

The Study of The Building Construction Robots through The New Movement

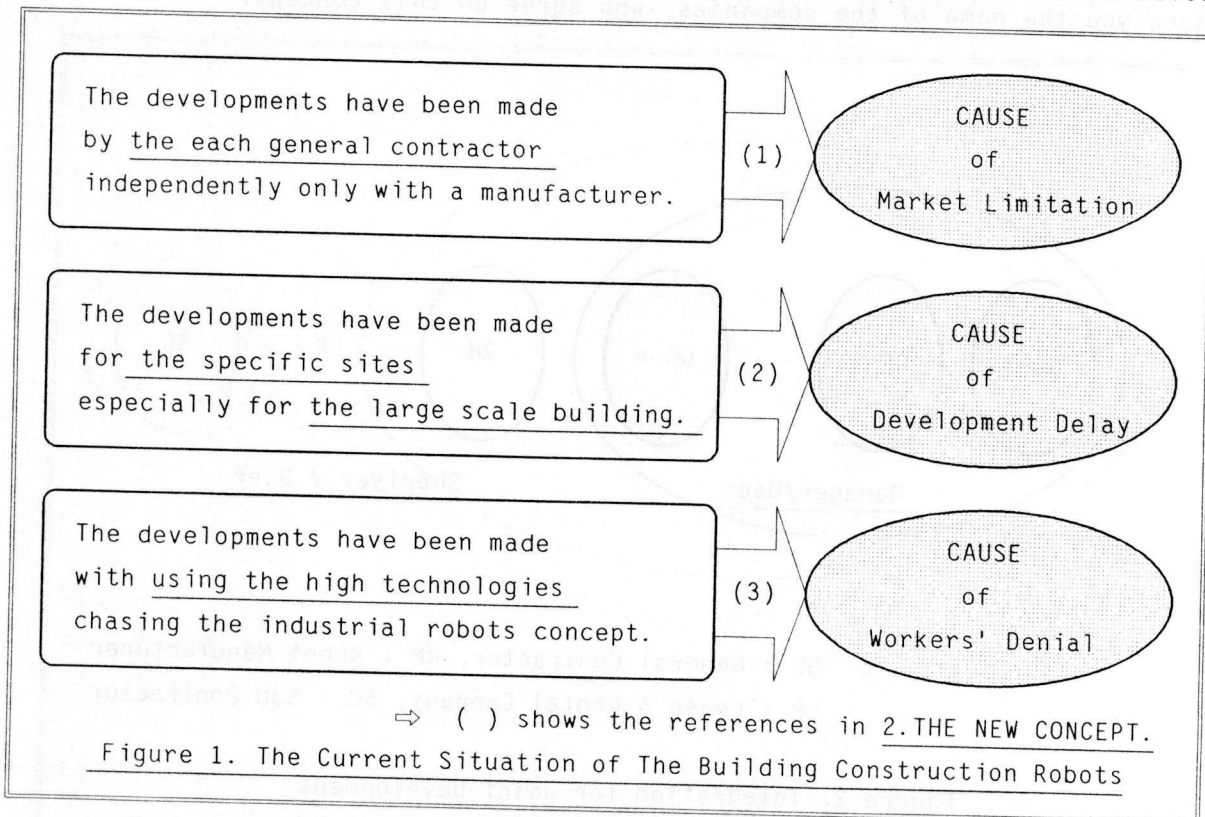
Fumio Shintani\* /Fuyuki Ishizuka  
Technology Department, Integrated Research Division  
The Japan Research Institute, Limited  
Kioicho Bldg., 3-12, Kioicho,  
Chiyoda-ku, Tokyo, 102 Japan

ABSTRACT

In this paper, the author presents the new concept of the development of the building construction robots and the activity based on the new concept. Although the experiment is now still under processing, it is the trial with about 30 general contractors and 10 manufacturers. Finally the author propose the future concept of robotization of the building construction from the view points of the construction methods, the research and development (R&D) and the labor forces.

1. INTRODUCTION

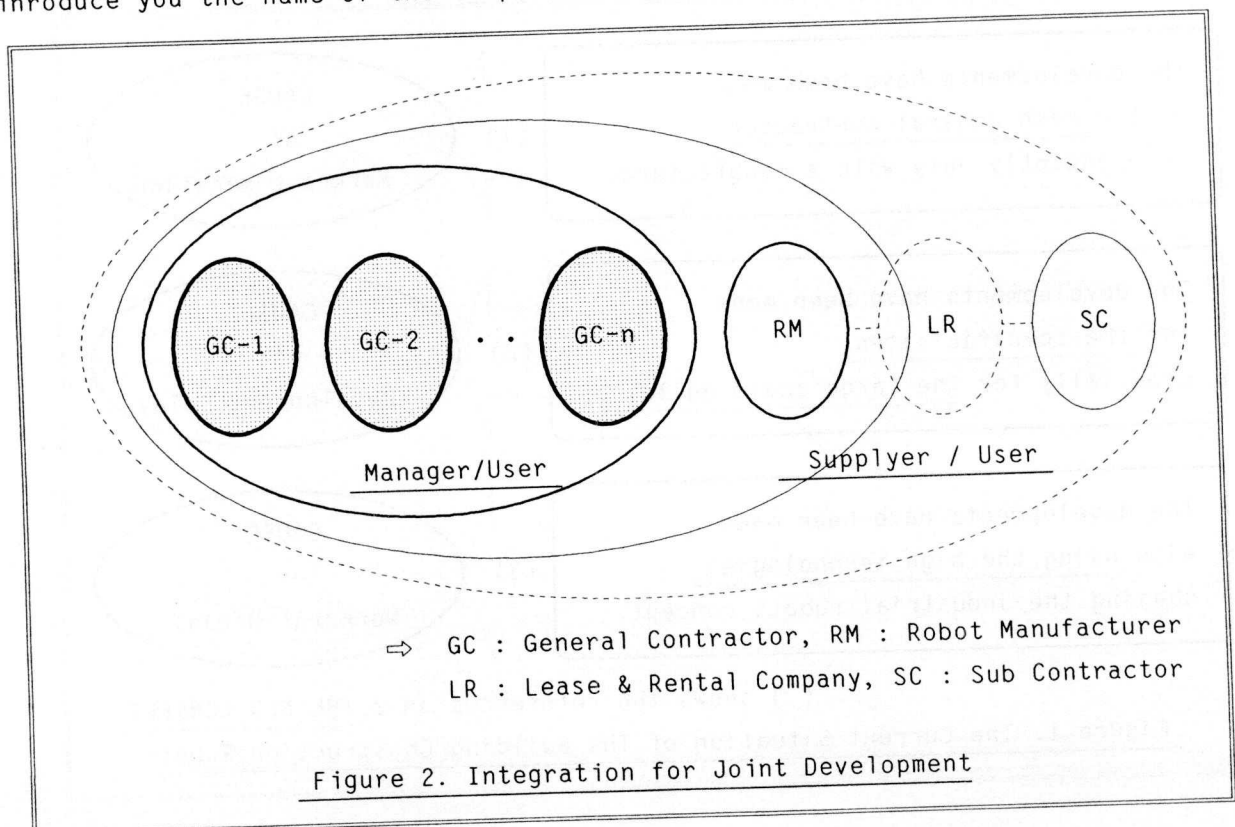
The current situation of the building construction robots are shown below.



## 2. THE NEW CONCEPT

### (1) INTEGRATED JOINT DEVELOPMENT CONCEPT (IJDC)

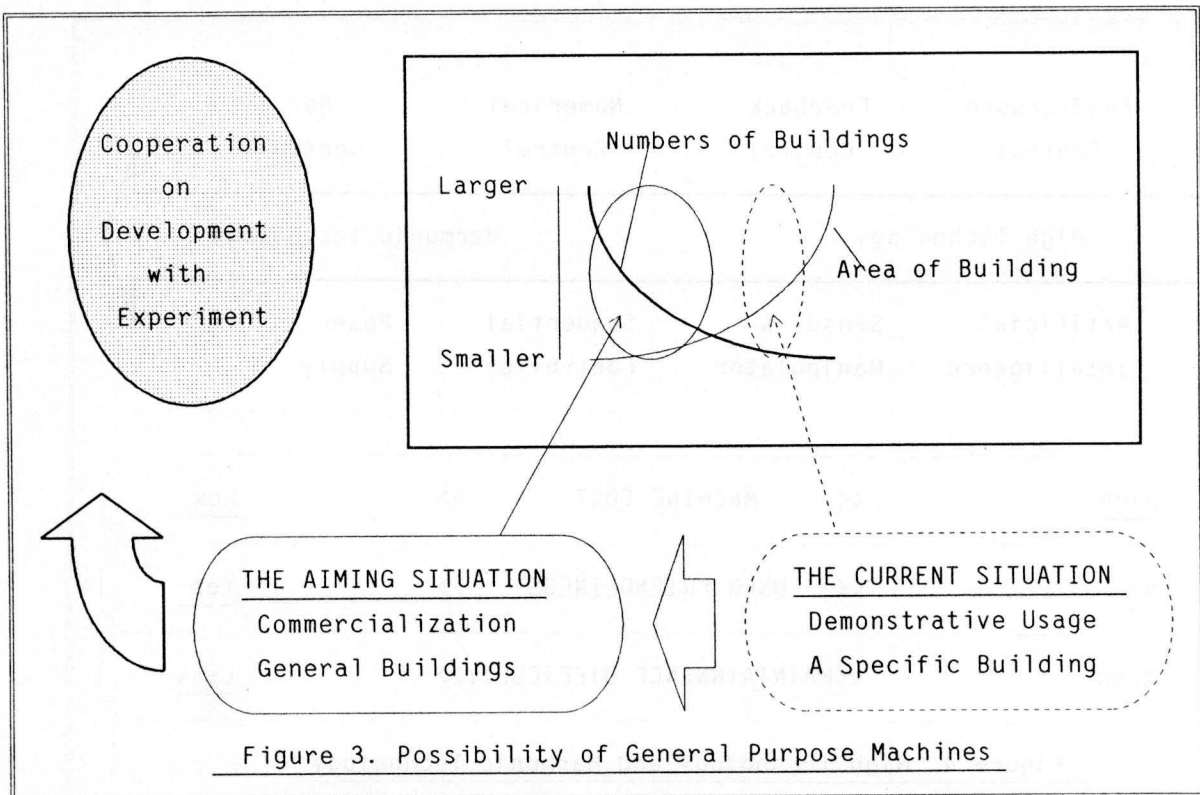
The effort of the development for the building construction robots has been made by the general contractors independently for 10 to 15 years. Of course there is no doubts that those efforts have contributed much for the identification of required technology. However because of the independent work of the each general contractors, it cause the market limitation. Sometime the ○○-brand robot may be hard to be used at the site of the ●●-construction company. To avoid this, INTEGRATED JOINT DEVELOPMENT CONCEPT may be one of the answer to assemble numbers of general contractors to eliminate the market limitation. Furthermore to organize robot manufacturers and sub-contractors is obviously the next step for the healthy development of the building construction robots, that is simply because to have real suppliers and users of the robots are important. With these members general contractors can roll as the managers to increase the productivity of the building construction. And the other member will be the lease/rental company who will enhance the market as a significant networker. It is now very clear that bonding managers, suppliers and users is the key concept as you can see in the Figure 2. At the end of this report we introduce you the name of the companies, who agree on this concept.



(2) INCUBATING PROCESS ENHANCEMENT CONCEPT(IPEC)

To think about the nature of development of machines, the key issue is to have the user's opinion continuously and reflect it for the advancement. The building construction robots are also the machines which must follow procedure above. Numbers of development have been made for the specific "land-mark type" buildings as the development of prototypes. However, those types of buildings are not so many in numbers and usually include new methods of construction, which mean the robots for these construction are more likely to be for specific usage and lacking of repeatability.

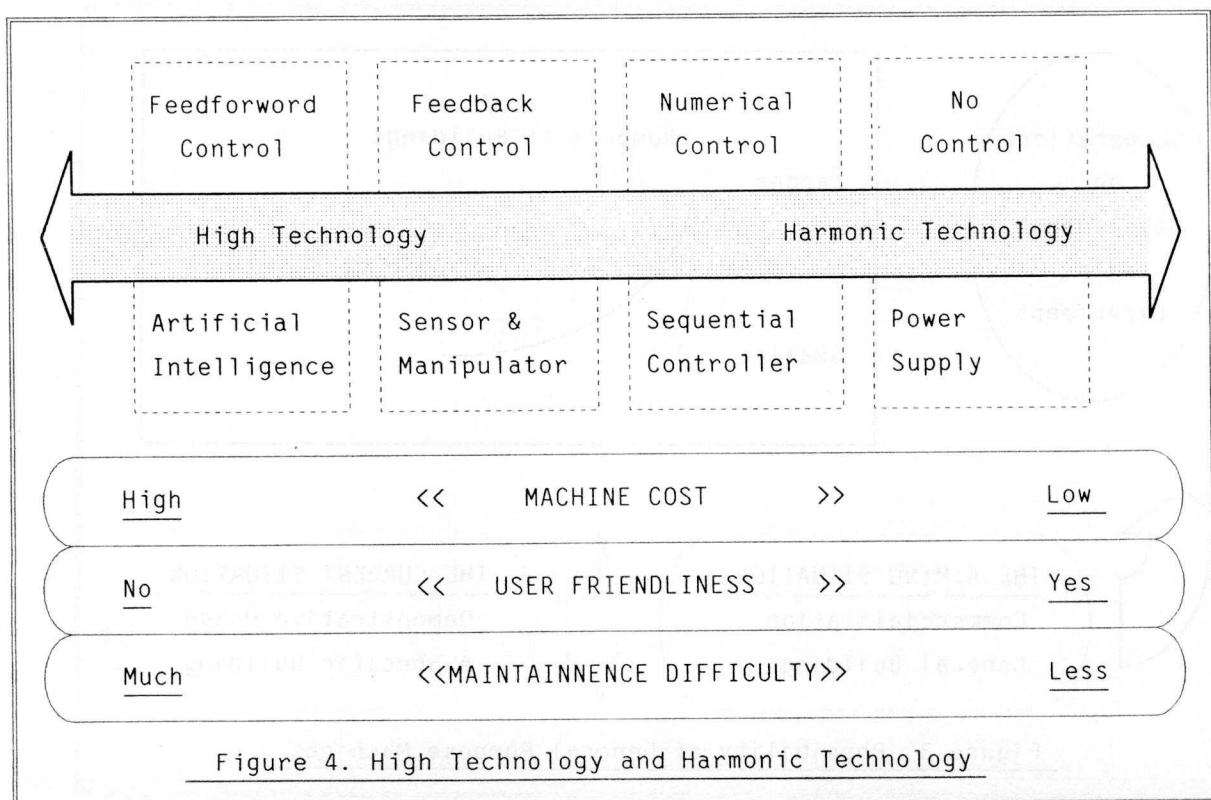
As shown in Figure 3., to keep the development process in shape, we should aim for small and midium size general building construction as a target of robots especially for the repeatability. And with this target, numbers of applicable building are much larger and this fact is also good for the manufacturers to incubate new business field. Furthermore to accelerate incubate process, general contractors and manufacturers should be cooperative not only in the process of development but also in the process of experiment and evaluation. With this INCUBATING PROCESS ENHANCEMENT CONCEPT general contractors will offer his sites to have the manufacturers be able to collect the information for advancement of robots.



(3) INNOVATIVE HARMONIC TECHNOLOGY CONCEPT (IHTC)

To do research and development, it is very easy to chase the state of art technology. In certain field, like electronic devices for home use, manufacturers are very competitive in developing products using high technology. However there are much aware of implementing user friendliness to their products. In the case of welding robots in plant, in the first stage they sold many robots includes small shops with 4~5 employers. The problem after that is workers are resistant to do teaching of those robots because systems are so complicated to be learned and it seems time wasting. This fact tells us that we should be very careful on developing the robots for the workers at the construction site whether or not the robots are user friendly.

To keep the user friendliness of the robots, there are two ways. The one is to design it quite operative by the human crews or to design with the state of art technology like artificial intelligence aiming for full automatic operation. However the latter has two problems concerning with the machine cost and maintainance difficulty, and also artificial intelligence is the technology still under developing. These are the reasons why we propose the INNOVATIVE HARMONIC TECHNOLOGY CONCEPT for the applicable building construction robots.



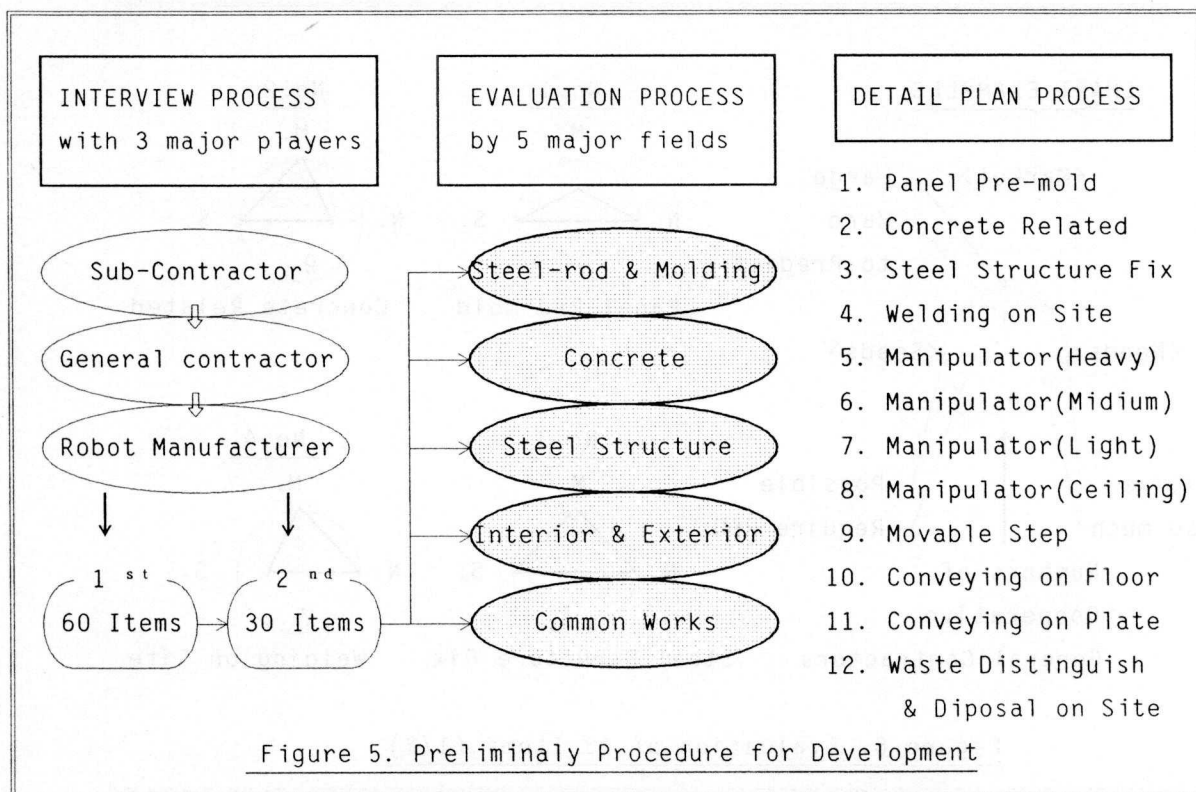
### 3. The Activity

#### (1) Procedure for Development

As you can see in the Figure.5 there are three main processes to find out what are the possible and required items to be developed.

First process is to collect information from the view point of users, managers and suppliers (30 candidates are selected by this process). Second process is to evaluate these 30 candidates by direct informative interactions of those users, managers and suppliers. In this process careful evaluation have done by each of five groups, such as "no concrete finisher can exist as far as good concrete levelizer come together". Through the second process twenty items are selected and DETAIL PLAN PROCESS is now under going by the one manufacturer and the numbers of general contractors with the support of sub-contractors.

In this third process, the conceptual design and the specification will be made by the fall 1992 and the development will be started from then, however, there are some difference in progress caused by the nature and difficulty of the each machine.



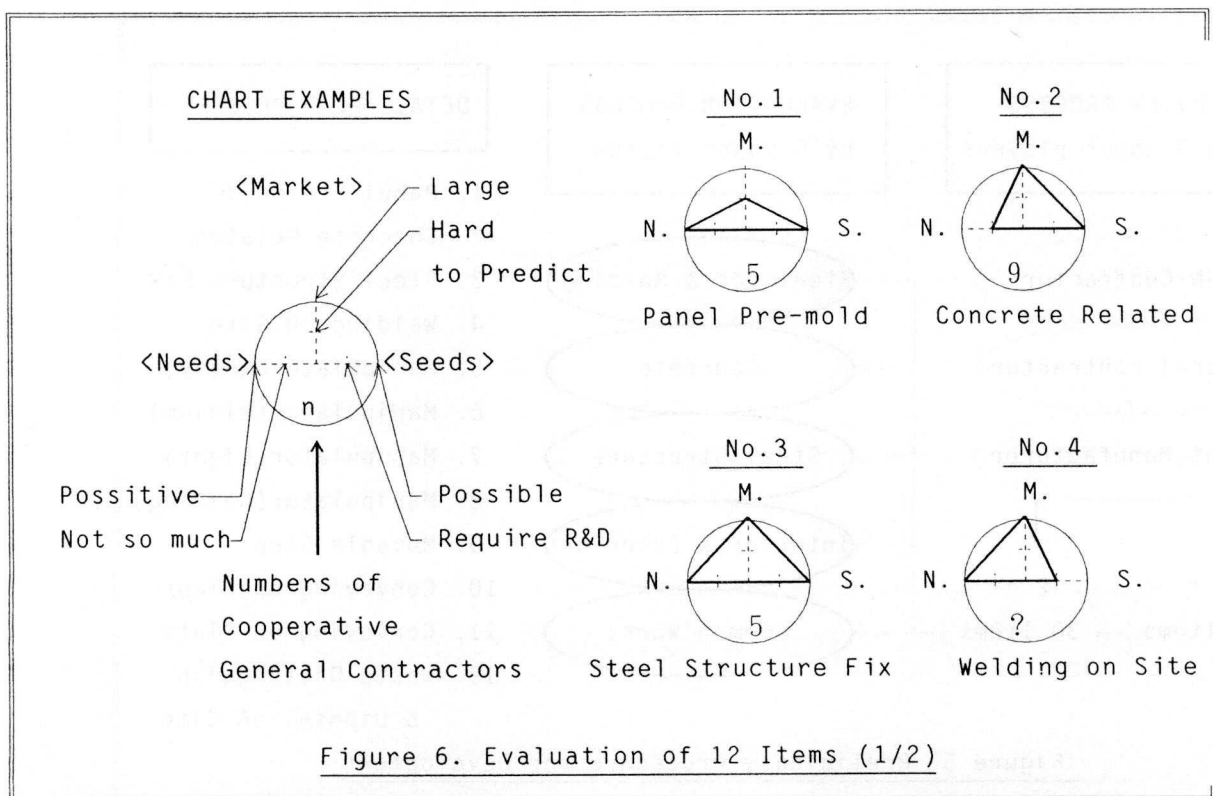
(2) Evaluation Results

Evaluation was made by the following three points of view.

- ① Business chance for manufacturers ( = Market)
- ② Strength of the needs of users and managers ( = Needs)
- ③ Possibility of technology ( = Seeds)

Except two items, - No.4:Welding on Site and No.12:Waste Distinguish & Disposal on Site - , each group has already started cooperative work. These are the items to which existing technology can be applied.

Concerning with No.4:Welding on Site, there exists large business opportunity and strong needs, however, it requires either the advanced welding technology or the new concept such as changing bevels or symbiotic work of human crew and robots. Also about No.12:waste Distinguish & Disposal on site, it is obvious that we can not consider the problem only on the site. Some boundaly conditions must be settled such as the nature of after-disposal site and the shape of transportation. For these two items, more deep investigation will be made next half of a year.



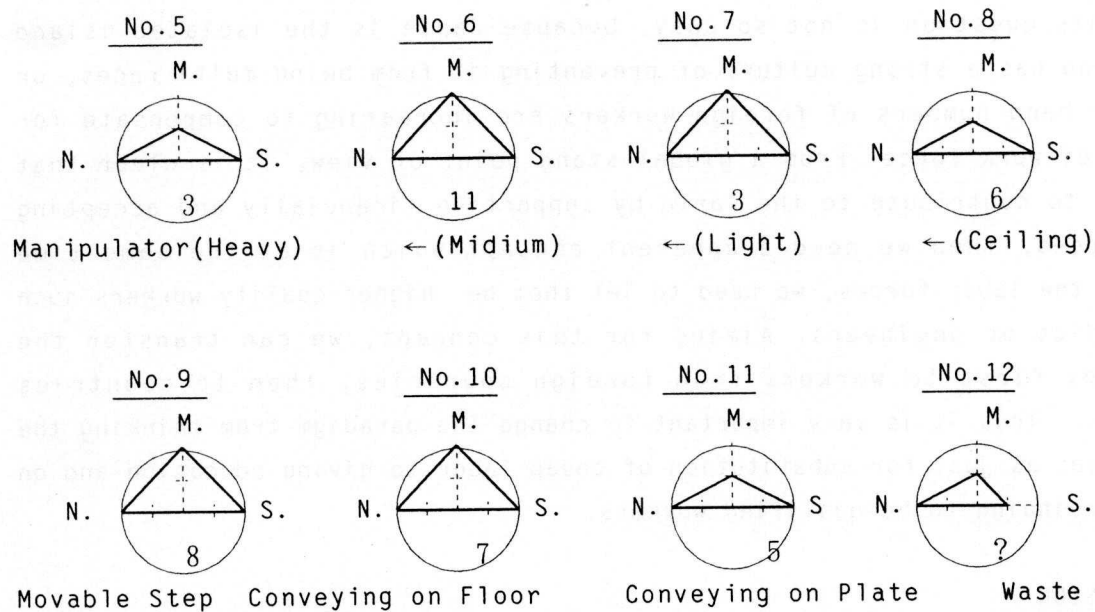


Figure 7. Evaluation of 12 Items (2/2)

#### 4. THE FUTURE CONCEPT

First of all, it was worth trying by the each general contractor to have done the research and development on independent items robotization. Because of these activity now we can easily find out the concept of the building construction robots. Now general contractors are working on the subject of fully automization using robotics technology. In this sense it is very clear that development of the building construction robots is in second phase. However, in the future, it will be highly possible that those two currents will be merged each other. For example the construction of the body will be mainly by the fully automization and the interior and exterior works will be by the independent items robotization.

From the R&D point of view, competition and cooperation can be both exist among general contractors in Japan. For the time being they are working together on developing independent items in the research and development consortium, and it will be the start point for the future collaborative works so that manufacturers and sub-contractors can be easily follow the movement of general contractors. So, in the future, in the phase of mergers of two current mentioned above the key concept will be the collaborative and cooperative R&D among the general contractors.

One of the biggest concern related to the construction robots is if the labor forces from the foreign countries could be the competitor for them. To answer this question is not so easy, because Japan is the isolated island country and has a strong culture of preventing it from being multi races, on the other hand numbers of foreign workers are increasing to compensate for shortage of work force. From a global stand point of view, it is clear that Japan has to contribute to the world by supporting financially and accepting labor forces. Then we need a apparent concept which is at the same time accepting the labor forces, we need to let them be higher quality workers such as mechanics or engineers. Aiming for this concept, we can transfer the technology first to workers from foreign countries, then to countries themselves. Thus it is very important to change the paradigm from thinking the labor forces as just for substitution of cheap labor to giving education and on the job training to be qualified workers.

## 5. CONCLUSION

We are trying to find out the solution to apply robotics technology to the building construction based on the three concepts IJDC, IPEC and IHTC with more than forty companies and will report continuously what will be going on. We will be glad to have any opinion or question related to this movement.

	PAST	PRESENT	FUTURE
Robotization of Independent Items	1 <sup>ST</sup> Phase	2 <sup>ND</sup> Phase	
Robotization with Fully Automation		1 <sup>ST</sup> Phase	2 <sup>ND</sup> Phase
R&D Concept of General Contractors	Competition(I)	Cooperation(I) Competition(F)	Cooperation(F)
Labor Forces from Foreign Countries		Substitution for Shortage	Mechanics or Engineers

Figure 8. What will happen in the future ?



Construction Robotics Consortium Member List

[ General Contractors ]

- Ando Construction
- Arai Corp.
- Asanuma corp.
- Chizaki Industry Co.,Ltd.
- Dai Nippon Construction Co.,Ltd.
- Daiwa House Industry Co.,Ltd.
- Fujita Corp.
- Haseko Corp.
- JDC Corp.
- Kajima Corp.
- Konoike Construction Co.,Ltd.
- Kumagai Gumi Co.,Ltd
- Maeda Corp.
- Matsumura-Gumi Corp.
- Mitsui Construction Co.,Ltd.
- Muramoto Construction Co.,Ltd.
- Nishimatsu Construction Co.,Ltd.
- Obayashi Corp.
- Ohmoto Corp.
- Penta-Ocean Construction Co.,Ltd.
- Sato Kogyo Co.,Ltd.
- Shimizu Corp.
- Sumitomo Construction Co.,Ltd.
- Taisei Corp.
- Takenaka Corp.
- Toa Construction Co.,Ltd
- Tobishima Corp.
- Tokyu Construction Co.,Ltd.
- The Zenitaka Corp.

[ Machine Manufacturers ]

- KOMATSU,Ltd.
- Kubota Corp.
- Nippon Gijutsu Center Co.,Ltd.
- Nishio Ren-all Co.,Ltd.
- Sanwa Kizai Co.,Ltd.
- Tadano,Ltd.
- Tamagawa Seiki Co.,Ltd.
- Toto Electric Industry Co.,Ltd.
- Yamakawa Engineering Co.,Ltd.
- Yanmer Diesel Engine Co.,Ltd.
- Yasukawa Electric Manufacturing Co.,Ltd