substantial progress by introducing new advanced technologies.
The author anticipates that the flexible automation and robot technology will take the major and important role for the future progress of construction industry. For such a purpose our international co-operation will be indispensable.

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