STRUCTURING OF SEKISUI HEIM AUTOMATED PARTS PICKUP SYSTEM (HAPPS) TO PROCESS INDIVISUAL FLOOR PLANS

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1. Summary

Sekisui Heim residential houses (herein "Heim") are made of factory-produced modules called "Units" which can be combined to complete any house plan. All "Units" to compose a house are unique and have different parts in different combinations. It is an important process to select and pick up about 30,000 parts correctly for each house, out of about 300,000 listed parts and feed them to the production line in time of work.

In this paper, the writer will introduce to you how to pick up the parts constituting Heim units, and certain technical points of the "HAPPS" (Heim Automated Part Pick-up System) which has materialized such method. In the end, the writer will touch on the efficiency and accuracy of such part pick-up method.

Keywords: prefabricated house, bill of materials, parts explosion, just-in-time

2. About "Heim"

2.1 Unit House

Sekisui builds and sells 13,000 "Heim" houses annually, which are commonly called Unit House. The Units have steel frame structure and are fabricated mostly in factory to a level of about 80% completion. This process is called "Unit Method" and minimizes work load at construction site enabling fast and high quality house making. An advantage of "Unit Method" is freedom in floor plan selection which is allowed by the strong steel frame structure. Floor plan of contracted "Heim" is divided into several standardized segments for the production of best suited "Units". (Fig. 1) There are about 70 kinds of Unit, of which 40 are standard cuboids varying in 10 lengths, 2 widths and 2 heights and others are special shape Units (trapezoid etc.).

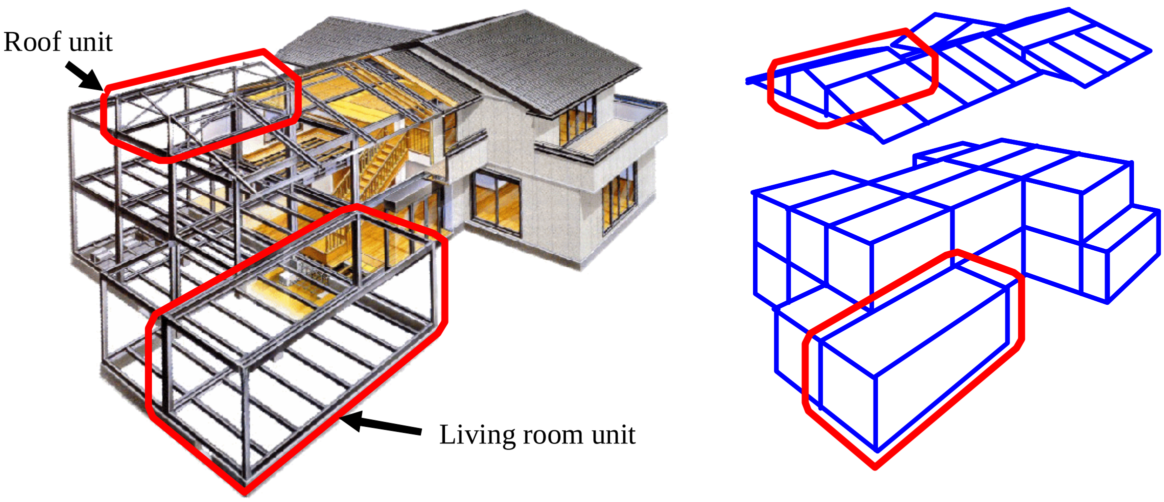

Fig. 1 Unit Method

2.2 Work flow from receipt of order to delivery

Once the customer places an order, each house is processed separately. Firstly the sales company draws the floor plan and secondly at the factory all necessary parts are picked according to the floor plan. The Unit frames are made from steel stocks by welding and fed to the assembly conveyor line where the installation of exterior and interior parts and equipment to the frames is performed by workers. (Fig. 2) Lastly the Units are transported to the construction site and tied together to compose a house. (Fig. 3)

A large factory makes 135 Units a day (1 Unit every 3 minutes), each of which is consisted of different parts placed in different locations. It is important to select about 30,000 specific parts correctly out of about 300,000 listed parts and deliver them to the assembly line in time of work. Engine, seat, paint color, audio component, etc. may be chosen in the assembly of automobile but even layout of seats or windows or size and shape of body can be selected, so to say, in the assembly of Heim. Here we introduce a parts explosion system for such freedom of design.

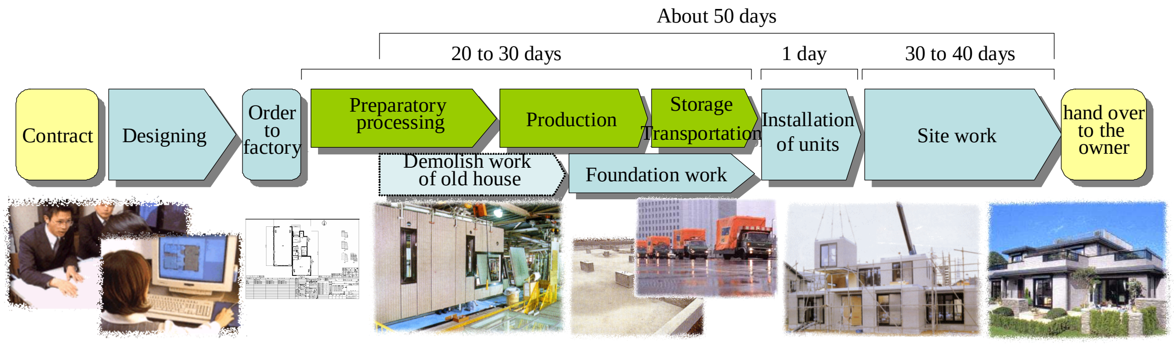

Fig. 2 Process of Heim making

Fig. 3 Factory assembling of Heim Units

3. Technical key points in parts explosion

There are two technical key points in the system. One is how to incorporate BOM (bill of materials) for ultra-high mix low volume production to give design freedom to customers who demand individual houses of all different floor plans, equipment and interior decoration. The other point is the explosion method which breaks floor plans down to parts.

3.1 BOM structuring

In general assembling industry, a BOM is constructed by exploding the product down to intermediates and then to parts. (Fig. 4) Concept of BOM is based on the standard model, to which optional parts are tied. In Heim, no standard house can be offered because individual floor plans would vary so much. To deal with this situation, a concept of imaginary intermediate is created which is a group of parts closely related. (Fig. 5) BOM tied to a group of parts plays an important role to process individual floor plan. These imaginary intermediates may exist temporarily in the production process or can just be imaginary (dummy). It can be defined as "intermediates, whether real or imaginary, used for effective explosion of product to parts." Identifying codes of these groups of parts are called MIM codes (Menu Item Master).

MIM code consists of many digits which indicate, for example in case of exterior wall, dimensions, neighboring parts, interfacing condition, color, etc. (Fig. 6) Such BOM method, specialized for parts explosion, enables to expose any floor plan efficiently.

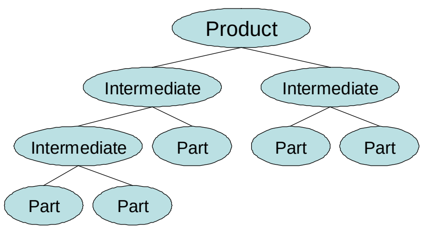

Fig. 4 BOM of assembling industry

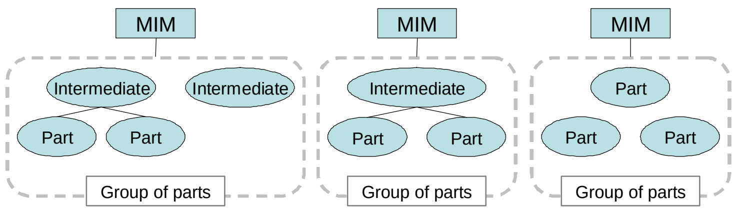

Fig. 5 BOM of Heim

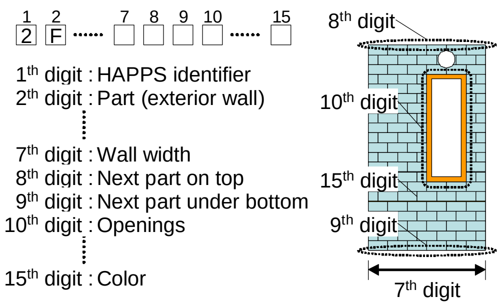

Fig. 6 Identification of intermediate by MIM code

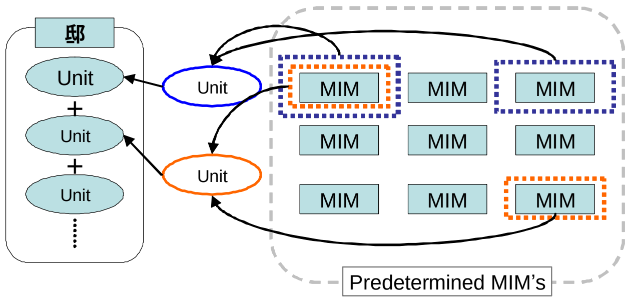

Fig. 7 Image of MIM picking up

(Example in external wall)

3.2 Parts explosion

BOM and MIM are prepared at the stage of R & D and there are about half a million MIM codes per one series of Heim product. Orders from customers are actually processed individually by picking and combining about 4000 MIM codes in average per house, out of half a million codes. (Fig. 7) Picked MIM's are matched to BOM's which are designed for explosion to parts. This is the parts explosion method in Heim production.

4. Important technical points in the parts explosion system

This efficient and accurate system of MIM pickup is called HAPPS (Heim Automated Parts Pickup System). The outline and the important technical points are explained below.

4.1 Outline of HAPPS

HAPPS is a system to pick up necessary parts when a floor plan of production order is put in. HAPPS is consisted of information receiving section and processing section. (See Fig. 8)

In the information section, input of floor plan data in graphic form, such as house type (snow accumulation class, exterior wall color, etc), Units, accessories (balcony, entrance porch), equipment (bath, kitchen), are converted to "objects". "Object" is abstracted floor plan information expressed in dots, points, lines and rectangles. "Objects" compose a modeled house in the virtual space. (Fig. 9)

In the processing section, "objects" are restructured (divided or combined) to new "objects" which suit MIM's of pickup system. "Objects" are principally in 1-to-1 correspondence to MIM's (groups of parts). "Objects" will meet and catch corresponding MIM's and determine number or letter in each digit, in consideration of surrounding conditions.

Fig. 9 shows a house expressed by Units and exterior walls and its conversion to a modeled house composed of "objects" in the virtual space

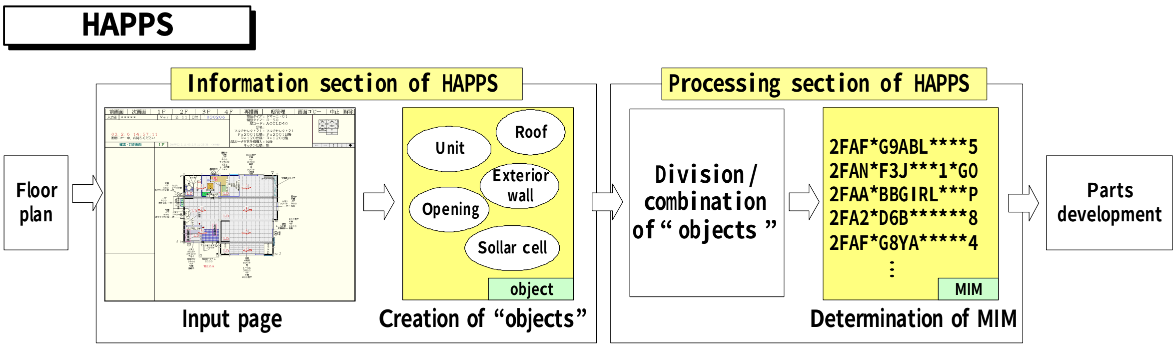

Fig. 8 Heim Automated Parts Pickup System 'HAPPS'

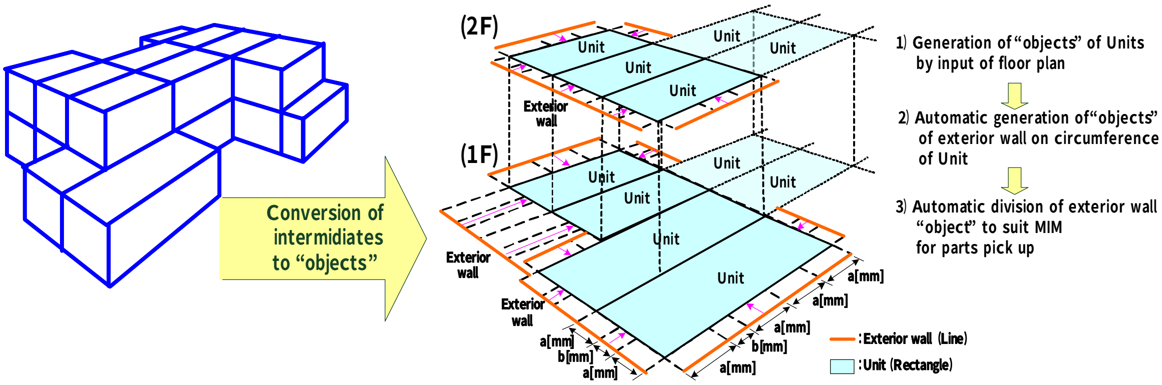

Fig. 9 Conversion of intermediates to "objects"

4.2 Important technical points in HAPPS

In HAPPS, it is an important process to convert intermediates to "objects" in the virtual space and to let the "objects" conform each other, prior to the pickup of right MIM.

4.2.1 Conversion of intermediates to "objects"

Based on the Unit information, location information within the Unit and interference information with other parts, "objects" are allocated to compose an abstract house, in places of actual intermediates, which process is required for parts pickup. Corresponding to the allocated "object", MIM will be output referring to the surrounding conditions and selecting figure or letter of each digit. Conversion of intermediates to "objects" puts out MIM's very efficiently, which otherwise require complicated judging. Configuration of exterior wall top (8^{th} digit of MIM) is shown, as an example, in Fig. 10.

There is an exterior wall on top of the exterior wall A. Hence, the "next part on top" is an exterior wall. There is no exterior wall nor Unit but roof on top of the exterior wall B. Hence the next part is roof. This information and other surrounding circumstances including interfering information of next part are required to identify the specific MIM. Similarly other digits such as 'next part under bottom' or 'openings' are determined in relation to the Units and other parts,

As such, in the modeled house composed of "objects" in the virtual space, mutual positions of "objects" become clear and MIM's can be identified accurately and efficiently. In addition, "objects" make the programming easier, by giving clear images of part fit. Also the visualization by "objects" makes the parts explosion very efficient.

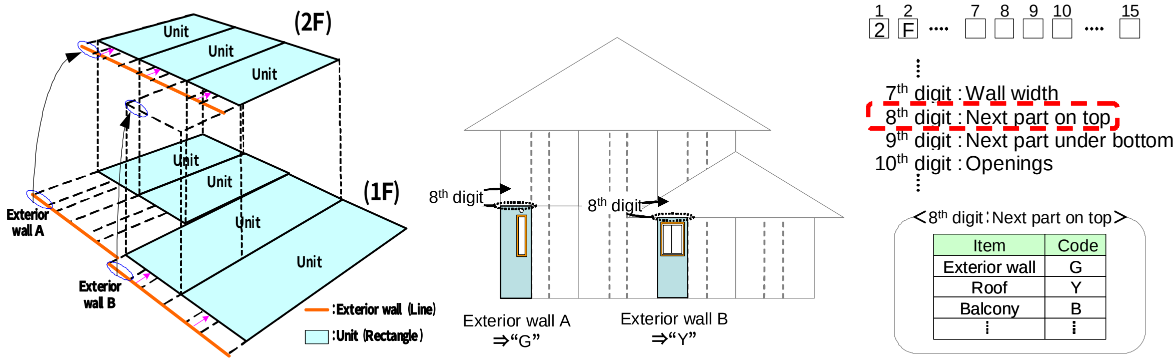

Fig. 10 "Objects" and example of MIM determination

4.2.2 Property inheritance from "object" to parts

About 10 new Heim models and about 400 modifications/improvements are introduced annually. It is necessary to modify or add to the program responding to such changes, by exactly defining the alteration work. It means the program must be durable for alteration or addition.

HAPPS program is made durable to alteration, by providing inherent relation between "objects" and subordinate parts. This relation enables to write just the additional changes less what is written in the superordinate program, minimizing the writing volume. It is easy to find affected points, which fact minimizes forgets and lowers error rate of program.

For example, if a new color is added to the house colors, it is given as an attribute of whole house. This information is needed for exterior wall, openings, balcony etc., to be exploded to parts, however, this attribute of wall color is not given to "objects" of these intermediates but it is inherited from the house attributes. In case of addition or change of wall color, modification of program is necessary only in the house information. The inheritance plays a role to reduce writing volume and error rate of modification.

4.3 Application scope of HAPPS information

Each "object" of HAPPS has location information of own intermediate and interfacing information to neighboring intermediates. These informations are also used for parts ordering and production instructions.

Integration of information from HAPPS and information of the production scheduling will produce instructions to workers and machines, in binary or printed form.

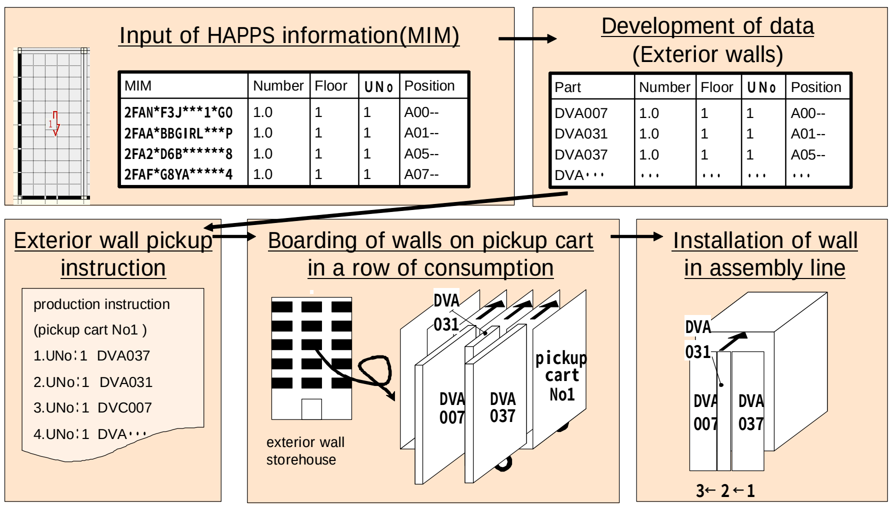

Fig. 11 Application of HAPPS information in exterior wall installation

Such function of HAPPS enables just-in-time, in-right-quantity feed of parts to assembly lines. As parts can be lined up in order of consumption, convenient environment can be provided for line workers who can just pick up the part at the end of lineup (Fig. 11)

5. Efficiency and accuracy of HAPPS

5.1 Parts exploding rate and time consumption in HAPPS

We reported the HAPPS above, however, we use other systems for parts explosion as well. HAPPS cover all the important parts which consist 70% of all parts of a house, including structural frames. HAPPS parts explosion takes 1 to 1,5 hour per house depending on the size and spec., starting from the input of floor plan and ending in the checking review. Total hours of parts explosion of a house is 5 to 6 hours.

5.2 Accuracy of parts explosion in HAPPS

HAPPS program is released once a month as a principle, corresponding to peaks of production. The system is checked by the input of about 70,000 test floor plans, before the release. If a model change takes place, current MIM's are checked for malfunctioning which may be caused by the program change. If a model is added, test floor plans are also added to make sure the program puts correct solutions out.

If a new series of Heim is launched, simulation check is conducted before the release. Rate of correct answer of MIM pickup is about 99,5% in simulations.

The error rate in actual operation in 2005 was 0,017 errors per house, being calculated from 223 errors in about 13,000 houses.

6. Future plan

HAPPS has been very helpful to increase accuracy of part pickup and to decrease picking time, thus contributing to the efficiency of part handling. We plan to further minimize the error rate by improving the definition of MIM and the parts grouping method. We intend to extend the application scope of HAPPS as well.

End.