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A MATERIAL-HANDLING SYSTEM IN THE BUILDING SITE

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ABSTRACT

This paper describes the development of a material-handling (carrying) system for interior finishes and the results of its operation at a building site. The system consists of automated guide vehicles (AGVs) which carry construction materials raised by a elevator (for material) to a designated place on a designated floor, control and communication equipment which gives commands to the AGVs and controls their operations. The use of this system at a construction site demonstrated its high capability of increasing the material handling efficiency and saving personnel requirements.

1. INTRODUCTION

The material handling at a building site accounts for a large part of all construction work. But this operation is less automated and unmanned than others, because it is auxiliary to other work and done as preparation or clearing away, materials to be handled are not uniform in size, weight and shape, and the handling place and its surrounding change with the progress of work.

However, the recent increase in construction work and a chronic shortage of work force indicated the necessity of developing an automatic material-carrying system to save personnel requirements and improve the working efficiency.

Under there circumstances, we carefully investigated how materials were handled at sites, and started to develop. After testing at a site, we further improved and developed a commercial system which was actually used at a construction site.

2. AIMS OF THE DEVELOPMENT AND REQUIREMENTS FOR THE SYSTEM

On the basis of our investigation on the actual conditions at building sites, we set up the following aims and requirements for the system.

2.1 Aims

(1) To reduce manpower
 a) Unattended unloading
 b) Unattended horizontal transfer
(2) Improvement of efficiency
 a) To reduce loading and unloading time

2.2 Requirements for the System

We aimed at developing a system which would meet the following requirements.

(1) AGVs were able to carry materials of various sizes and styles.
(2) Not necessary to reinforce floor slabs on which the AGVs travel.

(3) The unloading (storage) location was easy to be set and changed easily.
(4) The AGVs and elevator were able to operate by one operator.

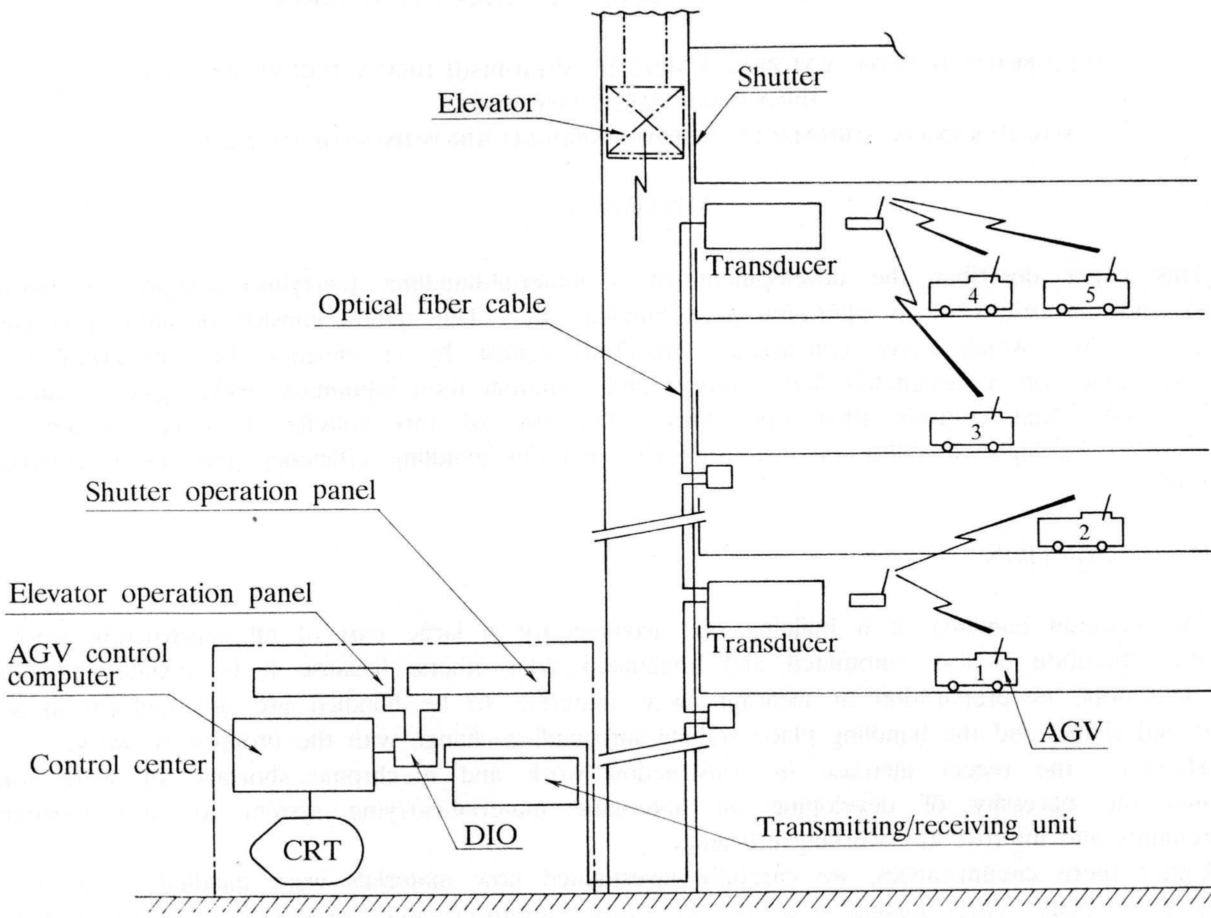

Fig.1 WHOLE SYSTEM

3. COMPONENTS OF THE SYSTEM

The whole system consists of a elevator, a shutter on each floor and a material-carrying system. (see Fig.1) At this paper, mainly we describes a material-carrying system.

3.1 AGVs

The AGV is composed of a travelling, guiding, a handling (fork) unit, a power supply unit, a control system and safety devices, etc.

Construction materials elevated to a floor is picked up by the fork and loaded on the vehicle which travels to a place commanded beforehand and unload the materials there. The AGV is powered by batteries.

The AGV is guided by optical sensors equipped on the vehicle and a reflecting tape laid on the floor. The travelling route of the AGV can be freely set to suit condition of the storage locations without any special work for the floor concrete. The AGV travels along the main route. When it detects an identification mark of a storage location, it runs in direction orthogonal to the main route without reflecting tape and unloads the marerials at the storage location. Then the AGV returns to the main route for next operation. (see Fig.2)

An alarm light and a chime on the AGV warn workers of its approach. The AGV is also equipped with a sensor to detect an obstacle ahead of it and to stop the further travelling. Furthermore a touch sensor to immediately stall the AGV when it comes into contact with any other object. The AGv stops automatically when any alarm condition occurs. For the sake of further safety, an emergency stop button mounted on the AGV stops all of its operations when it is depressed. Main specifications of the material-carrying system are shown in Table 1.

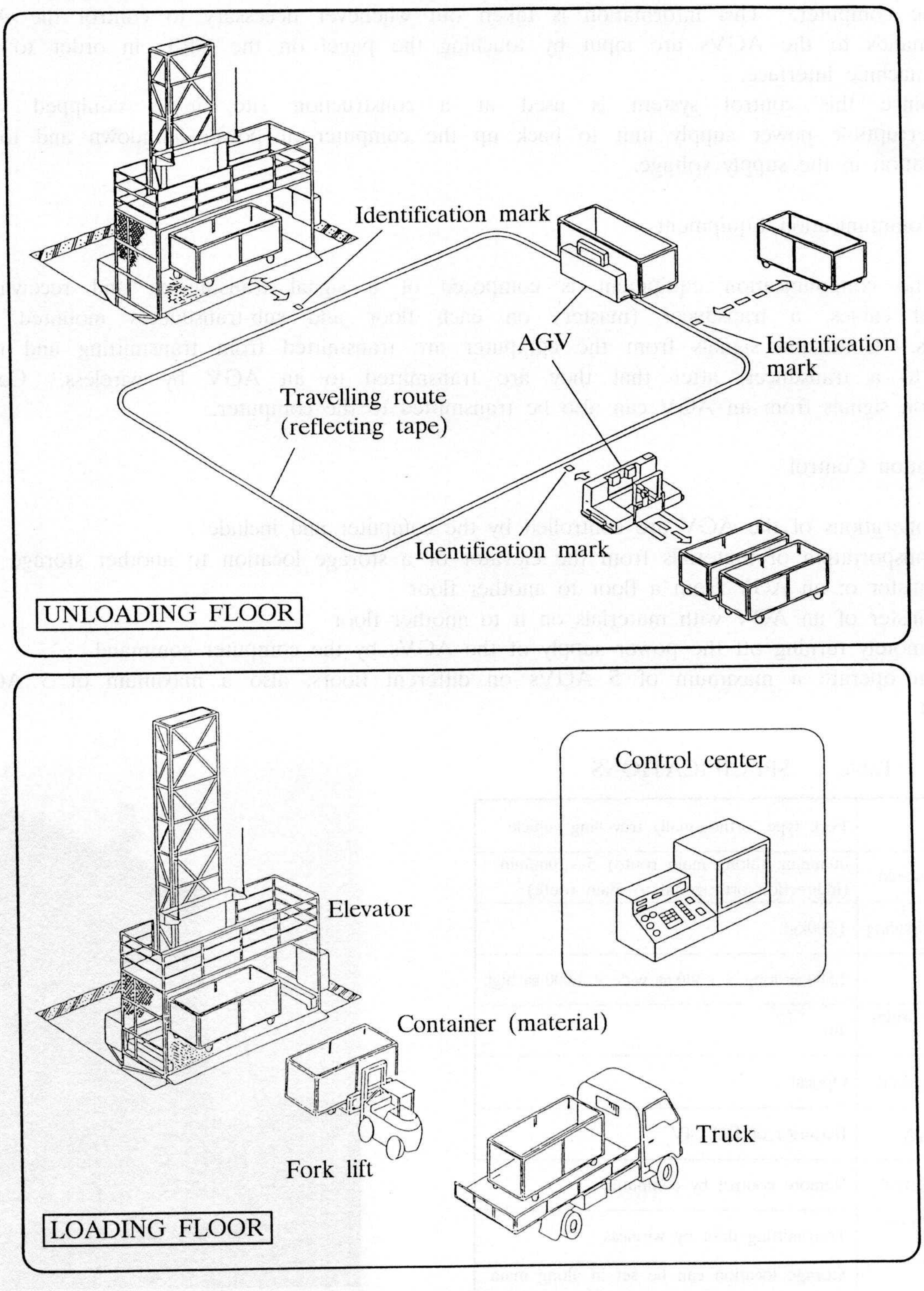

Fig.2 MATERIAL-CARRYING SYSTEM

3.2 Control and Communication Equipment

(1) Control Equipment

The control equipment is composed of a computer, a CRT, an uninterruptible power supply unit and a signal transformer. The information necessary to control the operations such as the layout each floor and storage locations are registered beforehand and are kept in the memory of the computer. This information is taken out whenever necessary to control the AGVs. Commands to the AGVs are input by touching the panel on the CRT, in order to improve man-machine interface.

Since this control system is used at a construction site, it is equipped with an uninterruptible power supply unit to back up the computer at power shutdown and to reduce fluctuation in the supply voltage.

(2) Communication Equipment

The communication equipment is composed of a signal transmitting and receiving unit, optical cables, a transducer (master) on each floor and sub-transducers mounted on the AGVs. Command signals from the cpmputer are transmitted from transmitting and receiving unit to a transducer, after that they are transmitted to an AGV by wireless. Conversely position signals from an AGV can also be transmitted to the computer.

3.3 Operation Control

The operations of the AGV are controlled by the computer and include :

- Transportation of materials from the elevator or a storage location to another storage location
- Transfer of an AGV from a floor to another floor
- Transfer of an AGV with materials on it to another floor
- Remotely turning off the power supply of the AGVs by the computer command

It can operate a maximum of 5 AGVs on different floors, also a maximum of 3 AGVs on same floor.

Table 1 SPECIFICATIONS

AGV	Fork type, orthogonally travelling vehicle
Travelling speed	40m/min. (along main route), 5 ~ 10m/min. (indirection orthogonal to main route)
Maximum loading	1,300kgf
External dimensions	2,500 ㎜ long × 1,300 ㎜ wide × 1,000 ㎜ high
Minimum turning radius	4m
Guiding method	Optical
Power supply	Batteries of DC 24V
Control method	Remote control by computer
Communication method	Transmitting data by wireless
Other	Storage location can be set in along main route

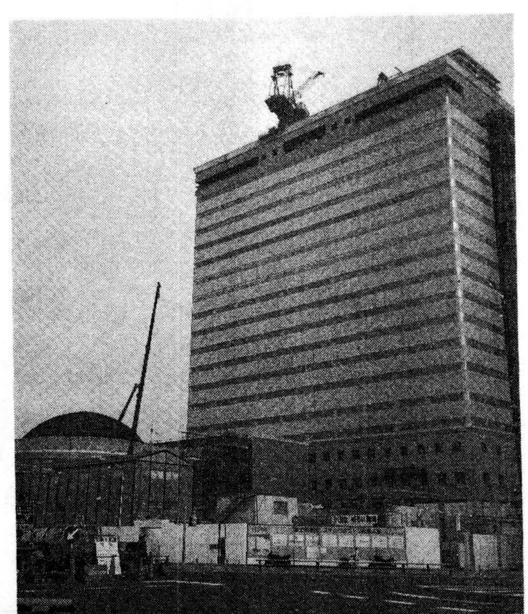

Photo 1 WHOLE VIEW OF SITE

4. APPLICATION AT A BUILDING SITE AND ITS RESULTS

4.1 Building Site

The developed system was applied at a construction site of the most up-to-date intelligent building in Makuhari, Chiba City. (see Photo 1)

(1) Name	: Fuji-tsu System Laboratory Construction Work
(2) Location	: NO.9, Nakase 1-Chome, Chiba-Shi, Chiba Pref.
(3) Site area	: 14,000.05 m^2
(4) Building area	: 9,174.13 m^2
(5) Number of floors and height	: 21 stories above the ground, one story of penthouse, maximum height of 95.8 m
(6) Structure	: S (partially SRC)
(7) Use	: Office
(8) Construction period	: From April 16, 1990 to June 30, 1992

4.2 Application of the System

The system was introduced into the site in June, 1991 and used for about 6 months to December, 1991.

(1) Floor Layout

Fig.3 shows the floor layout. One elevator was used to elevate materials. The travelling route of the AGVs was straight. Six storage locations were provided along the travelling route to stock the necessary quantities of materials for a work process. Besides the storage locations, a standby position of the AGV was provided.

(2) Carried Materials

The AGV was designed mainly to carry the following materials :

① Interior materials : Gypsum boards, fire partition materials, LGS (Light-Gauge Steel), ceiling materials, ALC, window frames, floor carpets and materials for access floor
② Equipment materials : Pipes, air-conditioning ducts and insulation materials.

Fig.4 shows the standard package styles.
At the construction site, the system principally carried gypsum boards for columns and walls, fire partition materials, LGS and ceiling materials.

(3) Operation Method

The elevating and carrying schedule of materials was preset on a basis of reservations. Materials transported into the site were loaded into the elevator by a conventional fork lift, and them elevated to the indicated floor according to the schedule. An AGV waiting on the designated floor received the materials from the elevator and carried them to the indicated storage location by command from the control center. The AGV continued the same operation until all materials were carried to the storage locations. When the AGV finished all the operation, it was moved to another area or floor according next schedule by command from the control center. After the completion of a daily schedule, the power supply to the AGVs was turned off and the batteries were charged.

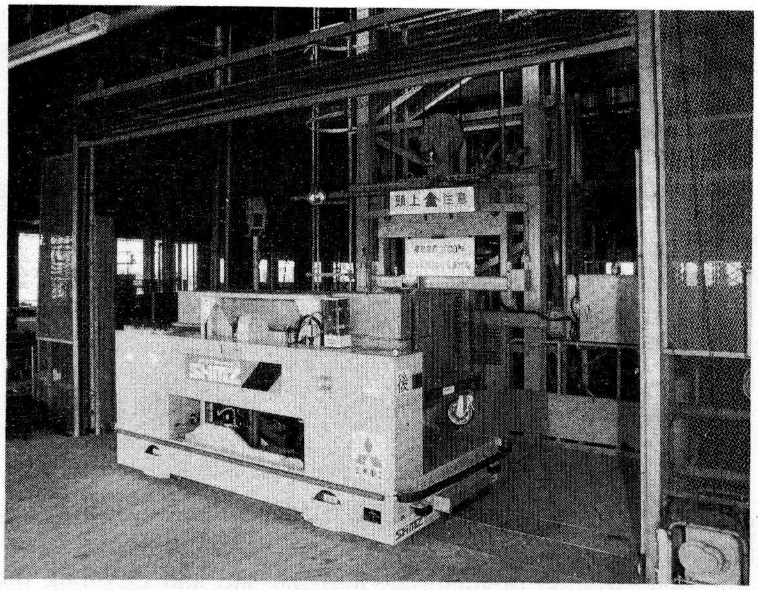

Photo 2 AGV : Riding into the Elevator

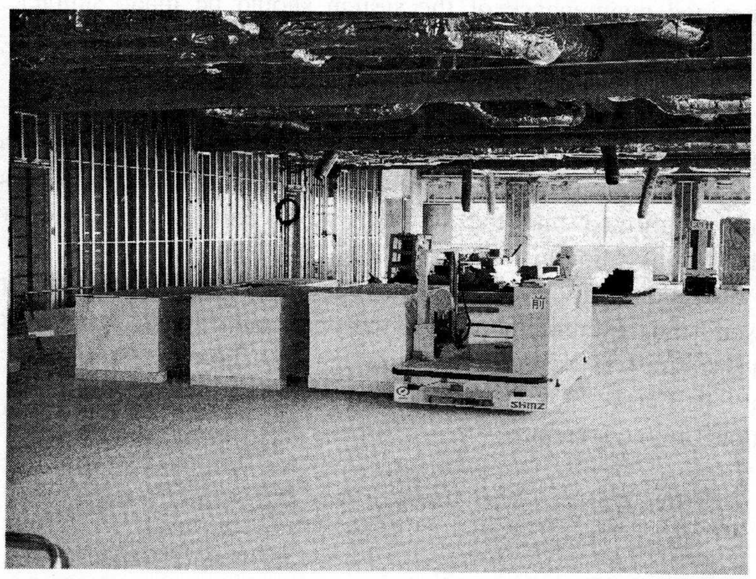

Photo 3 AGV : Unloading

4.3 Application Results and Further Requirements

(1) Effects

Introduction of this system :

① Eliminated the 4 or 5 workers necessary for unloading and achieved unattended unloading operation (see Photo 2)
② Increased the operation rate of the elevator 25 to 30% by reduction in the unloading period
③ Reduced the overtime of elevating and carrying operations of materials
④ Kept the floors in good order and facilitated the search for the stock materials as they were arranged at uniform intervals (see Photo 3)

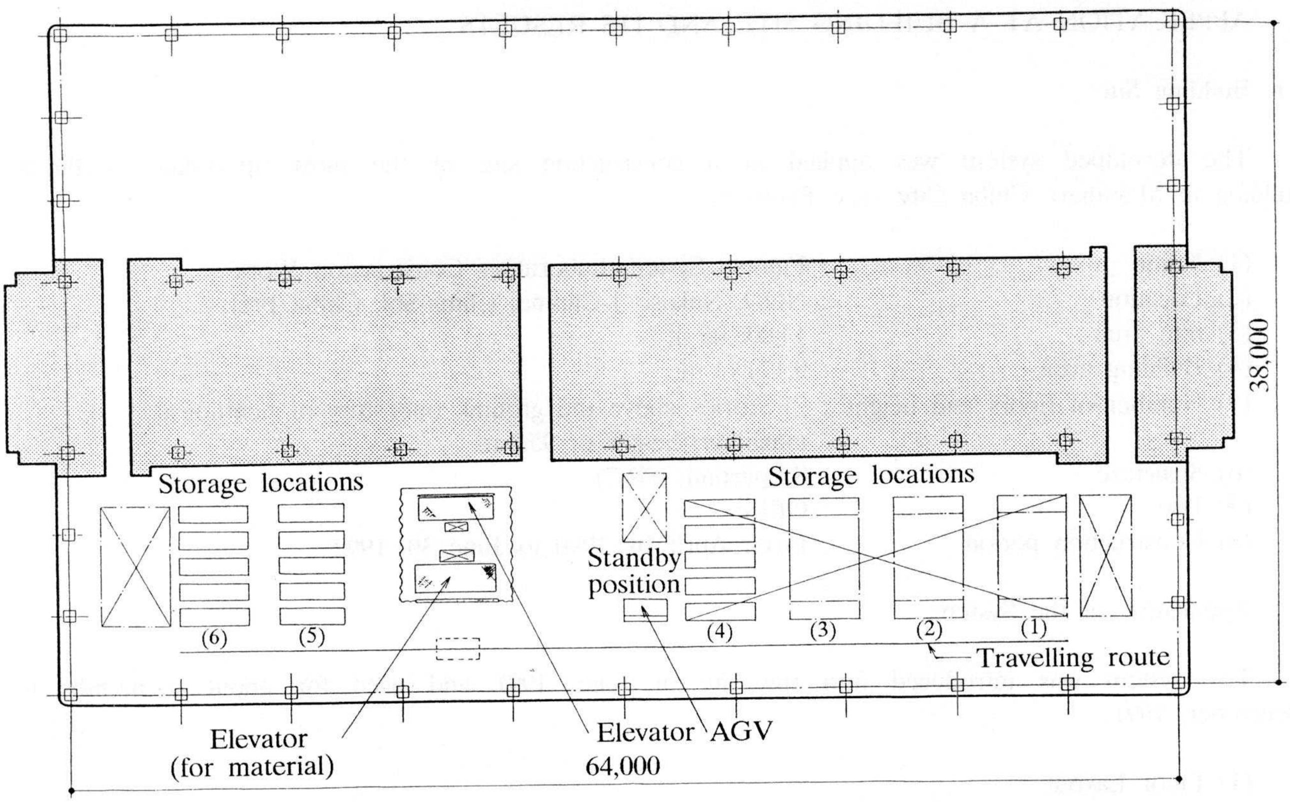

Fig.3 FLOOR LAYOUT

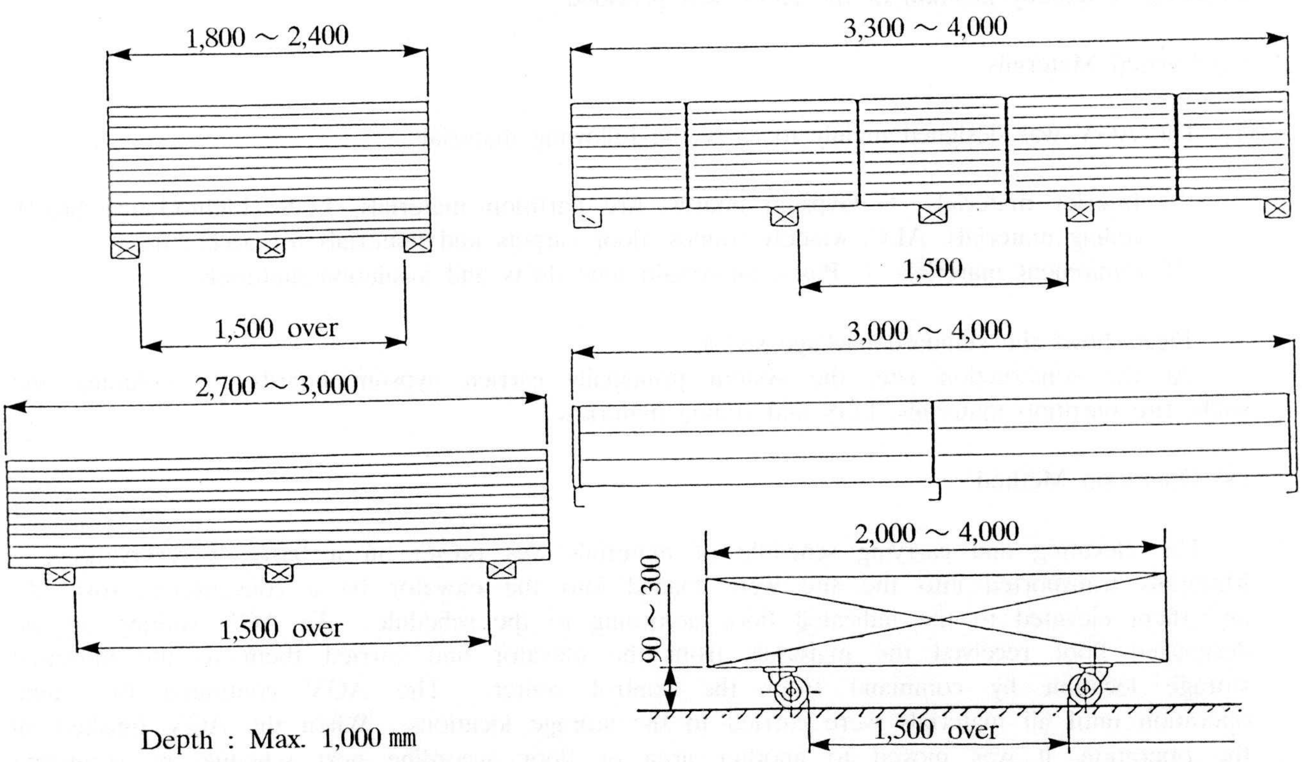

Fig.4 STANDARD PACKAGE STYLES

Furthermore, it was confirmed that the concept and the procedure of this system achieved automatic and efficient carrying of materials to an indicated destination on a designated floor.

(2) Problems and their Solutions

An AGV mistook a puddle for a mark, and the travelling guidance tape required much repair. These problems were quickly solved by changing the fitting direction of the sensor and the use of reinforcing tape.

(3) Further Requirements

For a wider application of the system, it is desirable to introduce the following improvements.

① The packing styles of materials should be standardized to increase materials which can be carried by this system.
② A schedule for transportation of materials into the site and elevating them to storage floors should be established to make the system work more efficiently.
③ For the smooth introduction of the system into site, the operations should be made simpler so that the operator can easily master the system.
④ The operation and maintenance of the system should be made simpler.

5. SUMMARY

A material-handling (carrying) system was used for construction of an office building, achieved unattended carrying of interior finish materials in the building, and increased the operation rate of the elevator. It was also confirmed that the system would contribute to requirement for man-power saving and shortening the working hours.

In the future, the operations of the system will be made simpler and the practical usage at the site should be reviewed the establishment of the efficient application. Moreover the system applicable to a medium-size site will be developed through the success of the present system.

Finally we express our sincere appreciation to all the people who extended cooperation for the employment and operation of this system.