

Development of Interior Finishing Unit Assembly System with Robot -WASCORIV Research Project Report (Part III)

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Abstract

The WASCOR (WASeda Construction Robot) research project was organized in 1982 by the System Science Institute, Waseda University, Tokyo, Japan, aiming at automatizing building constructions by robotics. This project is collaborated by nine general contractors and a construction machinery manufacturer.

WASCOR IV has been working on the Automated Building Interior Finishing System. In the symposium last year, WASCOR IV reported a summary of the first year's outcome in the report: Part I, which includes the outline of this three-year-project as well as the concept of Point Of Production System (POP System). In this symposium, Part II: Building System Design for Development of Automated Interior Finishing System and Part III: Development of Interior Finishing unit Assembly System with Robot are presented. This paper, which covers the Part III, is composed of the following two sections: 1) the details of finishing units and building methods, and 2) the schematic design of construction robots.

1. INTRODUCTION

As reported in the Part II, the automation has been put into practical use for skeleton work, whereas neither mechanization nor automation in interior finishing work as a total system are enthusiastically studied. Some kinds of construction robots for interior work which are considered repetitive and monotonous work, such as setting board on frame, has been developed. However, the research of automation in terms of the whole process of finishing work is hardly seen.

Interior finishing work consists of many phases of works requiring different skill, which makes the process of the work intricate. The project has been trying to develop the building system which can easily be fabricated with robot and propose the schematic drawings of the robots to be used.

2. THE OUTLINE OF THE BUILDING SYSTEM

After finishing skeleton construction work, usually finishing work is completed by the following sequence: furring strips, frames for openings, pipngs, dry-walls, wallpapering and fitting of fixtures etc., as well as setting scaffoldings to some of the works. The conventional method of finishing work has many problems to be improved because of the complicated work process mentioned above.

The project proposes a building method which is carried out by assembling factory-made interior units installed with frames, boards, papers, and fixtures, using construction robots.

Considering the dimensional variety of skeleton and interior units, as well as setting variety, adjustable quick acting joint which has the tolerance (7mm) is designed to make the interior finishing work more easily to be with robots. The prototypical building is designed based on a specific module and standardized members so that the numbers of dimensional types of the units are decreased by 25% comparing with conventional building design.

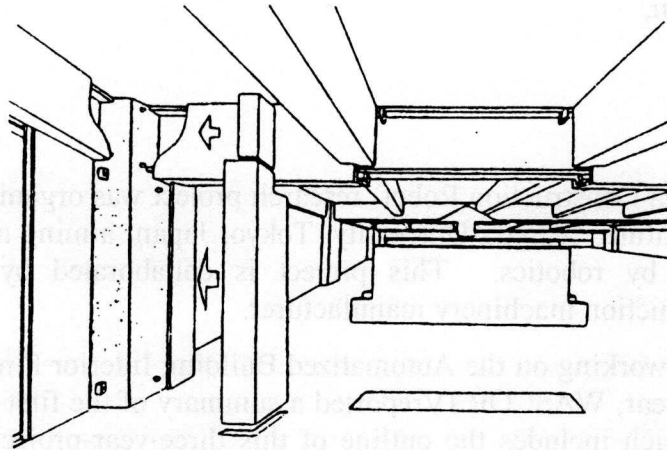


Figure 1. An image which wall, beam and column units are fabricated

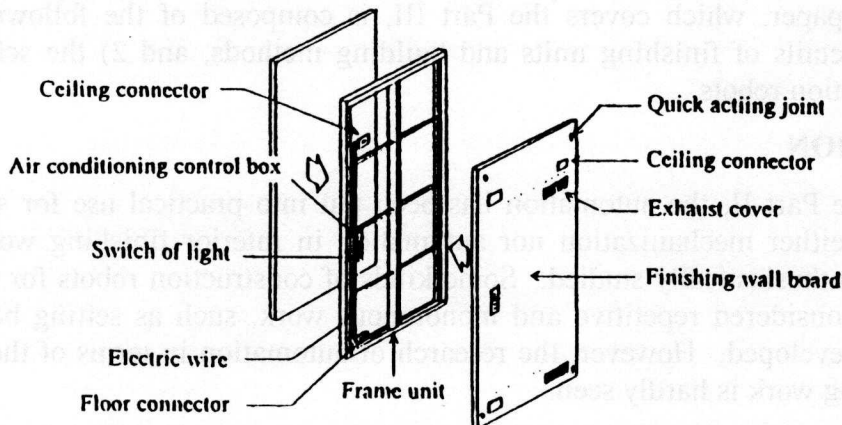


Figure 2. Detail of wall unit

2.1 Wall Unit, Beam Unit, and Column Unit

Such as fig.3 shown, fundamentally, the height of the wall unit is up to the bottom of the upper slab, while the constraint of handling makes the maximum width of the unit 1m.

The frame of wall unit consists of normal light gauge steel at the core, and channel steel are used for the upper and bottom edge, at where the quick acting joints are fitted. Each party wall has the quick acting joint on the wall face where the ceiling unit is fixed.

The project selected calcium-silicate-board finished by fabric wall covering instead of other alternatives, such as gypsum board and wall paper, steel board and painting, etc. The fire proof walls and the main partitioning walls are finished on the both sides, but the back face of an peripheral wall is not finished. Some walls are installed with outlets, switch of electrical fixtures, ventilators, etc.

Column units and beam units covering the skeleton are made of fire proof calcium-silicate-board and fabric wall covering, but they don't need frame because these unit are used only to cover the column and the beam. Structural beams concealed by the ceiling units are covered only by calcium silicate board if it is required. The height of the column units are the distance between the top of the floor and the bottom of the upper slab, and the length of the beam units is distance approx. 3m.

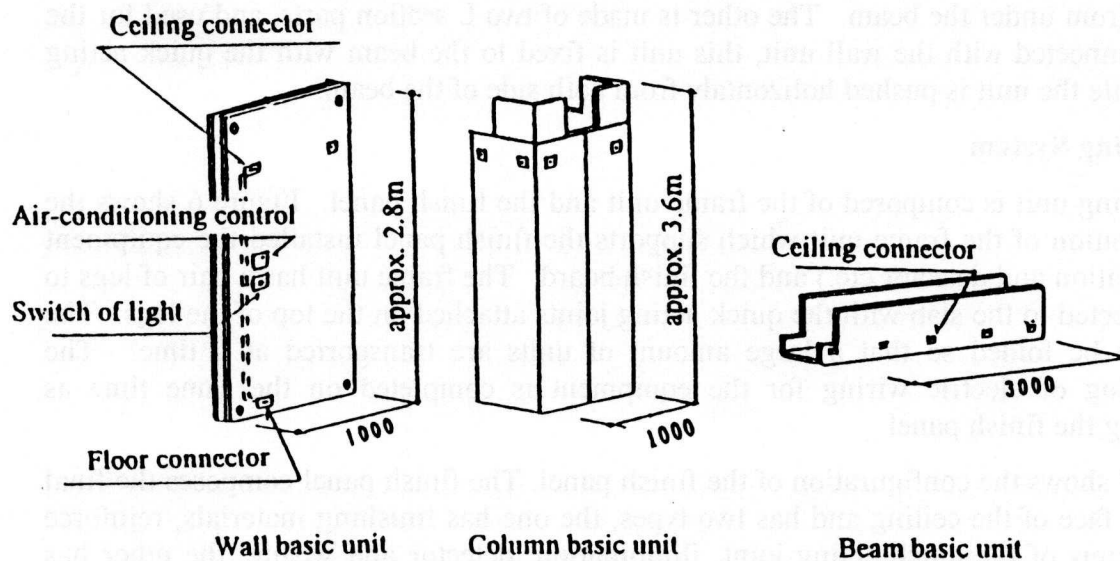


Figure 3, Wall Unit, Column Unit, and Beam unit

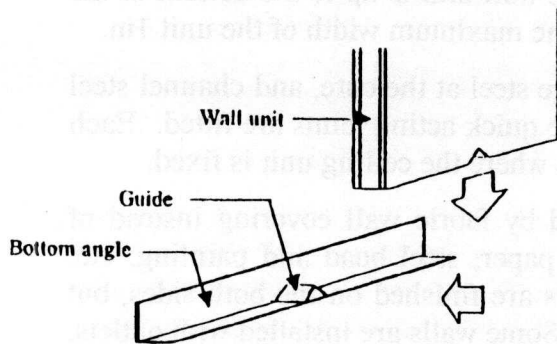


Figure 4 , Assembly of wall unit

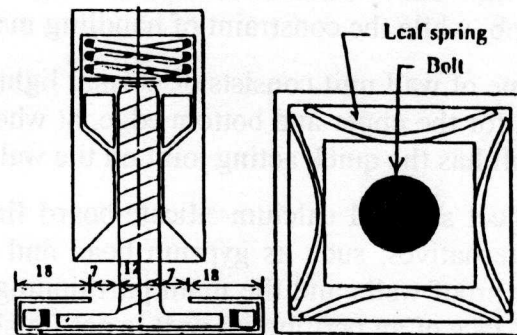


Figure 5. Detail of quick acting joint

The pieces of quick acting joint are set on the upper and the bottom angle, and the guide pieces are set on the bottom angle before fabrication, the upper angle is set on the face of the bottom beam flange and the bottom angle is set on the floor in accordance with the datum line marked. The guide piece makes the positioning of the unit by robot easily.

After the fabrication of all wall unit is completed, the beam unit is fixed. There are two types of beam unit, one is used for the beam not connected with the wall unit and has U section, this unit can be fixed to the beam with the quick acting joints while the unit is raising from under the beam. The other is made of two L section parts, and used for the beam connected with the wall unit, this unit is fixed to the beam with the quick acting joint while the unit is pushed horizontally from both side of the beam.

2.2 Ceiling System

The ceiling unit is composed of the frame unit and the finish panel. Figure 6 shows the configuration of the frame unit which supports the finish panel installed the equipment (illumination and detector etc.) and the finish board. The frame unit has a pair of legs to be connected to the slab with the quick acting joints attached on the top of the legs. The legs can be folded so that a large amount of units are transported at a time. The connecting of electric wiring for the equipment is completed on the same time as installing the finish panel.

Figure 7 shows the configuration of the finish panel. The finish panel composes the final finished face of the ceiling and has two types, the one has finishing materials, reinforce plate, screw of the quick acting joint, illumination, detector and wiring, the other has same composition except illumination and detector. Rock wool acoustic board is used for the finishing material.

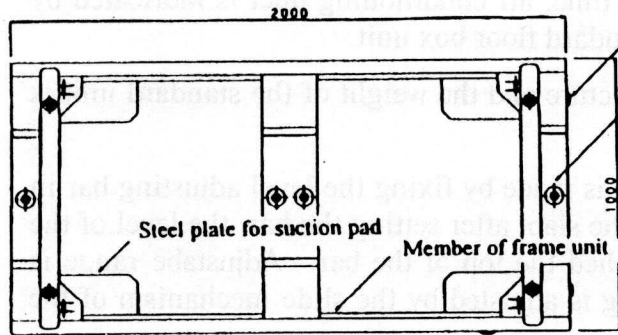


Figure 6 , Ceiling frame unit

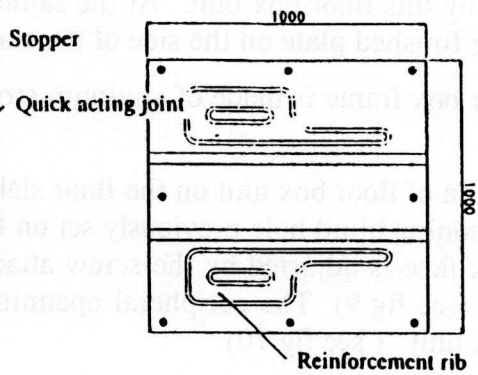


Figure 7 , Ceiling finish panel

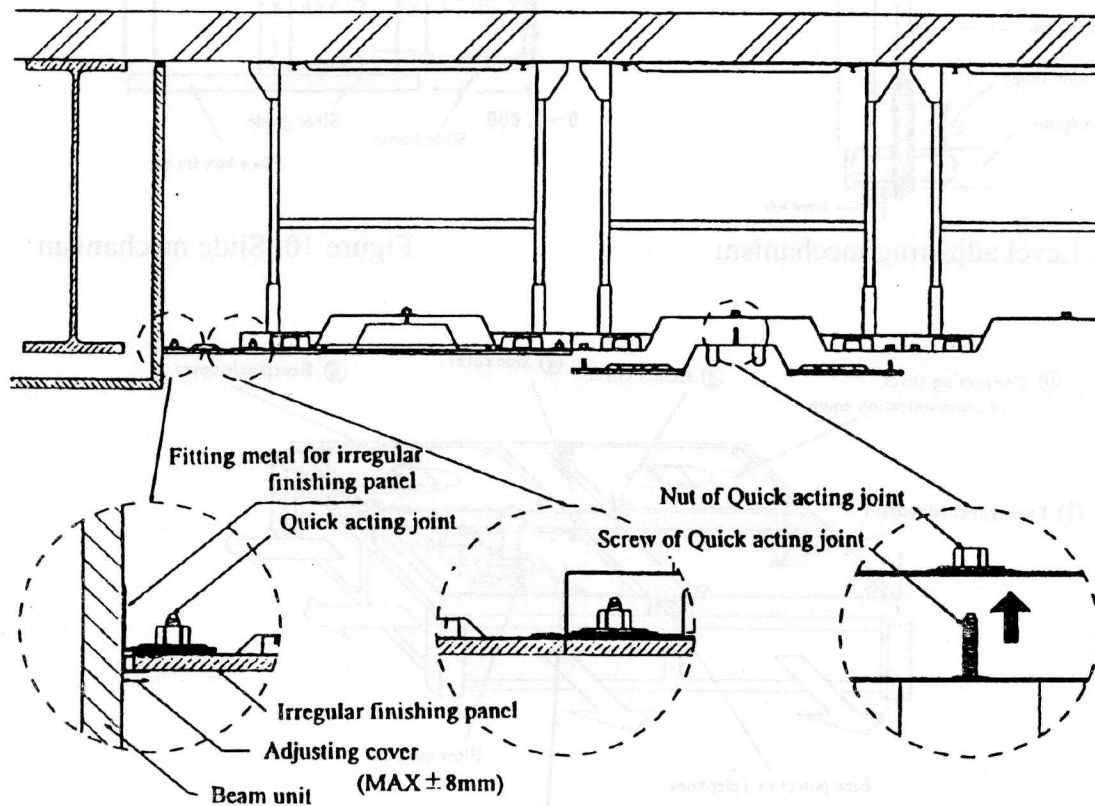


Figure 8 , Ceiling system outline

2.3 Floor System

The characteristic of this floor system is that the current arrangement of some functions provided on ceiling is moved on floor. Having considered the necessary function of the equipment and the arrangement for the living space, we decided to develop frame constructed floor box unit with necessary function and supporting floor finishing

material by this floor box unit. At the same time, air conditioning duct is fabricated by attaching finished plate on the side of the standard floor box unit.

The floor box frame is made of alminum structure and the weight of the standard unit is 18.3 kg.

Installation of floor box unit on the floor slab is made by fixing the level adjusting bar in the positioning blind hole previously set on the slab, after setting the bar, the level of the floor box face is adjusted by the screw attached the top of the bar. Adjustabe range is +10mm. (see fig.9) The peripheral opening is adjusted by the slide mechanism of the floor box unit. (see fig.10)

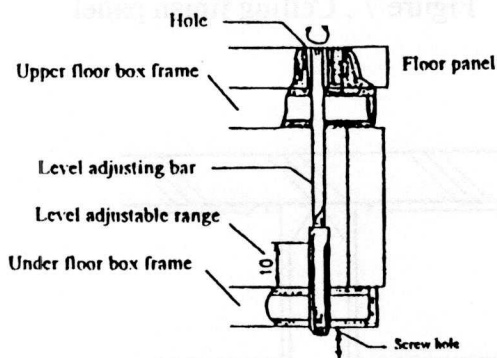


Figure 9. Level adjusting mechanism

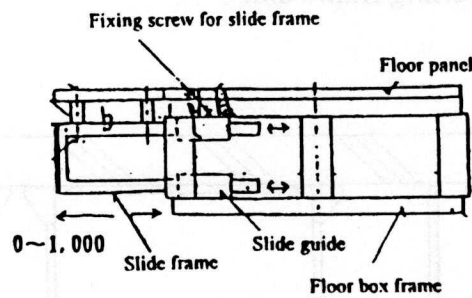


Figure 10. Slide mechanism

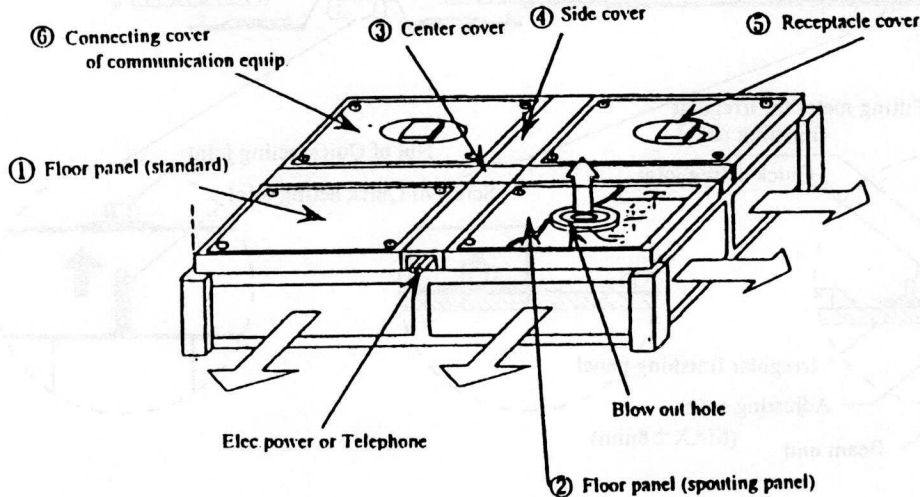


Figure 11 Construction of floor box unit.

3. THE SCHEMATIC DESIGN OF CONSTRUCTION ROBOTS

The development of construction robots calls for the issues indicated in the diagram shown in the figure 12. The theme of the project this year is to clarify the schematic design of construction robot, which is explained by the four items shown in the left side of the diagram.

The function of the construction robot can be divided into the two main functions: Holding and fabricating function, and locomotive function.

Module robot which has some versatility to different works, by exchanging its handling devise, is somewhat advantageous, however, the project didn't decide to adapt module robot after considering the work efficiency and work process as well as the configuration of each unit and the movement in the assembly process.

The mechanism of the locomotive function is common to each construction robot, therefore, the locomotion mechanism of the robots can be designed by the same way based on the same concept, even though the weight of each unit is different. On the construction site, each unit system is carried out by each robot, for each work, shown in the figure 13.

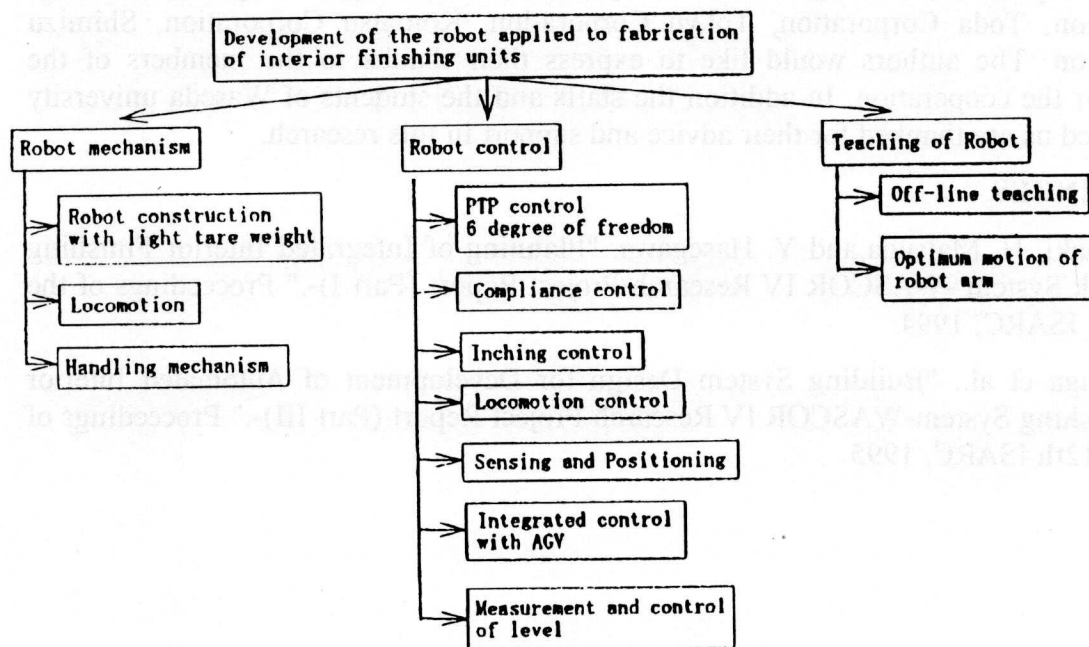


Figure 12, Problem of robot development

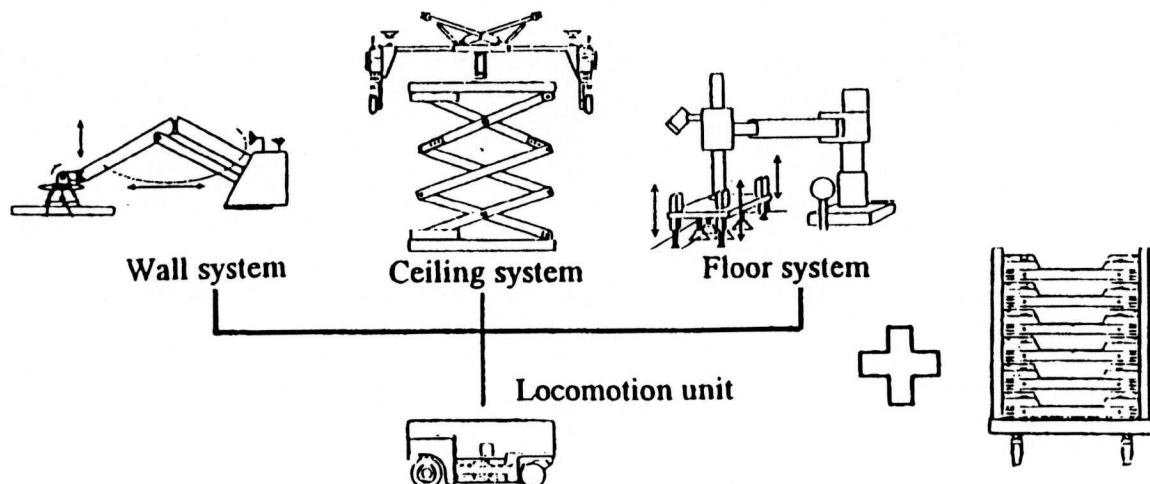


Figure 13, Robot composition image chart

4. SUMMARY

In this report (PART III), the concept of applying each unit for each finishing work is proposed as a suitable interior finishing work system for automation, and the suitable structural work method is also developed. At the same time, an image of the robots for the installation of each work is reported. The information control system reported last symposium as PART I, and the further study of this field together with the robot design will be reported next year.

ACKNOWLEDGEMENT

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