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Automation and Robotics in Construction: Social and Cultural Differences Between Japan and the United States

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ABSTRACT

In the past ten to fifteen years, many prototype robots have been developed, but few practical examples can be found on construction sites today. Nevertheless, several large Japanese contractors are aggressively pursuing R&D programs to introduce robots on construction sites. United States contractors exhibit little interest.

This paper evaluates construction automation and robotics technology in the context of its ability to satisfy the often conflicting demands of managers and owners, workers, and society in the United States and in Japan. In the United States, there is weak demand for construction automation and robotics. In fact, there may be considerable resistance. It is not surprising that technological developments have had difficulty gaining acceptance at the work site. In Japan, there is a great deal of demand for automation and robotics, much of it coming from workers and society in general. Technological developments have shown a strong ability to satisfy workers' and social demands, even if managers' and owners' demands of increased productivity, increased speed, and improved quality and safety have not been well satisfied.

Differences in cultural, economic, and business practices help explain why construction automation and robotics hardware is generating so much activity and investment in Japan while researchers in the United States focus on software.

INTRODUCTION

The Eleventh ISARC symposium announcement says, "The use of automation and robotics in construction is a real prospect. It is happening now. Whilst the enabling technology is continuing to be developed and refined, this is no longer the most significant barrier to progress." So, where are all the robots? What are the barriers to progress?

The fact is that most of the robotics hardware is being developed by large Japanese contractors. U.S. contractors traditionally perform little research, and some U.S. universities have veered away from hardware and are concentrating on software such as 3D CAD, Computer Integrated Construction (CIC), and management decision support systems.

Robots require both software and hardware. Why are U.S. and Japanese researchers taking such different approaches to robotics? The answer goes beyond technical challenges

and economic balance sheets. Fundamentally different industrial, social, and cultural systems dominate R&D efforts.

To help understand the differences in motivation for robotics R&D between Japan and the United States, it is useful to analyze the potential impact of robots on three different construction industry groups in each country. The first group is *managers and owners*. The second group is *workers*. The third group is the construction industry in general and *society* at large. Each group's demands differ from and often conflict with demands of the other groups.

Comparing the demands of the three groups to the potential satisfaction of those demands offered by automation and robotics in Japan and in the United States can help to explain differences in attitude toward automation and robotics R&D.

MANAGERS' AND OWNERS' DEMANDS

Construction managers and their clients, the owners, are primarily interested in profitability and satisfactory business performance. With respect to automation and robotics, managers' and owners' demands include increased productivity, increased speed of construction, improved quality, improved safety, constructability, and project economy (Arditti 1990). The types of managers' and owners' demands in Japan and in the United States are similar, but their magnitudes may be different.

In Japan, managers and owners expect the same success story for automation and robotics in the construction industry that has occurred in the manufacturing industry. Moreover, competition to increase market share and project a positive corporate image drives Japanese contractors. U.S. construction managers have responded to owners' demands for more cost effective construction with people oriented quality, safety, and productivity improvement programs, and information based technology rather than hardware.

Table 1 indicates these attitudes by scoring the intensity of managers' and owners' demand for automation and robotics hardware as weak in the United States and moderate in Japan.

WORKERS' DEMANDS

Construction craft workers are interested in job security, wages, safety, decent work conditions, and the reduction of heavy lifting and dirty, repetitive, and dangerous work. Several years ago, "3K", derived from "kitsui" (physically hard work), "kiken" (hazardous) and "kitanai" (dirty), became a fashionable term in Japan. Construction is said to be a typical "3K" industry, unattractive to young people. In Japan, although workers enter the construction industry knowing that the work will be physically demanding, hazardous, and dirty, the desire to improve "3K" working conditions is growing because working conditions in other industries have rapidly improved. In the United States, "3K" conditions are frequently considered to be part of the job.

The enterprise union (company union) is common in Japan while the craft union is common in the United States. Lifetime employment and the seniority system creates a much different relationship between unions and management in Japan as compared to the United States. Usually a single company union includes both blue and white collar workers, and the relationship between union and management is much more cooperative than that in the United States, though this cooperative relationship sometimes makes union bargaining power weaker.

		United States	Japan
Managers'/Owners'	Demand	weak	moderate
	Satisfaction	weak	weak
Workers'	Demand	weak	moderate
	Satisfaction	weak	strong
Social	Demand	weak	strong
	Satisfaction	weak	strong

Table 1. Demand and satisfaction for construction automation and robotics hardware in the United States and Japan.

This cooperative relationship comes from unique union and business systems in Japan. The union shares its fate with its company under the enterprise union system, so the union's advantage in wages, working conditions, and job security depends heavily on the company's business condition. Because the Japanese public holds strong negative images of labor disputes, good relationships with the unions are vital in management's maintaining a positive image of the company. Enterprise union members have little fear of losing their jobs to machines. Japanese workers are generally positive in their attitude toward automation and robotics (Muro 1990).

In the United States, the building trades unions have generally been less than receptive toward new technology. Traditionally, the relationship between managers and unions has been adversarial. One of the principal goals of unions and their members is job security. Labor saving technologies are often greeted with strong institutional and individual resistance. It is expected that the introduction of robotics and automation hardware in the construction industry will arouse considerable resistance among U.S. union workers despite the potential for reducing accidents and improving working conditions. Human barriers to implementation of automation and robotics include fear of unknown changes, a perceived threat of losing jobs or skills, fear of inability to handle new requirements and inadequate understanding of the need for change (Navon et al 1992).

Table 1 indicates these attitudes by scoring the intensity of workers' demand for automation and robotics hardware as weak in the United States and moderate in Japan.

SOCIAL DEMANDS

The biggest difference between the U.S. and Japanese demand for automation and robotics hardware is in social demands. In Japan, the "3K" image of construction is perceived by the workers, and strongly felt by the industry in general, the government, and the public. The negative image of construction has led to severe shortages of skilled workers, increasing wages and increasing the cost of construction. The Japanese policy of not allowing workers from other countries into Japan exacerbates the problem.

A Japanese Ministry of Construction's white paper identifies skilled labor shortages as one of the construction industry's main problems requiring immediate action. The Ministry of Construction planned the Industrial Structure Reformation Program in 1989 to improve productivity and help recruit young construction workers, among other goals (*White* 1990). One would expect robotics and automation to be an essential theme in the improvement of productivity and production processes. However, automation and robotics are also viewed as important components in the drive to improve working conditions, upgrade the industry identity, and attract young people.

To help accomplish these goals, the Japanese government allows favorable tax treatment for automation and robotics R & D. The federal government and professional societies play important roles; however, most R&D is conducted in-house by large contractors. The Big Five contractors each invest over $100 million per year in R&D, though not all in automation and robotics (Hasegawa 1988).

One reason is the difficulty of increasing market share in both public and private work. Until the recent political changes and bribery scandals, Japanese central and local government agencies employed a prequalification tender system. Only a limited number of designated contractors were invited to the bidding. The ability of contractors compared to the scale and the technical difficulty of the work was the main consideration for the designation. Contractors' capabilities were evaluated based on experience and accomplished volume in similar work. The chance of designation depended on past market share, making it difficult for a contractor to increase its market share in publicly funded construction. In private construction, long term client-builder relationships and strongly tied business groups characterize the Japanese business world. These groups impose barriers for outsiders, making it difficult for a contractor to find new clients.

It is not easy for contractors to increase their market share in either public or private work. However, if a contractor develops original new technology, it can attract new clients. Also, new technology can generate new construction demand and create a new market. Conversely, if a contractor falls behind in technology competition, it may mean loss of market share.

R&D is also used for public relations and advertising. By promoting new technologies, contractors try to polish their images (Yamada 1992). Corporate Identity (CI) programs have become very popular in the past several years in Japan. CI seeks to represent and communicate corporate philosophy and culture with logos, trademarks, symbols, and slogans.

Social demand is strong in Japan, but weak or non-existent in the United States. Labor saving is not a strong social demand because skilled labor shortages are limited to certain geographical areas and trades and the problem is more skill shortages than labor shortages. In the United States, training the abundant supply of unemployed or unskilled workers may be more practical than building expensive machines that may only put more people out of work. The U.S. construction labor force traditionally has been composed of white males. Minorities and women represent a huge untapped pool of potential construction workers. This is in contrast to the Japanese situation of not having enough people to fill the positions without going outside the country.

The U.S. construction industry has no unified public policy voice and no organized industry image improvement program. The U.S. market is being penetrated by foreign firms, but the industry as a whole does not seem to pay much attention. The U.S. government is the primary sponsor of robotics R&D for many academic groups. However, that research is directed to applications outside of construction. Providing job opportunities is far more

valuable politically than investing in technology that may be perceived as a threat to constituents' jobs.

A few examples of social demand for construction automation and robotics do exist in the United States. The hazardous environments of the Three Mile Island nuclear power plant prompted the only example of well organized R&D efforts by the government, private sectors, and university communities (*Japan* 1983).

In addition to nuclear power plant recovery and demolition work, underwater, outer space, and hazardous waste work have gained the attention of the U.S. government. Demand for outer space construction is currently limited to the federal space program. Cleanup of hazardous waste promises to be a growth industry and will likely include increased emphasis on machines rather than human workers. The Table 1 indicates these attitudes by scoring the intensity of social demand for automation and robotics as weak in the United States and strong in Japan.

DEMANDS VERSUS SATISFACTION

Demand for automation and robotics hardware in construction represents only half of the picture. To gain acceptance in the workplace, the new technologies must satisfy the demands for them. Technology push alone has not led to significant adoption of automation and robotics technology in construction.

Few practical or cost effective examples of construction robots can be found today, yet there remains a substantial interest in the U.S. research community and tremendous R&D activity by the large Japanese contractors. There must be other drivers keeping all this activity and investment alive.

By analyzing the ability of automation and robotics to satisfy various groups' demands, it becomes clear why construction automation and robotics hardware is such a hot topic among the large Japanese contractors and of relatively little interest to U.S. contractors and government agencies.

MANAGERS' AND OWNERS' SATISFACTION

For both U.S. and Japanese managers, the important issues are improved productivity, improved speed of construction, improved quality, and improved safety. Despite the introduction of many well publicized prototype robots, there have been very few examples of robots that can compete favorably with human workers. In both the United States and Japan, the ability of automation and robotics to satisfy owners' and managers' demands has been weak.

WORKERS' SATISFACTION

In the United States, workers' demands are primarily job security and wages, with working conditions secondary. Automation and robotics are a perceived threat to job security and wages, despite possible improvements in job conditions, so workers' satisfaction is given a weak rating. A common rebuttal to the notion that robots cost jobs is that new technology often creates new job markets with a net increase in jobs. While this may be true in a macro view, it offers little consolation to the workers whose jobs are eliminated.

In Japan, improved working conditions are considered very important compared to job security and wages. Automation and robotics are perceived to be of great benefit to

workers and there is little resistance to their introduction, so Japanese workers' satisfaction is given a strong rating.

SOCIAL SATISFACTION

In the United States, there is little social demand for construction robots. Neither the government nor the construction industry (Tucker 1991) appears to have much interest in supporting R&D or helping promote new construction technologies except for the few examples mentioned above. U.S. social satisfaction is given a weak rating.

In Japan, there is a great deal of social demand for automation and robots in construction. R&D is perceived to attract workers to construction, improve individual corporate images as well as the industry identity, and create new markets for construction. Even if no practical robots are developed, the impression that contractors are conducting R&D satisfies some social demands. Japanese social satisfaction is given a strong rating.

CONCLUSIONS

Table 1 summarizes why automation and robotics hardware is such a hot topic in Japan. Despite the relatively weak ability of automation and robotics to satisfy owners' and managers' demands of higher productivity, improved speed, quality, and safety, the strong ability of these new technologies to satisfy workers' and social demands more than compensates for current economic and technological shortcomings.

In the United States, there is little demand for construction automation and robotics hardware. In fact, there may be considerable resistance. Workers' and social demands are quite different than those in Japan, and automation and robotics do not satisfy the demands that do exist in the United States.

U.S. contractors, of course, have not totally abandoned the future. A 1991 Construction Industry Institute gathering of more than one hundred construction industry leaders concluded that computer and information based technologies such as integrated databases, simulation, expert systems, artificial intelligence, and CAD will influence construction for the next decade. Robotics will become increasingly important for off-site modular prefabrication, but not for field applications (Tucker 1991).

Many U.S. academics support the Japanese contractors' belief that field robotics will not only become practical in the near future, but they will become the logical and necessary final link in the drive toward integration of design and construction. Someday, hardware such as that being developed by the Japanese contractors will run on information supplied by computer systems such as those currently being developed in the United States. In the meantime, cultural and social influences are driving robotics R&D at least as much as technical considerations.

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