A New Management Tool for Robotized Construction Projects - Application of Computer Graphics in Construction Planning and Scheduling

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ABSTRACT

According to the robotization of construction works, project managers will be more required to understand all of the activities in the construction site. Therefore, relevant management tools are very essential for them in meeting the goal of projects. The authors pointed out the needs of computer graphics regarding the planning and controlling of the robotized construction project. An experimental system was developed and implemented to a building project in order to evaluate the effects of such methodology in the construction planning phase. In conclusion, the authors found the positive effects and their limitations of using the computer graphic system in planning, scheduling and controlling the robotized construction project.

1 INTRODUCTION

About five years have passed since the research of the robotization of construction began in Japan, corresponding to the technical evolutions of robotics (1,2). The authors and the group of colleagues in Waseda University have been developing new concepts for the robotization of construction works in these years under the guidance of Prof. Y. Hasegawa in WASCOR (WASeda COnstruction Robot) Research Project, and will finish the scheme designs for several types of robots to be applied in building construction sites until the fall of 1985.

In order to activate the robotized construction sites, it is essential to develop the appropriate management tools for planning and scheduling the complexity and congestion of the projects, in addition to the design of suitable mechanisms of robots in the site.

In the diffusion of micro-computers, many management systems have been developed and implemented to construction planning phase in construction industry. But, these applications have been limited to the specific areas of activities in planning and scheduling, such as PERT/CPM scheduling (3), cost accounting and word processing. The main reasons for these limitations are the restrictions on alpha-numerical presentations which micro-computer could make and also due to the gaps between project managers and these systems.

The authors confirmed that the techniques of computer graphics should be applied for supporting the project managers to make the comprehensive construction plans and schedules with micro-computer.

This paper presents the concepts of computer graphics for construction planning phase of building projects and the experimental study in which authors developed a computer program and implemented it to a building project.

2 COMPUTER GRAPHICS FOR CONSTRUCTION PLANNING PHASE

To manage the process of construction works in site, it is essential in management tools to consider the easy way of sound understanding and handling of the relative information.

Computer graphics enables project managers to plan and schedule the construction projects in a visual manner interactively and instantaneously. Furthermore, graphics with micro-computer could be installed in the construction site rather than the head office, therefore project managers will be able to plan, schedule and also control the project at his site office.

The interrelated factors which should be considered by project managers in construction planning phase of building projects are classified of the following four items:

1. Resource: workers, materials, construction, equipment
2. Activity: transportation in site, assemble works
3. Building Element: columns, beams, slabs, external walls
4. Space: work areas, stockyard, locations of building elements

To solve the problems of communication between project manager and micro-computer regarding the goal of planning and controlling of the building project, the following graphics could be helpful to managers in achieving the best results of his plan:

1. Graphics about construction resources in site
    a. Layouts of equipment and scaffoldings
    b. Status of materials in stockyards
    c. Daily utilization of resources
2. Graphics about the construction works

a. Area under work

b. Status of activities in site

c. Procedures of assemble works

d. Status of completion of the project on the due date

e. Network diagram

f. Barchart diagram

3. Graphics about building elements

a. Architectural drawings

b. Engineering drawings

c. Shop drawings

4. Graphics about site area

a. Layouts of stockyards in site

b. Locations of building elements

c. Layouts of gates and roads in site

3 DEVELOPMENT OF AN EXPERIMENTAL SYSTEM

The authors developed an experimental system to evaluate the effects of graphics with micro-computer for construction planning and scheduling. The experimental system covers all of the functional concepts mentioned before, and is written with BASIC language of four thousand steps.

The system is developed for the micro-computer with the following configurations:

Central Processing Unit	16 bits processor
Random Access Memory	512 kilo bytes
Peripheral Memory	10 mega bytes hard disk
Graphic Display	Color, 640 x 400 dots

There are four types of data required in this system. The details are described below:

1. The data of three-dimensional wire frames which represent the physical work elements in site such as materials, building elements, equipment, scaffolding, shuttering.

2. The data of both the activities to which the project is broken down and their procedures.

3. The data corresponding to the locations of the work elements and the place where the activities are to be performed within the site.

4 The data of the relationships between the activities and their work elements, as to which building elements the specified activity makes, and what work elements required.

With this system, project managers could figure out the locations of any work elements in site. The relevant information are presented with three-dimensional wire frames, to show the existence and transferrence of those work elements which are controlled on the basis of scheduled dates calculated by PERT/CPM network analysis.

Figure 1 shows the concepts of the whole system that consists of the following six subsystems:

1. Handling data for wire frames
2. Setting data regarding the three-dimensional locations of wire frames
3. Defining activities and precedences in network
4. Analyzing PERT/CPM network
5. Developing perspectives of wire frames from the three-dimensional data
6. Displaying graphics which are related to the construction process.

The wire frames are displayed to project managers in any figures to be required such as plan, elevation, section and in perspectives.

4 IMPLEMENTATION TO CONSTRUCTION PLANNING OF BUILDING PROJECT

The authors applied the system to the building project of an apartment house composed of steel framed and reinforced concrete structure. This building is six stories high and the area of a typical floor is about one thousand meters. (See Figure 2).

The steps of implementation are as follows:

1. Preparing data about the site layout
2. Preparing data for wire frames according to architectural and engineering drawings and construction plans
3. Breaking down the project to activities and defining procedures

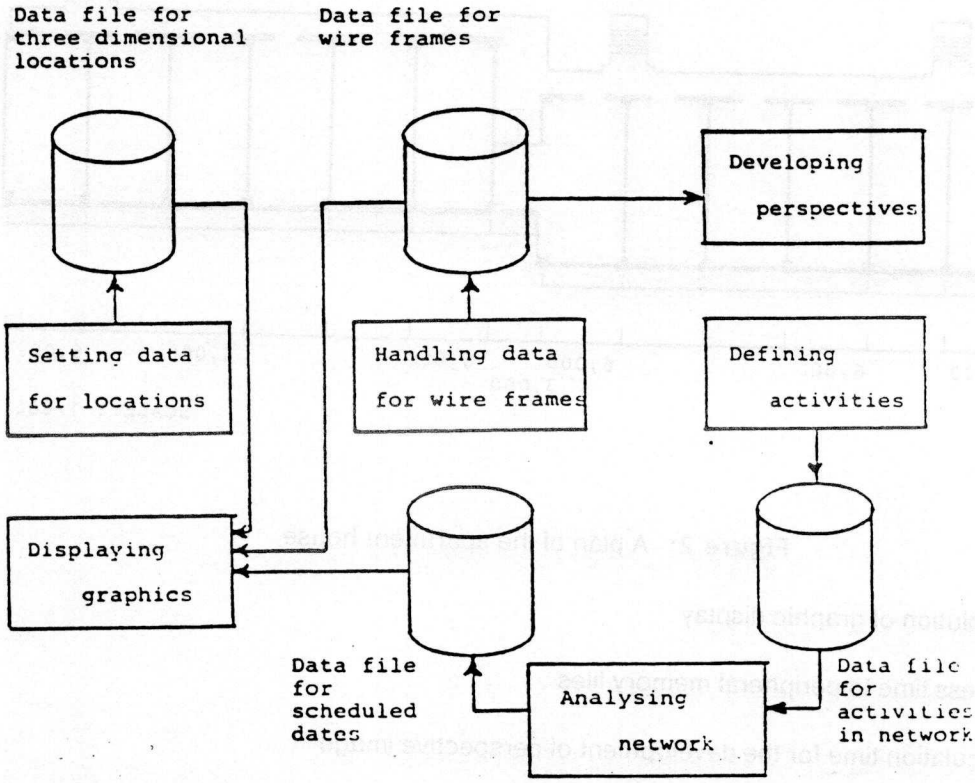

Figure 1: Concepts of the system

4. Scheduling on PERT/CPM network analysis

5. Displaying of perspectives of construction site focusing upon the due date

6. Making a photocopy from graphic display

To present the sequence of work, Figures 3.1-3.9 are used to show the building process in the construction site from its start point to the completion; for example, erection works of steel columns with a truck crane, reinforcing works, formworks, and concrete placings.

Through the development and implementation of an experimental system for the building project, positive effects of computer graphics for construction planning phase has been founded. However, there are some problems to be avoided before applying this system to actual construction planning phase. These problems are summarized as follows:

1. The speed to display graphics

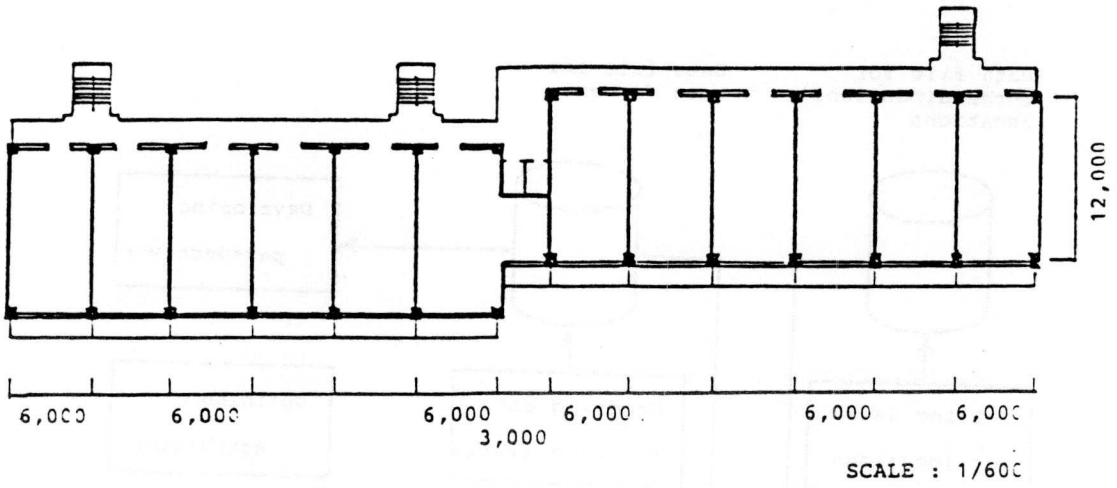

Figure 2: A plan of the apartment house

2. The resolution of graphic display
3. The access time to peripheral memory files
4. The calculation time for the development of perspective image
5. The time to make hard copy
6. The availability of a color copy device

It would be possible to conquer the above problems according to the progress of micro-computer in the near future.

5 CONCLUSION

The experimental study has shown that graphics with micro-computers could be a great support for project managers to improve their plans and schedules of robotized construction projects. These systems could supply much information in a visible manner to project managers instead of a bulk of alpha-numerical data. Therefore, managers are freed from inducing the necessary information from a bulk of data, and thus are able to devote themselves to analyze their plans and schedules and to optimize the construction project.

Although the applications of computer graphics with micro-computers are restricted, the authors could summarize the effective fields to apply them as follows:

1. To plan and optimize the process of robotized construction works

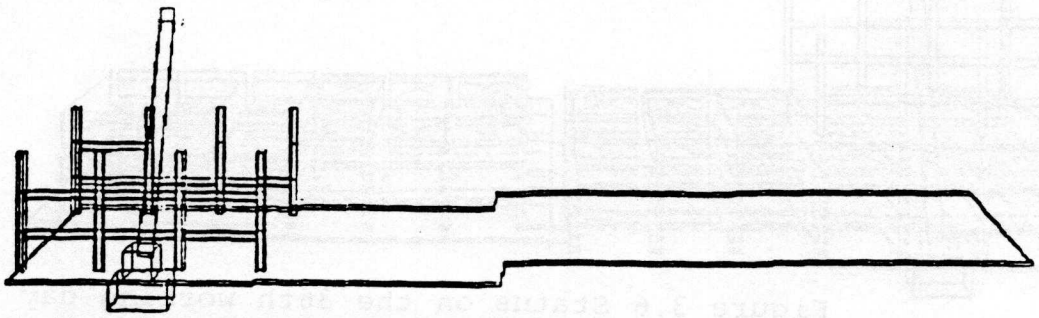

Figure 3.1 Status on the 6th working day

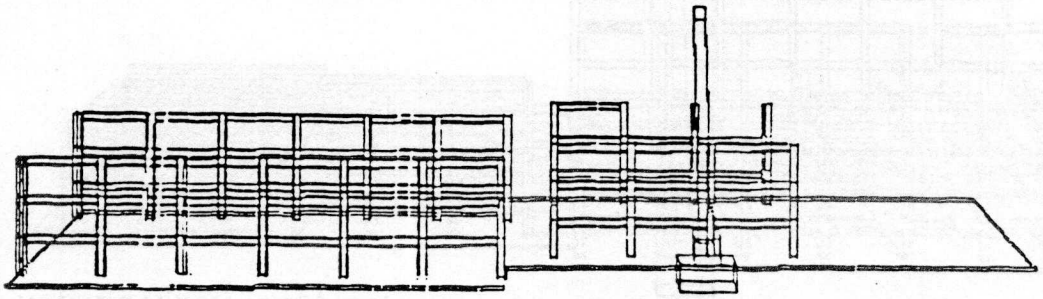

Figure 3.2 Status on the 10th working day

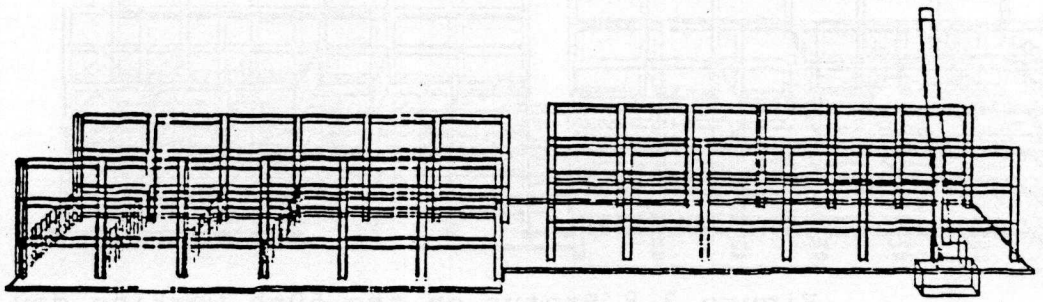

Figure 3.3 Status on the 13th working day

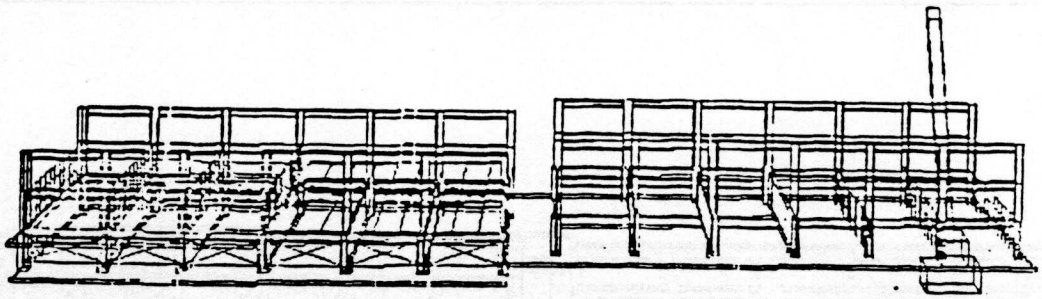

Figure 3.4 Status on the 19th working day

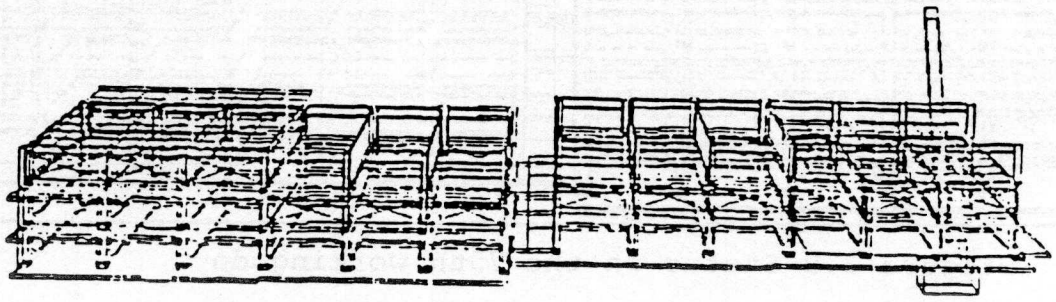

Figure 3.5 Status on the 33th working day

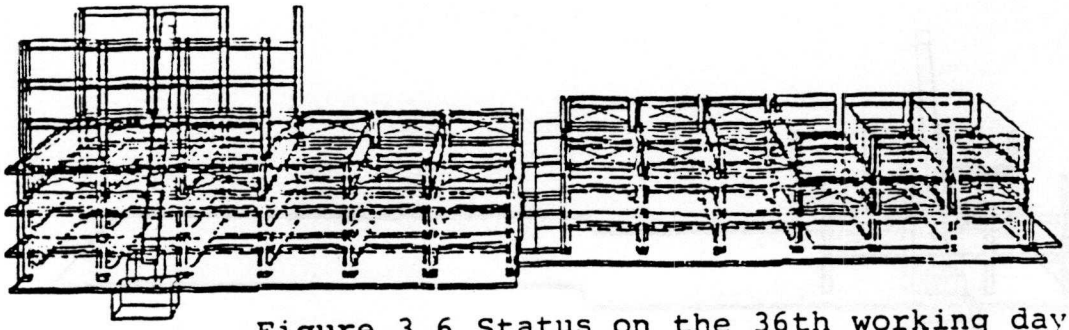

Figure 3.6 Status on the 36th working day

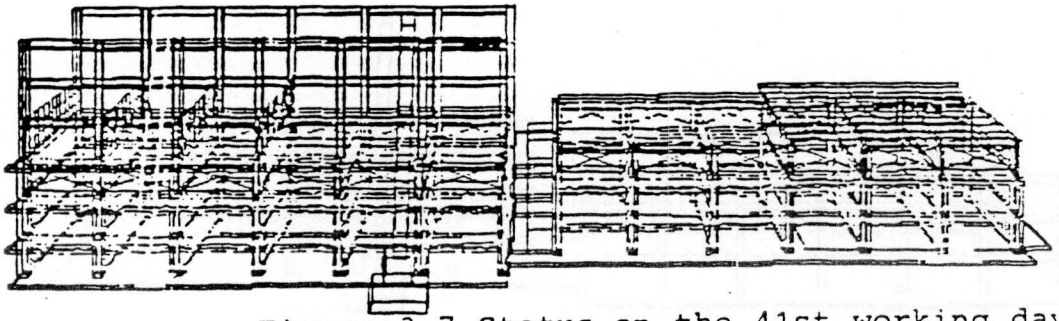

Figure 3.7 Status on the 41st working day

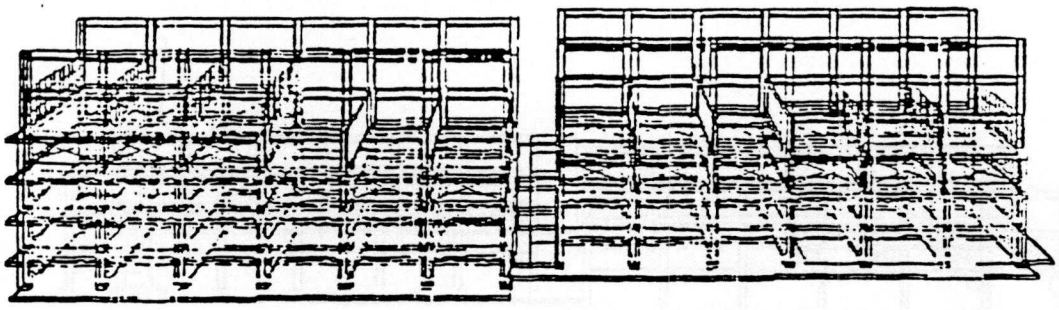

Figure 3.8 Status on the 50th working day

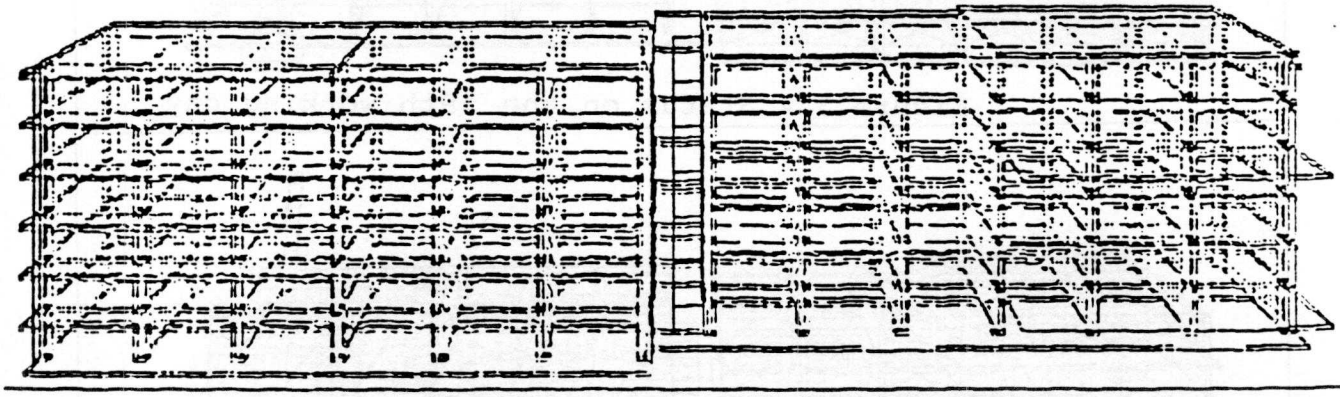

Figure 3.9 Status on the 75th working day

2. To check the interferences between robots in site

3. To simulate the predict of status of construction sites in the coming days

4. To make communications among project managers, foremen and workers

5. To explain the construction plan to owners, architects, engineers and subcontractors

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