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THE SURROUNDING OF CONSTRUCTION INDUSTRY  
AND PROBLEMS OF AUTOMATIZATION AND ROBOTIZATION  
IN CONSTRUCTION OF JAPAN

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1. Forword

It is said that, "A robotization is the most difficult field in construction industry", "Needs for automatization and robotization precede in the construction field", "Compared with other industries, automatization and robotization have not well developed in construction industry". There are various opinions for the definition for robotics in construction. When we think about automatization and systematization, it may fairly be said that mechanization and automatization and robotization in construction field have developed better than other industries.

Because of special circumstances in construction industry, realities of constructing sites have not shown people's eyes. But efforts for constructing methods centering around large sized machines and automatization and systematization and robotization of constructing machines have been made since olden times and contribute to modernization in construction industry.

This thesis discribes the problems of automatization and robotization in constructing sites which will develop under demands of an age.

2. The surroundings of construction industry

Construction industry has more different aspects compared with the others in the industrial form and has special circumstances caused by that. Followings describe in three different aspects.

① Construction enterprise aims at construction of public structures (social capital) and is managed by nation, local public body and so on. Therefore, the reliance of structures are attached importance and it tend to be conservative for new methods which have not yet brought good results and for introduction of new technology.

② On the other hand, construction enterprise has been made as one of the pump-priming or a policy for unemployment workers. Therefore, the order system of construction works is controlled by leagal prescription and principle of market is hard to work. And the motive of technical development is hard to cause.

③ Except for a few construction companies, most of the companies are small and they have weak foundation of management, small power for development and introduction of new technology.

One hand, economical society in Japan is expected to have various kinds of changes towards the 21 century and innovation of technology and network of communication have been already flourishing in industrial field. In these circumstances, surroundings of construction industry are as follow;

(1) Progress of internationalization

Though Japanese internationalization has been out bound, import was rather selective including exchanges of people. Tokyo is the one of the largest financial centers in the world at present, and Japan itself has been inevitably a stage of internationalization. Internationalization in of whole japanese society will progress in various aspects; not only economy but also culture and

human interchanges, in future. As you could see that construction of international conventional facilities have been active, you may easily imagine that adjustment of social capital will go forward in this direction.

(2) Greying of population

According to statistical data, the ratio of the people aged 65 years or over occupies the people aged 15 years or over was 13.1% in 1985 and it will be 18.9% in the year 2000. It is estimated that the ratio of the people aged 65 years or over in the whole population will occupy 15.6% from 13.2%. Greying of population has an influence on not only the balance of the age composition but structure of working population. Furthermore, it will bring a change of consumption structure like a development of new markets for greying society.

(3) Progress of maturity

Japan is at a stage of maturity from that of catching up to advanced nations. And maturitization of economic society will progress in various aspects effected by internationalization and greying of population. We can see this by surveys of public opinions in which 'elevation of ability and culture' or 'one's hobby' ranks high as worthy matters for living. Then, progress of maturity comes upon as a variety of life worth living and a change of consciousness of people. From a viewpoint of adjustment of social capital, an increase of them and their superannuation will be a big subject. Centering around big cities the phenomenon of urbanization will advance, and density in every respect in society and economy will more progress.

(4) Innovation of technology and progress of information

Centering around electronics innovation of technology will progress rapidly, and new technology like a utilization of high technology will bring an impact upon social and industrial structure. Above all, a progress of high-level information will develop a network in every respect in society and economy, and bring a big change to social and economical structures.

The surroundings of construction industry in Japan are as follows;

- ① Progress of internationalization
- ② Greying of population
- ③ Varieties of life worth-living and change of consciousness
- ④ Increase of social properties
- ⑤ Development of urbanization
- ⑥ Development of technical innovation
- ⑦ Development of high-communication
- ⑧ Restriction of resource and energy

These innovation of technology and progress of communication will contribute to making social and economical structures which answer the various kinds of requirements produced from several consumption activities and will bring a big effect on progress of maturity.

3. Background of automatization and robotization

Companies have made some efforts for automatization and systematization for working methods and machines in the construction field for a long time. It is known that efforts for development of technology in the construction field where constructing methods by human strength had been settled have been made since then, and have gained good results. It is not long time since that the focus of research and development was taken on robotization as "robotics in construction". Though some construction companies have already proceeded with robotization as a subject of the research and development in 1970's, it can be

said that robotics in construction has appeared since 1980.

Tendency of automatization, systematization and full-automation in constructing sites has been expanded by the rapid progress of the lots kinds of high-technology like electronics. Expectation for robotization which aims at progress of working efficiency and insurance of safety has been increased. The research and development have been proceeded involving a lot of problem, and so some of robotics in construction has been in practical use.

Construction has been influenced by the constructed objects or nature environment. It has been thought that construction field is difficult for rationalization and labor-saving, as represented by three words; 'experience', 'courage' and 'educated guess'. Though investigating and constructing methods has been progressed in recent years, there are still a lot of problems which have to solved in the respects of theory and elemental technology to improve the image of construction field. It is true that these problems are obstructions for rationalization and automatization of whole construction industry. Now, efforts for automatization and robotization in the construction field have been continued in order to respond the subjects which are listed as follows;

- ① A variety of requirments for social capital has been caused by high-leveled life.
- ② No matter how construction is one of the principal industries, improvement of productivity is not shown compared with other industries.
- ③ Because of the credentialism of Japanese society, constructing workers have been aged and high-educated, and so experienced workers are lacking.
- ④ A rate of labor accidents is high and there are a lot of works in inferior environments (high place, high temperature and humidity, atmospheric pressure, underwater, nighttime, outside and so on). Therefore, there are few good impressions for the works as a common idea.
- ⑤ Many news are reported that the development of new material and technology have been proceeded actively in other fields.

These problems have been caused for a long time. Though we have recognized that they are hard to be solved immediately, we have made much efforts on development and introduction of construction technic.

As an effort for high-systematization of construction technology, we can consider two main respects: after gained a wide and better knowlege, to develop into a new field beyond thr sphere where construction industry dealt with, and to rationalize and to improve laber-saving and productivity, and to equalize the accuracy of construction.

The former presents an attitude to inherit and accumlate peculiar expertise from experienced engineers to develop the construction industry in new images by introduction and utility of knowledge which is used in other fields.

On the other hand, the latter aims at ;

- ① rationalization of management by a few picked staff
- ② to improve an existent image by making engineers free from hard works
- ③ equalization of investigation and accuracy of construction at a high level

Robotics in construction is in this category. It seems that both are going to be united, but they are going forward on their own ways under present conditions. As means to survive in future, high technology; new media, mechatronics, biotechnology, new developed material and so on; have become indispensable conditions for the field of construction.

In recent transactions of societies, magazines specialized on construction and research reports, plenty of theses and articles about hightechnology; which

have been proceeded by ministry of construction, construction companies, and related companies; are shown. Most of them are still in a category of trial or suggestion but we can see a positive attitude for research and development. Though one of the keys to resolve various problems which the field of construction holds is the hightechnology, they have just gone over the first hurdle of utility of technology of computers which have progressed rapidly in accuracy, capacity and speed. The road to robotization in the construction fields is far away and steep.

#### 4. Circumstances of automatization and robotization

Table-1, based on the data which was investigated as one of the activities of 'Robotics Committee in Construction' of 'Japan Society of Civil Engineers', shows the circumstances of research and development for robotics in construction in Japan. As a source material we divided it magazines and newspapers, and investigated theses and articles reported by eight magazines and seven industrial newspapers. We cannot assert that it precisely represents the circumstances of construction industry in Japan but it shows a transition of the research and development of robotics in construction in 1980's in Japan. The contents of investigations are totalized in each classifications which are chronology, companies, matters of development and documents respectively, but omitted because of space limitations.

The following are pointed that distinctions of the research and development for robotics in construction in Japan.

- ① A good result of the research and development started at about 1980-1983 has been brought in recent years.
- ② A number of the research and development started in 1980's has increased rapidly. And there were few results of the research and development reported before 1980.
- ③ Theme of the research and development covers at a wide range all over construction works.
- ④ The research and development have been propelled by large construction companies excepting a few manufacturers.
- ⑤ There is a tendency that the research and development have been propelled by various companies including medium companies in recent years (1986-1987).
- ⑥ A lot of theme of the research and development aim at automatization and full-automation of mono-function, not robotics in construction as one system.

Table-1 A number of reports of the research and development of robotics in construction which are chronologized.

YEAR	MAGAZINES	NEWSPAPERS
1981	6	10
1982	9	13
1983	16	19
1984	25	13
1985	28	48
1986	93	40
1987	135	72
TOTAL	312	215

#### 5. Subjects for Automatization and Robotization

The subjects in promoting the automatization and robotization will be described in four respects: technical, economical, on the system of developing and on the system of diffusion.



### 5.1 Technical Subjects

The needs of the arrangement of social capital are quite variable in Japan. Great development of constructing technic will be required to realize these needs and to develop the prosperous national land. Technical development is a necessary element for promotion of construction field which supports national land development. The three kinds of technical problems of automatization and robotization in construction field are as follows:

(1) Technical development for realization of the needs towards the social capital. The amount of investment in construction till the year 2000 is supposed to be 1,000,000,000,000,000yen. It is not difficult to imagine that constructing work in the future will not be the same as the one in the past in the various requirement and in the technical progress. Moreover it is important to manage the enlargement of the social capital stock.

① Technical development which answers various kinds of requirement

Social maturity makes various requirement for the arrangement of social capital and so will grow the requirement for the high technolization in the matters served by social capital. Besides, as it is expected to increase the more dangerous environment like in the sea, in deep underground, and in the over crowded city, the technical development which can manage the various kinds of construction will be required. Because the varieties of the requirements expand not only to the accumulation of the social capital and the services but also to the method and procedure of the arrangement of the social capital, the technical development is necessary in the stage of planning and research in order to fulfill the various kinds of requirement.

② The social capital will increase adding to the present accumulation year by year, and so the amount of social capital for maintenance and administration like repair will rapidly increase, too. The national requirement of arrangement of social capital will increase and it is necessary to add some new functions or services when repairing without deterioration of the standard of economical activities. The technical development to improve the existing facilities and to reduce the cost of social capital control will be required.

(2) Technical development to solve the present problems in the construction field. It is the indispensable subject and the prerequisite for fulfilling the new various requirements in the future to solve the problems in construction field now. In other words, the technical development in order to solve those various problems such as: inferior productivities, dangerous working environment, lacking of skilled workers and difficulty of quality and precision control, that is, to improve productivities, safety of working environment, quality and precision, and environment control should be the starting point of automatization and robotization.

(3) Technical development as a weapon towards the prosperous construction field.

The outgrowing of the construction field is required to become an attractive industry which supports the prosperity of Japanese economic society. An information oriented society and an international society is based on the superior arrangement of society capital. It is inevitable to develop the constructing technic in order to advance the new territories like the universe, underground and ocean. Also, technical development is required as a motive power which can make dreams come true.

Present subjects of technical development are as follows:

- ① Handling technic of the heavy-weighted
- ② a full-automatic carrying car, and transporting technic

- ③ sensor-equipment which can adapt to constructing site
- ④ technic and function which can stand for the inferior environment of constructing site
- ⑤ technic for miniaturize and lighten the functions
- ⑥ self-support and self-contained motive power

## 5.2 Economical Subject

- (1) About the expenditure of the development.

As the expenditure on development of constructing robot is enormous and it can be an obstructive factor, a step such as system of state subsidy and warm reception on a tax system by Nation has to be made.

- (2) Establishment of rental system.

Increase of expenditure makes the price of each constructing robot high and ratio of working low, and so the introduction of the step like rental system is inevitable.

- (3) Inclusion to the estimation.

The working cost increases because of the expenditure for development. To solve this problem, it is to include the expence of the development of the robot to the estimation of the construction.

- (4) Repayment of advantages for developer.

When automatization and robotization can save power, increase efficiency and make the cost of construction low, the developers and users most gain these benefits. Cost down of construction must not decrease a sum of money when receiving orders next time.

## 5.3 Subjects on System of development.

- (1) System of efficient that development of large-scale research only depends on private companies because this is rather risky. Development and research must be made by co-operation of nation, private companies, and universities and nation has to take the lead in efficient development and research.

- (2) Co-operative research of nation and private enterprise.

Development is risky and co-operative research is desirable for large-scale development. It is necessary to draw a clear line between each part and to secure the the advantages of private enterprises, that is, management of patent right, and so on.

- (3) Co-operative research of private company and private company.

The cases that many companies makes the researches on the same construction work and the same subject can be seen frequently. Each company needs to discuss about the development to avoid the duplication of expenditure and ineffective investment. It is important to co-operate among the companies.

- (4) Purpose of development.

Improvement of safety and working environment which is the essential purpose of development may be left behind when emphasis is laid on the power saving. Developers have to examine in various points of view.

- (5) Change and alleviation of law.

There are many methods and rules for human power which have been established for a long time. It is seen that introduction of system of automatization and robotization is difficult because of the old methods and rules in construction field. It is requisit to change and alleviate the law along the change of the world.

- (6) Co-operative system of industry, university and nation.

Constructing robot is the accumulation knowledge in various field, and it is also applied to high technology. It is necessary to make co-operative system of industry, university and nation.

(7) Standardization of design.

Though it is important to develop each elemental technic of the constructing robot at a time by necessity of constructing site, it is necessary to standardize the constructing objects in order to make superior environment for automatization and robotization.

5.4 Subject on system of diffusion.

(1) Making the environment that promotes diffusion.

It is important to make superior environment that promotes development and diffusion of constructing robot. It means to guarantee some volume of constructing works more than the fixed numbers when using the developed constructing robot, to preferentially order the constructing works that can use the same robot continuously, and to repay the advantages which are brought by improvement of working efficiency and quality to the builders.

(2) Promote of pilot enterprise.

Pilot enterprise that can adapt developed technic to the actual construction and make necessary change after checking the efficiency must be preferentially ordered.

(3) Securing developer's gains.

When the new technic is used, design and estimation should be carefully considered in order to secure the developer's gains.

(4) Adoption to public works.

It is expected that the machine, which is effective for improvement of productivity and working environment, is positively adopted to the public works.

(5) Training of technical experts.

Training of technical experts who are in charge of maintenance and control is necessary to use constructing robot actually.

(6) Improvement of quality.

It is the motive power of introduction of constructing robot to get the standardization of quality and improvement of working accuracy.

(7) Advantages for orderers.

The environment that orderers can get advantages is necessary when constructing robot is developed and the developed robot is ordered for construction.

6. Conclusion

We can easily imagine that constructing site will expand to the area as like underground, deep sea, and outside the atmosphere. Automization and robotization is unavoidable subject, willing or not. The time of automatization and robotization which is now just in the imaginary world might come earlier by the development of high-technology. We are looking forward to seeing that.

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