Development of the elevator for medium-low rise housing

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ABSTRACT

For the purpose of encouraging the low-level end of the elevator market and assisting the aged and the physically handicapped in going up and down the stairs, the design guidelines for residential elevators (for middle-low rise housing) were made public by the Ministry of Construction in March '96. Mitsubishi Electric started the development of such an elevator .This elevator, known as the "MELWIDE", was the first in the market place in March '97.

Through adopting the side fork type and using a platform without vibration rubbers, miniaturization and the lightening of equipment were achieved. However, due to these improvement, the car will exhibit increased vibration and frame deflection. In this thesis, the specification and structure of the "MELWIDE" elevator, the vibration control technology, and the rigidity analysis technology are described.

1. Introduction

To facilitate the installation of elevators in low-medium rise buildings and to improve access for the aged and the disabled for whom it is difficult to use stairs, the "Elevator Design Guidelines" were published by the Japanese Ministry of Construction in March '96.

In response to this, we (Mitsubishi Electric) initiated a product development based on the published "Design Guidelines" and successfully brought to market the "MEL WIDE" elevator for low-medium rise buildings in March '97, ahead of other competitors in this field. The basic concepts for this development are as follows;

(1) Suitable for all passengers, including the elderly or disabled.
(2) Reduction in installation space
(3) Manufacturing time is reduced to suit the needs of small & medium scale property developers
(4) Energy and maintenance costs are reduced.

This paper describes the specification, structure and technology of the newly developed "MEL WIDE" elevator.

2. Specification of Product

Table 1 lists the standard specification of the "MEL WIDE". The traction method is used for the driving mechanism, enabling a reduction of motor capacity by 30% as compared with our 4-person "COMPACT 4" elevator, thus conserving energy. The "MEL WIDE" system does not require a machine room, resulting in a more efficient layout. Furthermore, this supports compatibility for wheel-chair users, the aged and the disabled,

Table 1 Standard Specification

Rated Passenger	4 Passenger
Rated Speed	45 m/min
Rated Load	3 2 0 Kg
Driving Method	Traction Type
Control Method	Inverter Type
Operating Method	Selective Collective
Max. Stops	5 Stops
Max. Rise	13 m
Power Source	Drive/Control 200 V
Motor Capacity	2.7 KW
Door Type	Two-speed single side sliding door
Shaft Size (mm)	Width 1550×Depth1650
Cab Size (mm)	Width 900×Depth 1400
Door Size (mm)	Width 800×Height 2000

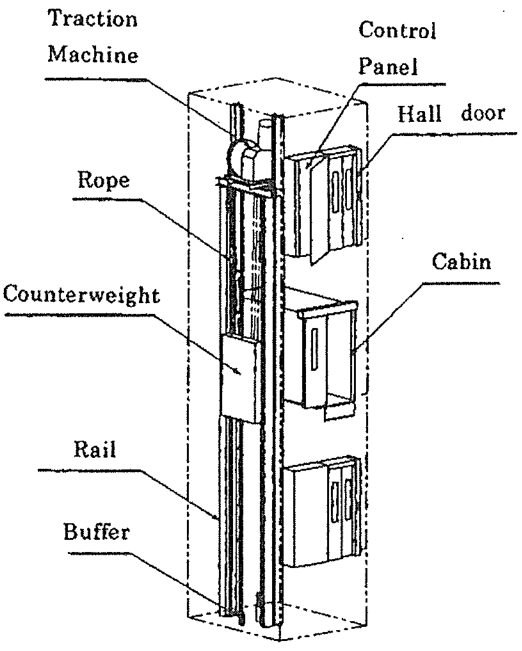

Fig.1 Elevator system

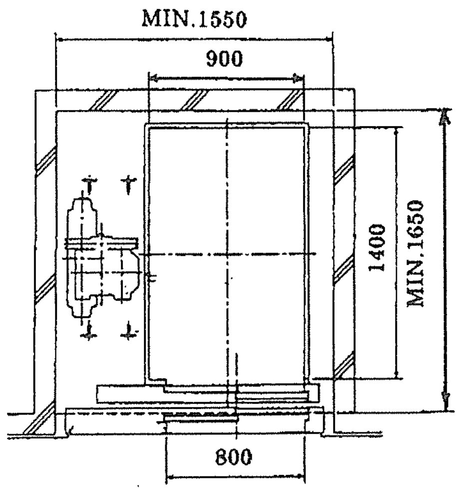

Fig.2 Shaft size

with respect to a spacious car with an internal width 900mm, a depth of 1400mm and the location of the car operating panel on the side wall.

3. Structure

3-1 Equipment Structure

Fig's 1 and 2 illustrate the entire elevator system and shaft-way layout, respectively. The traction machine of the "MEL WIDE" is fastened to the upper part of the counterweight rails, which results in the perpendicular load being transmitted through the rails, rather than the building structure. The control panel, for the traction machine, is incorporated within the door operation equipment (hall-side) on the top floor.

The "MEL WIDE" uses the side fork lift layout, whereby the car is supported by a framework which is guided along rails. This allows for a simple structure and space reduction.

In consideration of building regulations and exterior appearance, the required overhead dimension (above the top floor) was kept to a minimum. The traction machine consists of a reduction worm gear and a low noise -level motor, ensuring both the miniaturization of the components and a reduction in noise levels. Measures to reduce noise and vibration levels are particularly important for the "MEL WIDE", due to its installation within the shaft-way, which places it in close proximity to adjacent residential rooms. In addition, the compact disc type brake designed for noise prevention was adapted for this system.

With regard to the hoisting rope ends, a new design, called the swaging shackle was developed to reduce manufacturing costs. Unlike the conventional "Babbitt filling process", the hoisting rope and shackle are assembled at the factory rather than on-site. An outline drawing of the swaging shackle is shown in Fig.3.

3-2 Control Equipment

The control panel is installed in the door operation equipment (hall-side) and housed behind the inspection door. The system specifications for the "MEL WIDE" are similar to those of standard residential elevators, however these simple changes facilitated a reduction in the amount of space required. The inverter was realized using an Intelligent Power Module that raises the PWM frequency above 10KHz reducing noise in the lower frequencies which are more offensive to the human ear. Through the use of a high performance micro-controller, for inverter control of the traction machine motor drive, it was possible to completely digitize the control panel. The adoption of a digitized control system has helped to ensure reliability and a comfortable ride.

3-3 Appearance Equipment

Fig's 4, 5 and 6 illustrate the cage, the car operating panel and the hall devices, respectively. The cage is fabricated from polyvinyl chloride-coated carbon steel sheets and provides a convenient free volume (width 900mm, depth 1400mm, height 2100mm) for transportation. The car operating panel is mounted on a side wall, in the center of the cage, and is equipped with car indicator and direction lamps as standard. In addition, it is possible to install an extra control panel.

For ease of use, digital hall indicators system are installed on each floor, and the hall buttons are positioned at 1m above the floor.

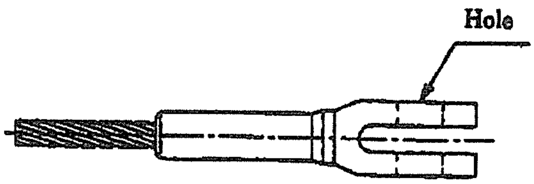

Fig.3 Outline drawing of swaging shackle

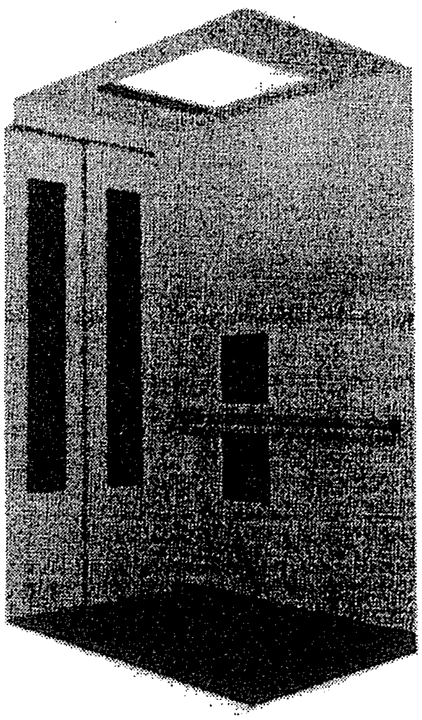

Fig.4 Cab design

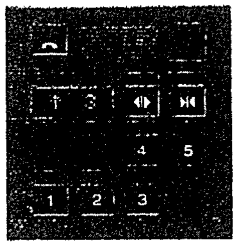

Fig.5 Car operating panel

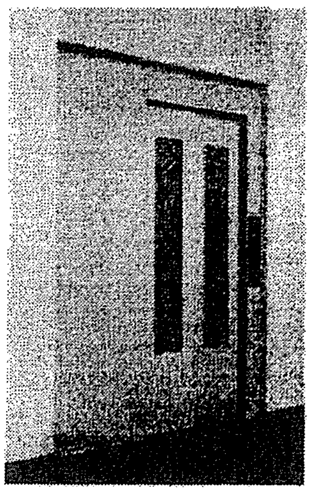

Fig. 6 Hatch door operator

3-4 Additional Specification

The optional specifications, such as handrails, photoelectric devices and 2 gates are available to improve access for users. Of these, the feature of 2D-2G enables wheel- chair users to exit from the car without a change in direction, which reduces the space in the architectural layout.

Optional emergency specifications are also available ; automatic landing device during power failure, an earthquake emergency return operation device equipped with S wave and P wave sensors which powers the elevator to the nearest floor, the emergency recall operation device which moves the car directly to the evacuation floor and stops in a fire emergency.

Options for the visually impaired and the hearing- impaired are available ; Braille plates, photoelectric devices and an audible system announcement which provides the elevator operation schedule information.

4. Technical Matters and Countermeasures

Since the "MEL WIDE" is designed to be installed in a small shaft-way, it was necessary to simplify the design and minimize the equipment. Hereinafter, we are going to explain non-resonance design without vibration proof rubbers, technology to reduce guide roller vibration due to the offset of the hoisting rope and car frame stiffness.

4-1. Elevator System Vibration

Generally, passenger elevators use an anti-vibration floor structure in which the car enclosure is supported upon the car frame using vibration proof rubbers. However, the "MEL WIDE" does not utilize a vibration proof floor structure, in order to achieve car weight reduction and simplicity of the structure design.
Due to the use of a car structure without vibration- proof rubbers, there was concern that the car may exhibit increased vibration due to resonance from the traction machine gear and hoisting rope. Therefore, a vibration analysis of the system was carried out on the control simulation software program MATLAB.

The analytical model which was generated is shown in FIG.7. The hoisting rope is modeled as a distributed parameter system of scalar mass and scalar spring elements. The shackle and the car are depicted as scalar-mass elements, and the shackle spring as a scalar spring element.

Fig.8 shows the correlated results between the hoisting rope length and the natural vibration frequencies of the car in the vertical direction, based on the model in Fig.7. The analysis results proved that due to the low travel distance and the short hoisting rope, the engagement frequency of the gear mechanism and the system's natural frequency did not coincide. Therefore, there would be no increase in car vibration as a result of resonance from the traction machine or hoisting rope.

4-2. Vibration due to Roller Guide Shoe

Since the "MEL WIDE" elevator's car frame structure uses the side fork lift layout, it is inevitable that the reaction force will pass through the guide shoe, due to the offset of hoisting rope. Compared with our residential "COMPACT 4" elevator, the "MEL WIDE" car frame is wide and heavy, resulting in an increase of load applied to the guide shoe. Due to this increase in load, it was anticipated that the car vibration in the horizontal direction

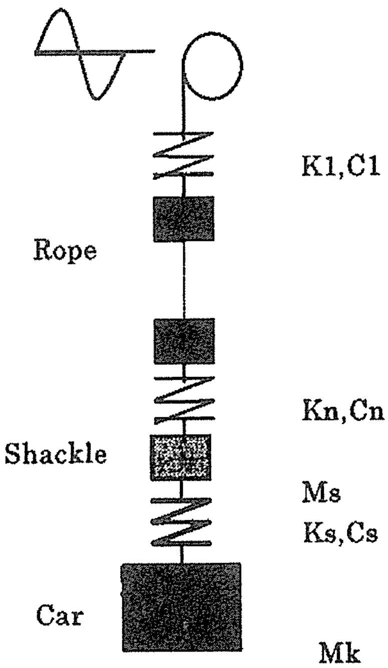

Fig. 7 Analytical model

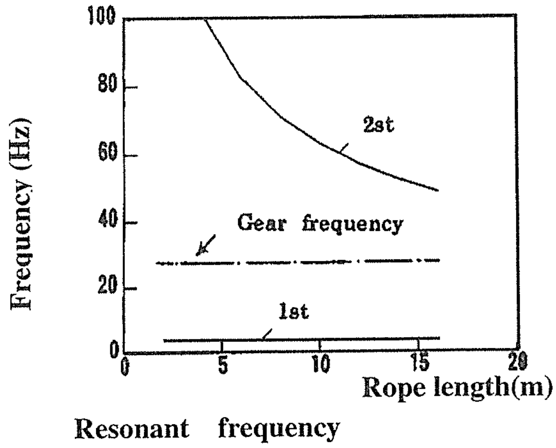

Fig.8 Result of calculated natural frequency

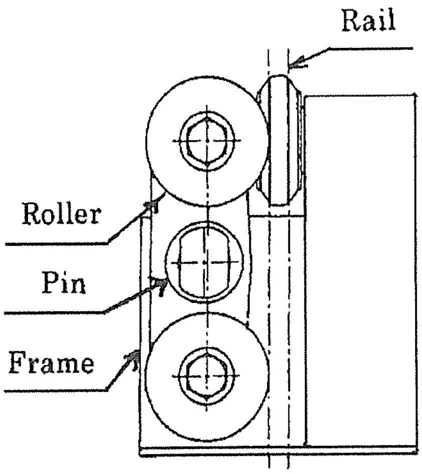

Fig. 9 Outline drawing of roller guide shoe

would be increased by deformation of the guide shoe roller. Also, since it was considered that the system acceleration would result in increased vibration, the load on the guide rollers was dispersed by mounting 2 roller assemblies at the top and bottom of the frame and the improvement of the roller material in order to reduce car vibration.

Fig.9 shows the structure of the roller guide shoe. To reduce the load applied to the rollers, two-roller assemblies were horizontally mounted at the upper and lower parts of the car frame.

Compared with the rollers made from conventional materials, it was determined that the rollers made from the improved materials demonstrated a reduction in deformation by approximately 30 %, thus reducing a causal effect of vibration.

4-3. Analyzing stiffness of car frame

When using the side fork-lift layout, the applied load will result in deflection throughout the car frame and structure. In accordance with the car weight reduction, the dimensions of the car frame and platform were reduced, which would obviously have an effect on the structure stiffness. To investigate these effects, the stiffness was analyzed using the IDEAS finite element package, for load when boarding (positioned at car entrance) and full rated load (positioned at car centre).

Fig.10 shows the analytical model, consisting of the roller guide shoes as scalar elements and the car structure (car frame and platform) as a series of shell elements. Fig.11 shows the deformation results of the analyzed car frame under load, based on the model shown in Fig.10.

Table 2 shows the comparison between the results of calculated displacement and the actual measurements taken from an elevator operation test.

With respect to results for load when boarding the car, the relative displacement is a comparison between points A & B (refer to Fig.10). For the test for full rated load, it is the relative displacement between points B & C. The analysis results were almost in accordance with the measurement results, and it was clear that a high accuracy analysis had been obtained. This verification proved that the resultant deformation was less than or equal to 1mm and that there would be no practical problems.

5. Conclusion

In this paper, we have explained the specification and structure of the newly developed [MEL WIDE] elevator, its technical aspects and countermeasures.

By conducting the vibration analysis using MATLAB and preventing the resonance of gear and rope, we confirmed that it was not necessary to use vibration-proof rubbers under the car floor and therefore car lightness was achieved. Also, the vibration, which was caused by the guide rollers mounted on the car frame structure, was reduced by adopting the newly developed rollers. In these ways, improved comfort ride and space reduction were realized.

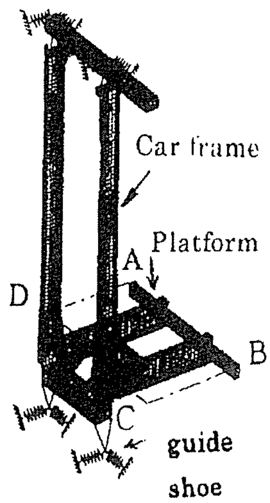

Fig. 1 0 Calculation model

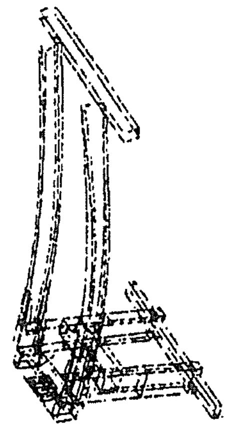

Fig. 1 1 Result of calculated displacement mode

Table 2 Car platform displacement

		Relative displacement(mm)
When entering car	Calculated value	1. 0
	Measurement value	1. 0
Full load	Calculated value	0. 7
	Measurement value	1. 0

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