The concept of the parts oriented production system

Autor(en): **Kunugi, Takashi / Takada, Hiroo / Mine, Naoto**

Objekttyp: **Article**

Zeitschrift: **IABSE reports = Rapports AIPC = IVBH Berichte**

Band (Jahr): **79 (1998)**

PDF erstellt am: **22.06.2024**

Persistenter Link: https://doi.org/10.5169/seals-59949

The Concept of the Parts Oriented Production System

Takashi KUNUGI
Mgr
Shimizu Corp., Technol. Dev. Div.
Tokyo, Japan

Takashi Kunugi, born 1958, has devoted the last 15 years in the development of structural analysis software, production planning and control software

Hiroo TAKADA
Gen. Mgr
Shimizu Corp., Technol. Dev. Div.
Tokyo, Japan

Hiroo Takada, born 1942, obtained Doctor of Eng. at Tokyo Science Univ. and has devoted the last 30 years in the study of new construction methods.

Naoto MINE
Dep. Gen. Mgr
Shimizu Corp., Technol. Dev. Div.
Tokyo, Japan

Naoto Mine, born 1946, obtained Doctor of Eng. at Waseda Univ. and has devoted the last 26 years in the study of construction productivity issues.

Summary

The authors propose the PARTS ORIENTED PRODUCTION SYSTEM (POPS) as a revolutionary concept to solve the various problems currently being faced by the construction industry in Japan. The ultimate goal of this system is the pursuit of transparency of all information and all processes in construction production. It does not stop at construction performance processes but aims at reform in the construction production process as a whole, including design at the early stages, and at the parts procurement stage. At present, partial testing and application to construction sites is being carried out in order to verify the benefits of this system.

1. Introduction

Currently, the construction industry in Japan must struggle with problems related to productivity improvement and responses to the diversification of customer needs. It is predicted that in ten years twice the current level of productivity will be required. Meanwhile, customer needs are diversifying and becoming more sophisticated. The level of social requirements to buildings becomes higher and the trend of building requirements changes faster. This therefore results in the major problem of how quickly companies can provide buildings which satisfy these complex and diverse conditions. In order to do so it is necessary to break away from the labor intensive construction production systems of the past, and to undertake radical reform which incorporates all processes of construction production into the perspective.

The goal of the Parts Oriented Production System proposed by the authors is to make lower subsystems transparent in the early stages. Furthermore, by clarifying the mutual relationships between a variety of information, it will be possible to control quality, cost and work duration earlier than usual. This system makes it possible to rapidly realize buildings which satisfy the demands of customers.

2. The Concept of the Parts Oriented Production System

This system comprises three major subsystems. The first subsystem is design. Considering a building to be made up entirely of parts, it is possible to describe the building in terms of the properties of each part, i.e. the qualities and shapes of parts, and part unit prices. The designer then decides on the volume of the building as a whole, and the structure and layout of each space, taking into account the restricting conditions such as the demands from the customer, the site conditions and the laws and regulations which apply to the site. Next, in order to achieve the performance of each space, the designer selects the materials to be used in the parts which make the space, and decides on the dimensions after considering individual demands for each space and the building as a whole, based on existing design cases and the designer's knowledge gained from experience. In parts oriented design, the designer advances the design process by selecting the parts one by one based on his or her knowledge gained through experience and the attribute information of each part. If a designers wishes to make the most of his individuality in building or space, or if a conscious attempt is made to differentiate that building or space from others, original parts may be developed. It is also possible to use designs which intend parts replacement to extend the building's life. Through such processes as these, a list of the parts to be used in the building as a whole is completed, and it is easy to obtain the total numbers of each part including a total of each type of part, and a total unit cost.

The second subsystem is procurement and distribution. Procurement plans are formulated by referring to the parts list for each building provisionally decided upon in the design subsystem, and taking into account the process for each building. The design subsystem entails review of each individual item, but in the procurement and distribution subsystem, review is carried out to bring together the lists of parts for each building and to increase the quantity of parts purchased as much as possible. If it is judged that the performance of particular parts are roughly the same, but the quantitative effect against cost is higher for the parts of a different manufacturer, review must be carried out once more to establish whether it is possible to make changes in the design subsystem. If it is impossible to make one order due to slight differences in the delivery date, at the same time as reviewing the possibility to changes in delivery date at the construction site, the possibility of provisionally setting up a temporary stockyard at the company or the manufacturer should be reviewed. In addition, in order to purchase parts more cheaply, production planning of parts manufacturers shall be considered. It is necessary to constantly exchange information with parts manufacturers, and possess low-cost parts information in real time.

The distribution subsystem reviews how the procured parts will be delivered to the construction site. Up until now, there has been a high degree of reliance on manufacturers for the distribution of each part, and the distribution costs of parts have been tacitly added onto part unit costs. In the distribution subsystem, it is important to review conventional customs, to clearly differentiate part unit cost and distribution costs, and to develop a mechanism which enables cost control of the two. The necessary parts must be delivered to each construction site at the necessary time (just in time), but if parts ordered all at one in large quantities are shipped at the one-sided convenience of the manufacturer, the management at each site becomes confused. Two methods available to prevent this from happening are that the manufacturer maintains a temporary inventory, or the company provides a temporary storage area. Taking a look at the conventional state of carrying in materials to construction sites, there are many cases in which a large truck comes only carrying a minuscule quantity of materials. It is also important to review the ideal packing method and form of packaging for transportation based on the dimensions, shape, weight and material of each part. This would then make it possible to select a truck in accordance with the quantity, thereby improving distribution efficiency. Additionally, using the return trips of trucks which have carried in parts to recover temporary parts which are no longer necessary, and patrolling other sites located nearby will also contribute to improving distribution efficiency.

The third subsystem is pre-assembly. Most of the assembly systems in current construction production entail carrying out work continuously one by one on a final assembly line leading to completion. i.e. the straight line production system. Taking a close look at this production process, it is not necessarily the case that it must be implemented on a final assembly line. That is to say, there are a considerable number of parts which can be unitized or assembled into panels in a place inside or outside the site, before being installed on the final assembly line. If this parallel production system (hereinafter referred to as "pre-assembly") is used, it becomes possible in principle to divide up and carry out in parallel the production processes in accordance with the required work duration, thereby dramatically reducing the work duration. In unitizing parts or assembling panels, there is the method in which a production yard is set up and operated within the construction site, the method which uses the factories of manufacturers of related parts, and the method which uses a temporary storage area discussed in the distribution subsystem above. Whichever method is used, it is separated from the final assembly line (sub-line), and a good work environment may be expected. That is to say, an attitude which is easy to work in is adopted by creating tools to fit the parts, or deciding on supply routes for parts which minimize the walking distance of workers. Improvements in the work environment will also make it possible to simplify the work which conventionally requires highly developed skills. For example, if work done facing upwards is changed to work done facing downwards, that alone makes work easier to perform. This makes it possible to use unskilled labor, which in turn enables companies to keep the cost of labor down. In addition, when different occupations perform work one after the other, it becomes possible for workers from different occupations to perform simplified work. That is to say, it makes workers multi-skilled. The same may be said if machines are used on the sub-line. If simple regular position work is adopted, and processing machines are used, sophisticated machinery becomes totally unnecessary. Unlike conventional construction robots, there is no need for the machines to automatically approach the parts. Machines should be operated using cheap labor, with a mobile pedestal for the machines or the parts to be assembled.

A further benefit of the pre-assembly method is the prevention of unproductive waiting time. Conventionally in locations related to equipment and the interiors of buildings a variety of occupations become jumbled, and there is a tendency for workability to suffer. In such locations, by breaking away from a final assembly line, and assembling at a sub-line, not only is it possible to achieve a more spacious working area, but by establishing multiple sub-lines and making workers patrol on cycles which correspond with the cycles of the final assembly line, it is possible to prevent unproductive waiting time from occurring and to achieve dramatic improvements in workability.

The content of the main three sub-systems has been described above, and while these three processes have a slight time differential, work can be advanced simultaneously in parallel through cooperation. As mentioned at the beginning of the design subsystem section, by adopting an approach which recognizes that the individual parts which make up a building are separate and have their own unique attributes, it suggests the possibility that matters which may have seemed extremely complex in the conventional macro perspective may be able to be organized clearly.

3. Application

In order to verify the effectiveness of this concept, the authors are carrying out construction testing assuming actual construction, and are applying this concept to construction sites. Two cases are presented here.

3.1 Utilization of Multi-skilled Labor in Interior and Equipment Works for Multiple Dwelling Housing

Conventionally, the systematization of construction of interior and equipment work is lagging behind that of structural work, and there is a tendency for processes to become complicated and the working efficiency to suffer as a result of the work of different occupations becoming intricate in confined areas such as plumbing areas. This case was an attempt to overcome this problem by making carpenters who were conventionally specialists into multi-skilled workers, and having them implement part of the equipment work. In this test, the carpenter carried out wiring and plumbing, mounting of ventilation fans, and mounting of electronic equipment in the presence of specialist workers. In order to make it possible for the carpenter to also carry out the water and hot water plumbing, parts made of cross-linked polyethylene pipe, which is lightweight and can be bent, were pre-assembled at the factory in accordance with the residential layout. In addition, in an effort to improve productivity of partition walls, half panel parts constructed from plasterboard and wooden studs were used. By using cross-linked polyethylene pipes it becomes possible for the carpenter to carry out woodwork and plumbing alone, which in turn makes it possible to reduce the ineffective work time caused by jumbling of different occupations. Photographs taken during the test are shown from Fig. 1 to Fig. 6. The cross-linked pipe parts and partition wall half-panels pre-assembled in this case both have unique attribute information (materials, dimensions, unit price, constructability, etc.) It is without a doubt that the act of referring to some of this attribute information in the design subsystem and focusing on the construction stage to decide on part of the attribute information, makes lower subsystems transparent in the design subsystem. This case made multi-skilling possible by the utilization and development of parts which can be constructed without highly developed skills, thereby improving productivity. At the same time, this case actively made lower subsystems transparent in upper subsystems.

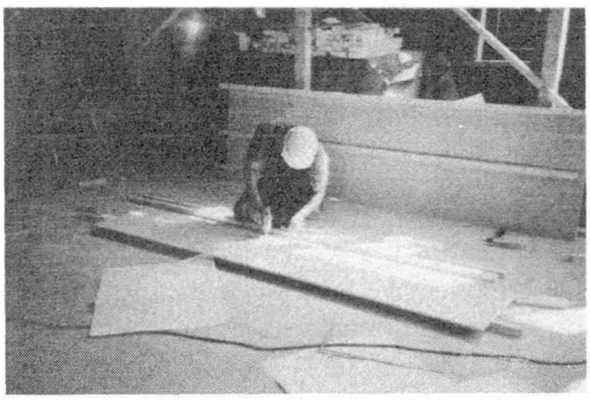

Fig. 1 Production of half-panel parts

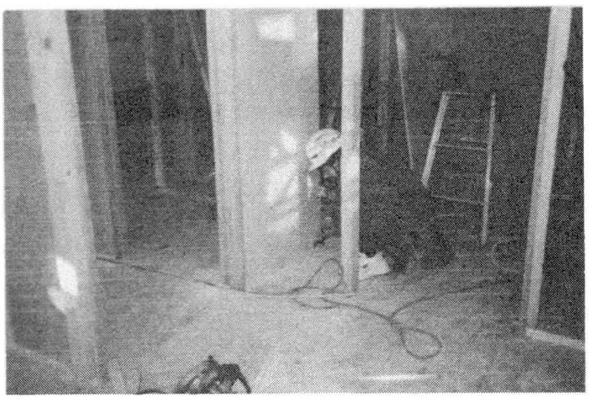

Fig. 2 Installation of half-panel parts

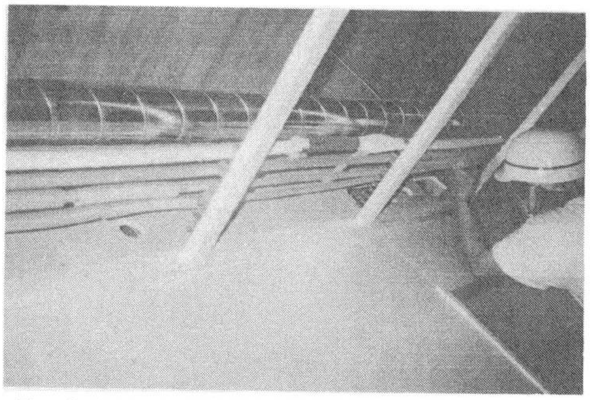

Fig.3 Laying of crosslinked polyethylene pipes

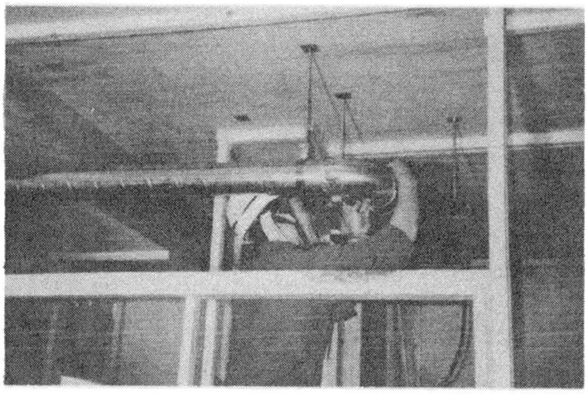

Fig.4 Mounting of ventilation fan and duct

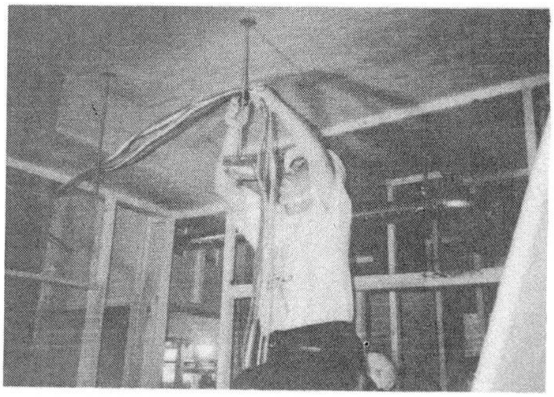

Fig. 5 Electric wiring

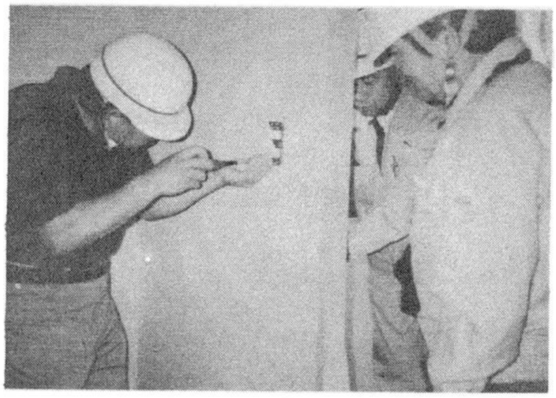

Fig. 6 Installation of switch box

3.2 Parts Oriented Assembly of Meter Boxes for Multiple Dwelling Housing

This case entails the parts oriented assembly of the pipes and the precast concrete panel which supports such pipes inside the meter box for multiple dwelling housing, and it is currently being applied to actual construction. This multiple dwelling housing in this case is a 17 floor building with a total of 332 residences, and construction is being carried out in four construction areas. Fig. 7 shows a plan of a typical residence. The area around the meter box shown in the plan is a confined area in which the work of different occupations becomes jumbled, as was the case in 3.1. The decision was therefore made to remove the work around the meter box from the main work in an effort to level out and improve the efficiency of labor. The production of precast concrete panels is implemented on site, and pipes pre-assembled at the factory are mounted at the same time as the precast concrete panels are completed. This production cycle is planned to be synchronized with the structural construction process and to reduce the number of steel forms in this cycle process and the stockyard area. Steel form onto which fittings for inserts have been mounted is used to enable the production of precast concrete panels by unskilled labor. This production of meter box parts by pre-assembly becomes parallel with main works, and not only contributes to reducing the input of labor, but also makes it possible to keep labor costs down by utilizing unskilled labor in parts production itself. Fig. 8 to Fig. 12 show photographs of the meter box parts and the state during construction.

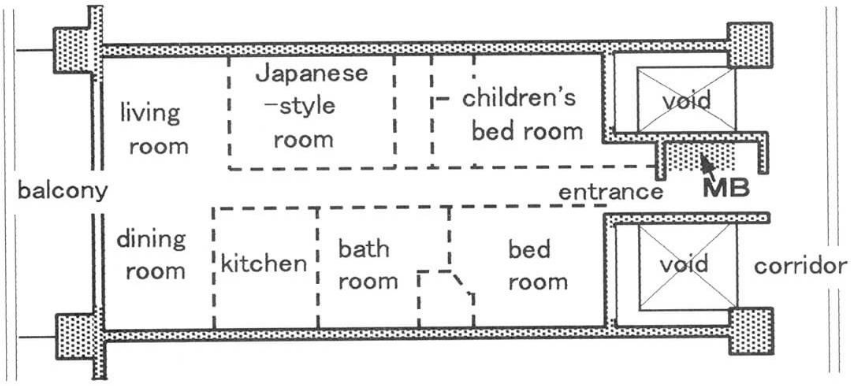

Fig.7 Plan of a typical residence

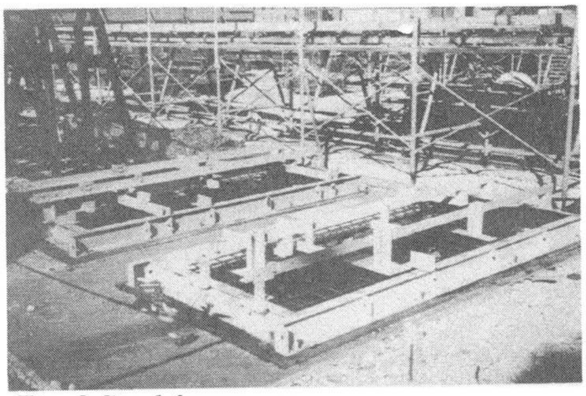

Fig. 8 Steel form

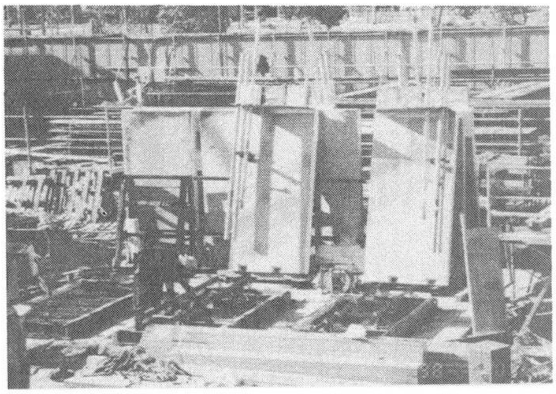

Fig. 9 Site yard for production of precast concrete panel parts

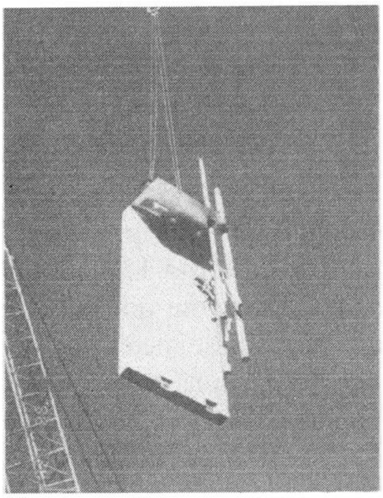

Fig.10 Lifting of precast concrete panel parts

Fig.11 Installation of precast concrete panel parts

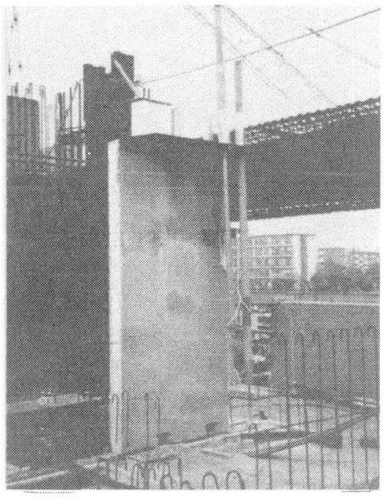

Fig.12 Installed precast concrete panel parts

4. Conclusion

The authors propose the Parts Oriented Production System as a mechanism to solve the problems faced by the construction industry in Japan, and have discussed the content of the three major subsystems which make up this system. By focusing on the attributes unique to each part and having the three subsystems cooperating simultaneously and in parallel, it is possible to achieve greater transparency and control than conventional construction production processes. Partial testing and application to construction sites is currently being carried out in order to verify the effectiveness of this system. In the future the authors hope to carry out further testing and application to construction sites for the rapid realization of this system as a whole.