# An Integrated Construction Management System for Site Precast Concrete

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Abstract

In order to manage site precast concrete construction which has been increasing, an integrated construction management system employing a unique 3-D modelling method and analogue process input method was developed. At the planning stage, the system supports interactive planning between member configuration and installation planning by a visual method and with an accurate quantity. At the process control stage employing common 3-D model, the system supports coordinated process control between member installation and on-site manufacturing based on the actual result to meet the whole construction schedule often changed.

## 1. Introduction

The precast concrete construction method is being increasingly adopted because of an increase in construction work and a shortage of skilled labor. Precast concrete member can be manufactured at fixed plants of manufacturers and at on-site temporary factories. Either of these methods can be selected in accordance with the conditions of a project, or both methods can be used together. Especially for a large project, on-site manufacturing has great merits, and the construction manager plans member manufacturing at the site simultaneously with member planning. Therefore, a method to support these planning and process control is being sought. In response, we have developed a Construction Management System to support planning and process control of manufacturing and installing for site precast concrete integrally and interactively.

## 2. Needs for Precast Concrete Planning and Management

When making a precast concrete construction plan, a study is made on what part will be made by precast concrete and how it is to be designed, then what part is to be made at the site. In the construction process, precast concrete members are installed in coordination with the overall construction work, and the members are manufactured to conform with the installation.

### 2.1 Member Configuration Planning

When planning precast concrete members, the adoption range of precast concrete is first determined in consideration of the conditions of the project and its environment, then the member configuration plan is decided, and a lifting schedule plan is made in consideration of the weight and number of members. However, an optimization trial in the later process sometimes does not

match the plan for the previous process, for example, the size of a member is restricted by the capacity of cranes equipped at the site.

In practical terms, the detail design is often not decided at this stage. It is necessary to improve the practicality of both the member design and the construction plan in the course of interactively executing member planning and manufacturing/installing planning.

Construction managers do planning work often by employing color classified drawings, or by preparing miniature models. However, these methods are not efficient for a three-dimensional study, and have the weak point of taking a lot of time for repetitive study. To solve these problems, a method, which can simulate the form of the member and its installation employing 3-D models and can freely recognize and display the relation between the whole building and its inherent location, is being sought.

## 2.2 On-site Manufacturing Planning

Precast concrete manufacturing on site has the merits reducing transportation, timely member supply matching with installation process at the site, reducing installation work due to the adoption of large members without the restrictions of on-road transportation, in addition to reducing on-site labor which are features common to prefabricated construction methods.

To secure the merits of precast concrete site production, which are large in a large-scale project, it is necessary to plan the manufacturing equipment and resources allocation to match the schedule for total construction. This plan is made interactively with member planning while considering the site conditions.

## 2.3 Process Control for Member Installation

The schedule for installing a member is often changed due to various factors, because it is a part of the whole site work. Precast concrete related work is managed integrally within the total process including other works.

In many process control systems up to now, many data input such as types of member, location, various schedules, etc., have been required for each member. This raises problems in that much manpower is required, and different concepts are involved to traditional manual work when converting to a coordinate-system, and judgement in planning grasping the status of the previous stage is difficult. A method is required to visualize the status as much as possible to obtain an easy grasp of the present status, and which allows details of the next stage of a plan to be easily grasped.

## 2.4 Process Control for On-site Manufacturing

To improve manufacturing efficiency, it is necessary to install the minimum quantity of mold frames and equipment, and to make full use of them. However, it is difficult to expect stable production as in the case of fixed plant from the start, because of the temporary characteristics of the site plant with out-door work and the low level of training for workers.

Manufacturing independent on the whole on-site schedule, which is often changed, will result in a stock of unnecessary in-process items. Moreover, because of the limited stock-yard there is a risk that manufactured members cannot be stocked.

To remove those restrictions and obtain the merits of on-site manufacturing, integral process management is required. Matching on-site work and plant manufacturing process is definitely by grasping types and quantity of members exactly, and by planning the next stage based on information of the latest actual results.

## 3. Integration Conception

The system using micro computer supports both planning and construction/ manufacturing stage. The term "integration" can mean various things and we define this system as shown in Fig. 1.

First, at the planning stage, member planning and erection planning are performed precisely and interactively. Then, a common building model is used at the planning and management stages. Moreover in the process control stage, schedule of the whole construction including member installing, and the installing, stock and manufacturing is harmonized. At this stage, planning of the next stage also depends on an accurate recognition of the latest results.

## 4. Member Configuration Planning System

The system, employing an original 3-D modelling method, supports interactive planning between member configuration planning and installation planning, which is important at the early member planning and equipment planning stage.

### 4.1 3-D Modelling Method

The introduction of a general-purpose CAD can be considered as a method of precisely configuring process members, however, this is inadequate for handling construction processes at present, and there is a problem that it takes time to change modes with other program modules. Moreover, when actually processing a member arrangement with a computer at this basic planning stage, it is more understandable to express the member as an exaggerated miniature model rather than actual dimensions.

In this system, an originally developed 3-D graphical modelling method is adopted. This model has specific features which allows the division and combination of members to be freely studied, with saved data capacity, and to judge the priority of members being installed. The expression is made at the outline dimension, and is different from normal CAD in the use of color for identifying the types of members, however, it is effective to express the progress of the work in time series. The model determined can be commonly employed in the process control system described later.

### 4.2 Member Division/Combination Planning

To process three-dimensional members easily, the input operation of members is performed indicating arbitrary horizontal or vertical sections of a computer image. The divided or combined status of each member is expressed at this stage, and the division and combination of member can be instructed by changing the status. Editing functions such as copying and transferring, are improved to reduce input man-hours. Each member is automatically recognized at its inherent location in the whole building, and is individually named.

Input results of arbitrary types of member can be expressed graphically in an arbitrary range, and by an arbitrary method. Fig. 2 is an example of a plan and Fig. 3 is an example of an isometric drawing. Combination member planning, such as unifying floors and beams, or a large member plan to extend to many spans, and so on, can be made by a variety of methods and levels of ease by only indicating the part to be marked.

### 4.3 Installation Planning

Constitutional members can be grouped for each erection unit, and each order is automatically generated by indicating the installation conditions such as work area, story, type of member, and their priority order. The priority order for each member, for example a beam can only be installed after a column is installed, can be automatically diagnosed.

In practice, an optimum installation plan cannot be obtained only with such a simple priority designation. Therefore, several plans are prepared and compared, and finally optimization of an installation plan is supported by the editing function in the unit of erection group or the independent member unit. Figs. 4 - 5 are examples of the installation order.

A member plan and an installation plan are closely related. It is definitely necessary to input a member configuration plan and installation plan by a visual method, and both processes must be performed interactively by employing a visual display of each stage and an accurate quantitative tabulation. For this processing, it is effective to use these subsystems with repeated simulations.

## 5. Process Control System for Precast Concrete Manufacturing and Installing

### 5.1 Outline of the System

This system supports integral process control for precast concrete members from site manufacturing to installing. In detail, the overall construction processes are set, and each installation schedule included in it is assigned to each member, then manufacturing process control determines what member will be made at what time to meet the installation schedule. These processes are performed by confirming the latest results and the schedule of manufacturing, stock and installing, and finally the daily instructions of manufacturing and installing are prepared.

This system has specific features, such as analogue input method for

scheduling, daily mold assignment for member manufacturing and member management employing a 3-D model. Because the system is operated by the construction manager himself, it was considered to follow the conventional work procedure, and to be a highly operable system which can be learned in a short time, and a graphic expression was adopted for easy understanding.

Productivity is grasped simultaneously, combining actual data on manufacturing and installing and labor results.

### 5.2 Site Process Management

In process management, in consideration of practical application, an originally developed analogue input method was adopted. This basically follows the conventional method in which construction personnel in charge draw construction processes on paper. In this subsystem, the monthly and weekly process schedule of the whole construction work including precast concrete member installation are prepared.

The process is input by first indicating the starting point and end point on the operation sheet of a computer image with the mouse as shown in Fig. 6, then the name of the process which has been registered previously is selected. Editing functions such as copying and transferring are improved to increase practical usability in response to changes in processes.

Daily operational conditions, such as holidays at the work site, holidays at the concrete plant, are decided separately. The operation process is calculated with service days, and automatically changes the process in accordance with holiday or a change of operation schedule. On the other hand, the calendar date is used for calculations of curing dates for concrete.

### 5.3 On-site Manufacturing Process Control

This subsystem determines the final manufacturing process of precast concrete members, and prepares manufacturing instructions. In practice, a molding frame is assigned due to the installation plan of each member sent from the above subsystem, taking the standard lead time (For example members are manufactured at least four days prior to the date of installation). The manufacturing date is adjusted so that a member, for which a molding frame cannot be assigned on a standard lead time date, is manufactured by assigning the molding on the previous day, and checking the possibility of storage.

Fig. 7 is an example of inputting a manufacturing process. Generally, cycle manufacturing processes are set to match the cycle processes at the site, however, in practice, correction of the cycle process is often necessary. This subsystem supports the rapid preparation of a manufacturing process plan, and outputs daily member manufacturing instructions.

### 5.4 Member Management Method

The 3-D model described above is built into this subsystem. A visual display of schedules and results of manufacturing and installing employing this method

allows the current status of work to be grasped easier.

This model is also used for data inputting. Change of schedule or results are input first by selecting the input mode, then only clicking the member on the drawing with a mouse, and the items input are immediately classified and indicated on the display (Fig. 8). This can be said to be a reproduction of the conventional method of color classifying design or work drawings, which had been performed by a construction manager, on a computer display.

Fig. 9 shows a part of the installation instruction employing this method. It clearly indicates what member is installed at what place at a glance, and clear instructions can be given to workers.

## 6. Conclusion

An integrated construction management system, in which a unique 3-D modeling method and analogue process input method, etc., are incorporated and which integrally supports member planning and process control and their interrelations, was developed. This enables accurate, quick, and easy planning and process control of on-site precast concrete manufacturing and installing.

At the planning stage, when planning for division and/or combination of members and installation planning, it becomes possible to perform interactively and flexibly the work using a visual display and to accurately quantify the results. This planning support system can be used in common for the process control systems of site precast concrete, as well as the general planning of member mounting type of construction work.

At the construction stage, precast concrete member erection and whole the construction work, and manufacturing, stock and installing, are performed in good coordination. This system, which is visual and user friendly, and offers accurate data in time series, has been applied in actual four projects and has obtained good results.

Support for construction equipment planning, replenishment of process diagnosis function, automatic generation in manufacturing process planning is the task for the future.

## References

[1] Sasaki,Y and Kanaiwa,T et al.(1990), Cube Composition Modelling for Building Construction, 6-th Symposium on Organization and Management of Building Construction, Architectural Institute of Japan, July, Tokyo

[2] Kanaiwa,T and Sasaki,Y et al.(1990), Integrated Construction Management System for Site Prefabricated Construction Method, 6-th Symposium on Organization and Management of Building Construction, Architectural Institute of Japan, July, Tokyo

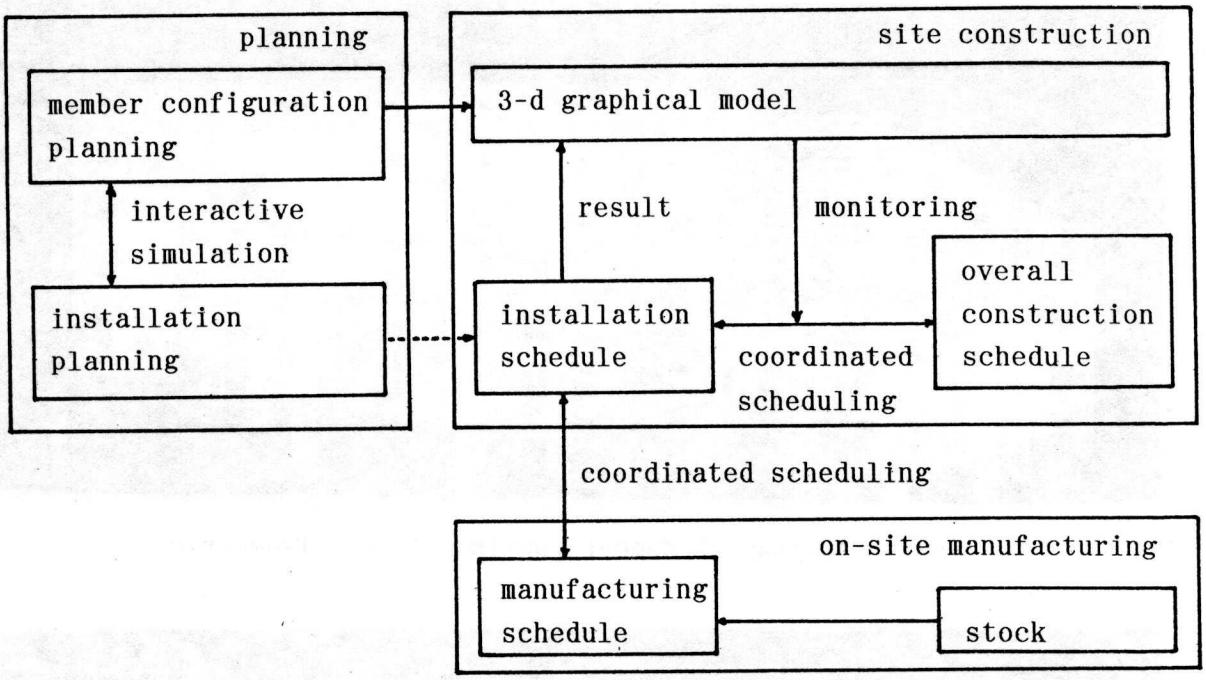



Fig.1 Integration Conception

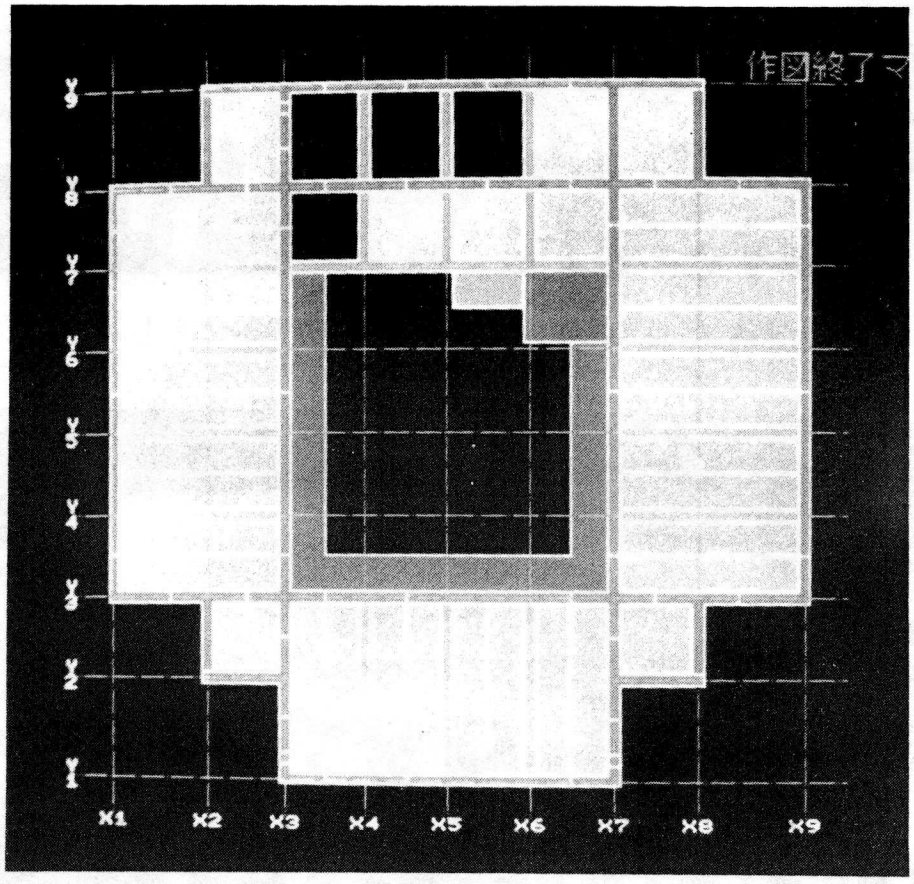



Fig.2 Display of Member Configuration - Plan

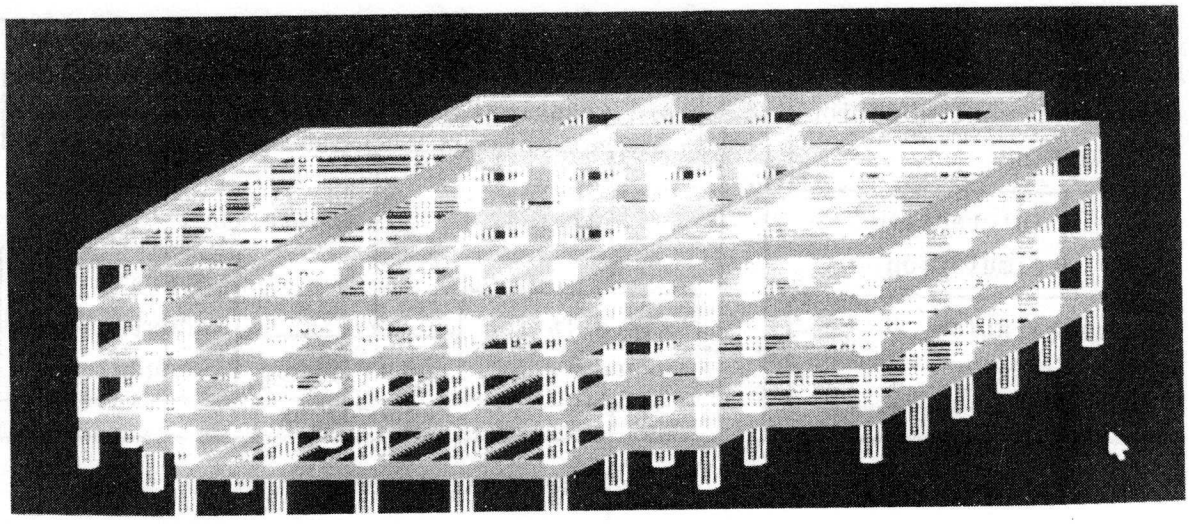


Fig.3 Display of Member Configuration - Isometric

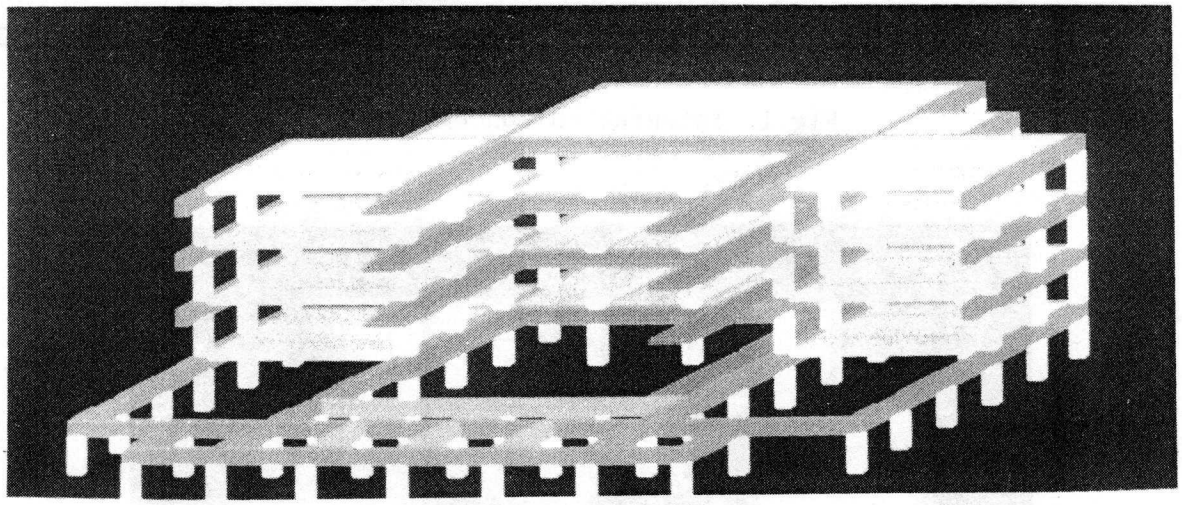


Fig.4 Display of Installation Order - 1

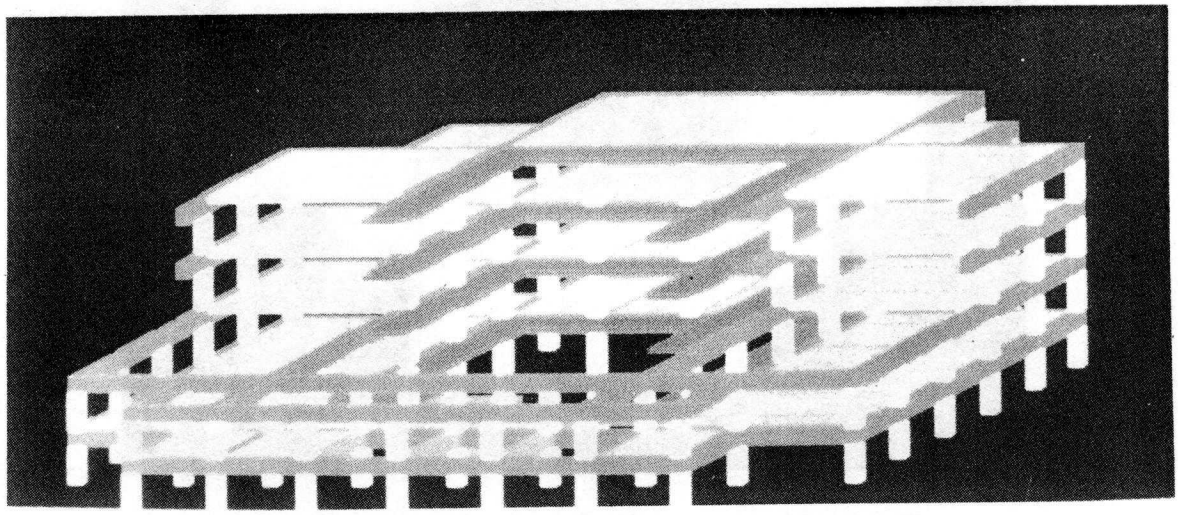


Fig.5 Display of Installation Order - 2

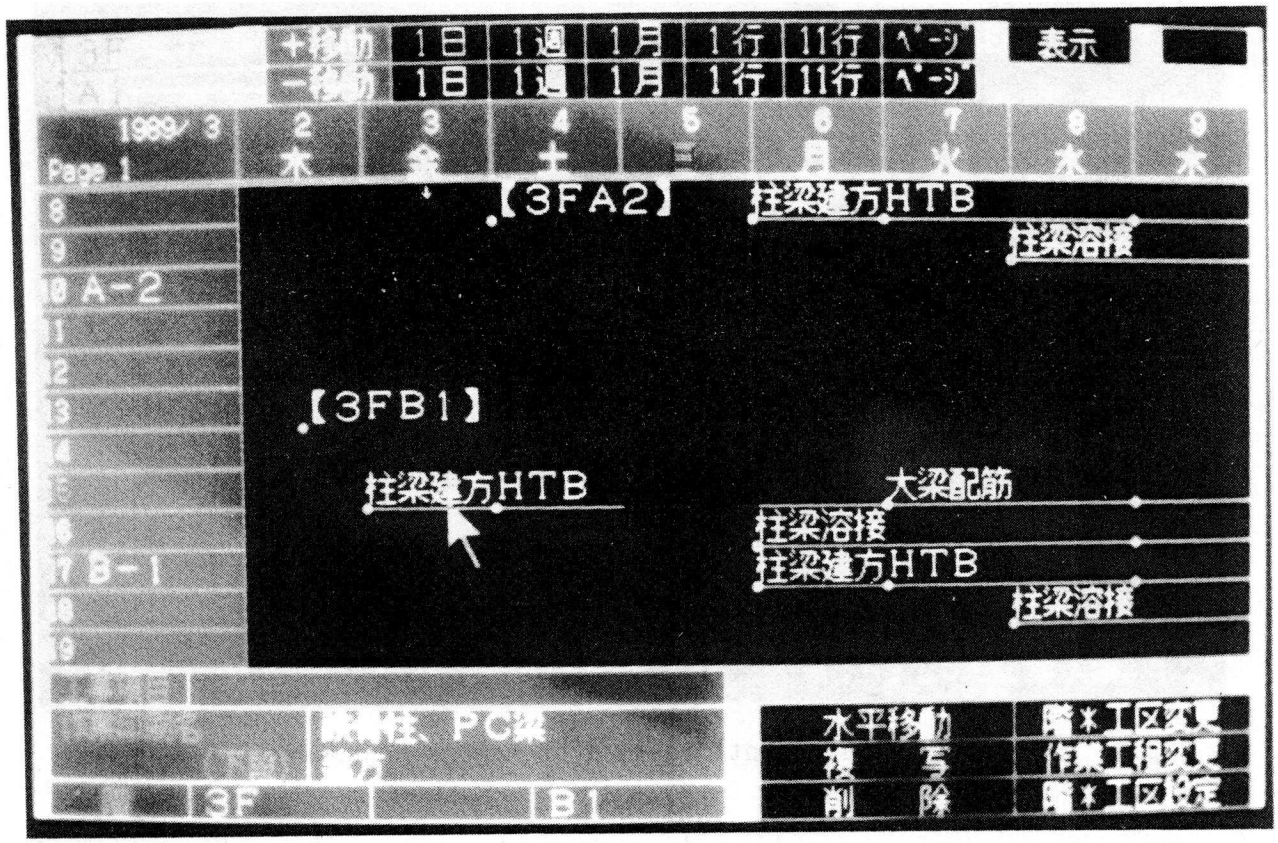



Fig.6 Input and Visual Identification of Overall Site Schedule

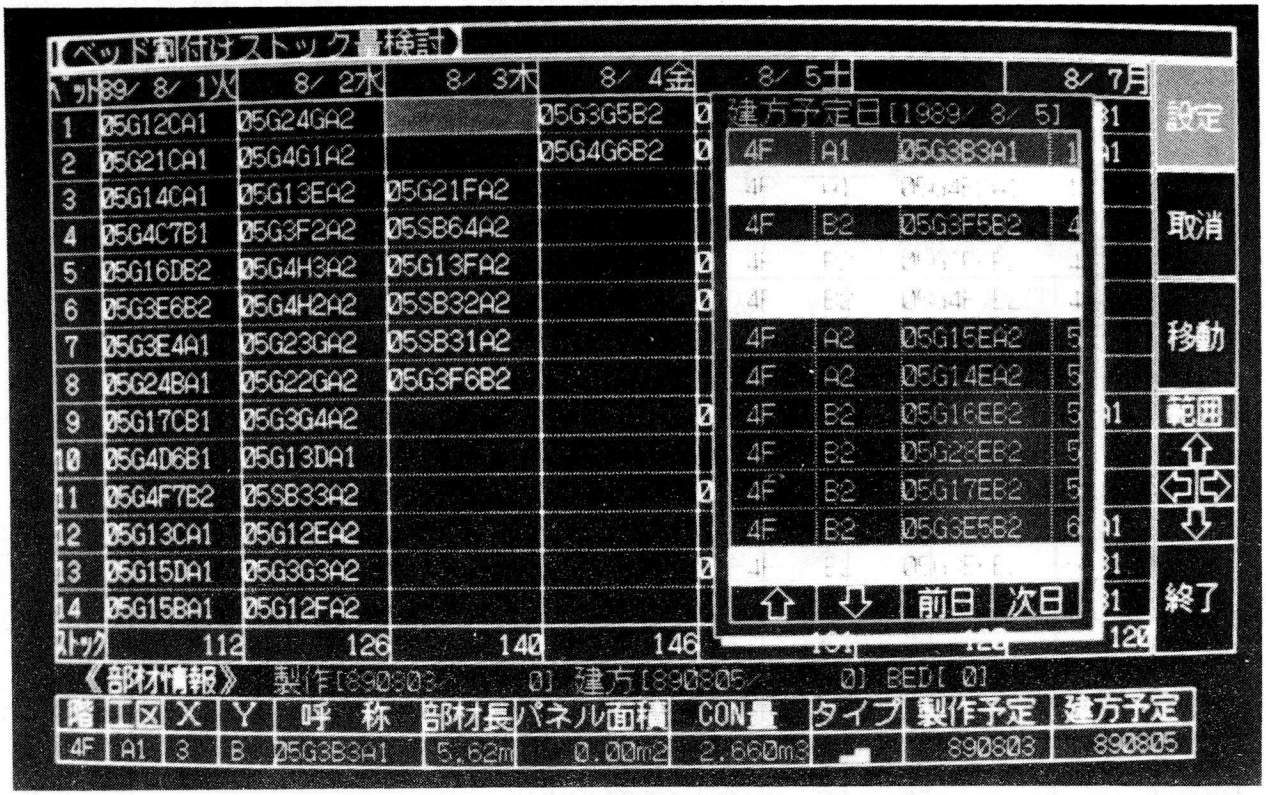



Fig.7 Input and Visual Identification of On-site Manufacturing Schedule

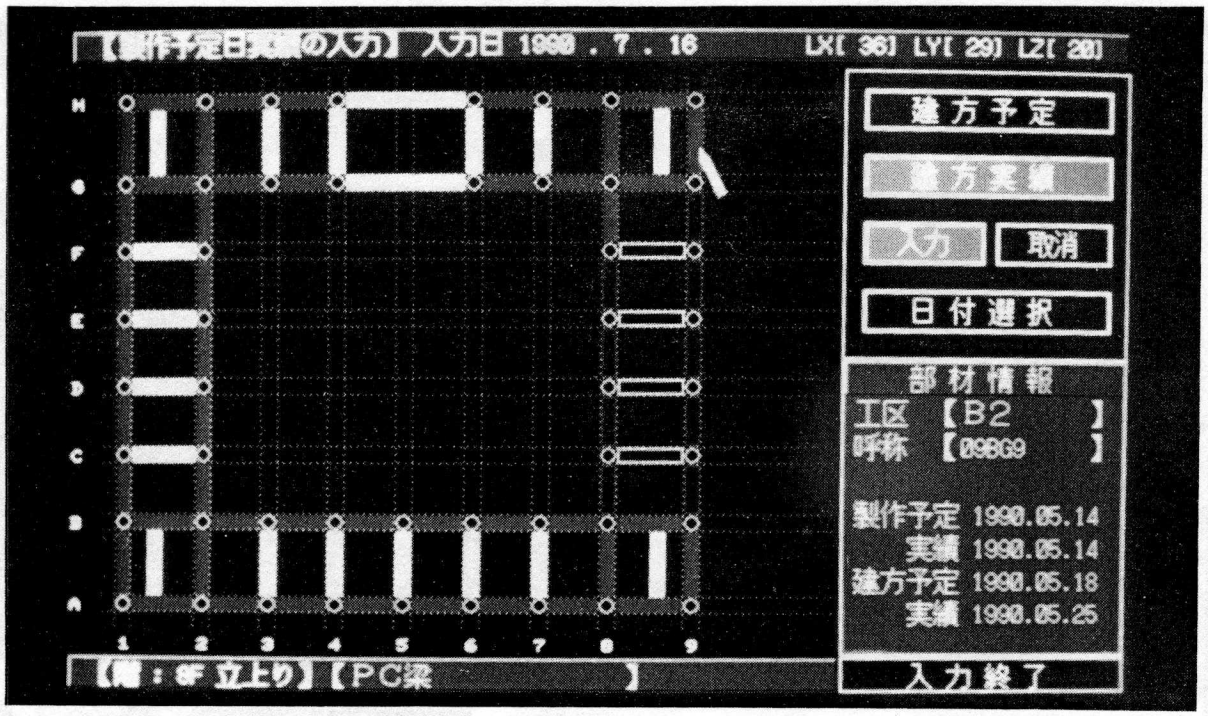
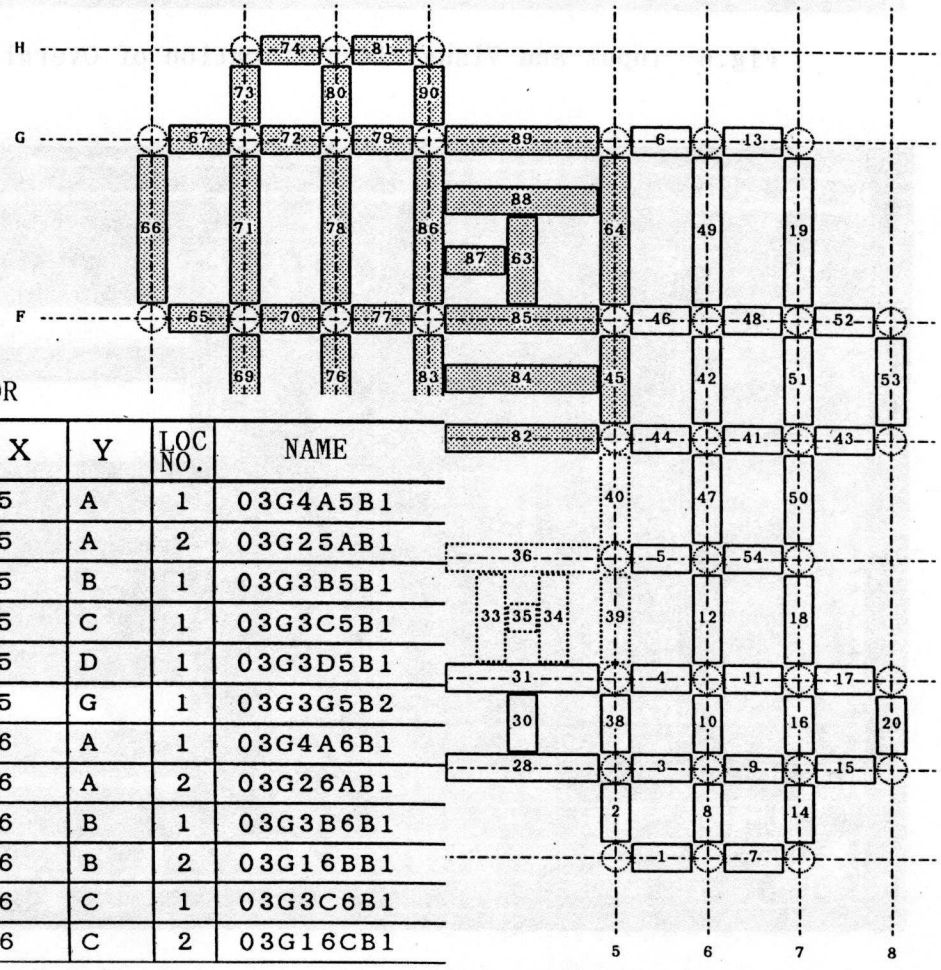



Fig.8 Input and Visual Identification of Member Management Information




STORY : 3 FLOOR

| NO. | WORK AREA | TYPE OF MEMBER | X | Y | LOC NO. | NAME |
|---|---|---|---|---|---|---|
| 1 | B1 | HPC梁 | 5 | A | 1 | 03G4A5B1 |
| 2 | | | 5 | A | 2 | 03G25AB1 |
| 3 | | | 5 | B | 1 | 03G3B5B1 |
| 4 | | | 5 | C | 1 | 03G3C5B1 |
| 5 | | | 5 | D | 1 | 03G3D5B1 |
| 6 | B2 | | 5 | G | 1 | 03G3G5B2 |
| 7 | B1 | | 6 | A | 1 | 03G4A6B1 |
| 8 | | | 6 | A | 2 | 03G26AB1 |
| 9 | | | 6 | B | 1 | 03G3B6B1 |
| 10 | | | 6 | B | 2 | 03G16BB1 |
| 11 | | | 6 | C | 1 | 03G3C6B1 |
| 12 | | | 6 | C | 2 | 03G16CB1 |

Fig.9 Installation Instruction