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# Field experiments on natural energy utilization in a residential house with a double skin façade system

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**Abstract**

Energy consumption in the residential and commercial sector accounts for over 25% of the total in Japan. With the information technology revolution and the improving requirement for indoor air environment, energy consumption for household air conditioning is increasing. In this research, a double skin facade is proposed for a two-story house in Kitakyushu of Japan. The stack effect in the double skin space during the summer, the green house effect during the winter and the availability for free air-conditioning during the autumn have been studied. The temperature distribution, thermal performance in the double skin space and its impact on air-conditioning load in rooms have been measured. Results show that the double skin façade leads to about 10–15% energy saving for cooling in the peak of summer because of heat exhausted by natural ventilation, 20–30% energy for heating in winter because of the green house effect, and the temperature adjustment is quite large with the different operation mode of the double skin system during the intermediate seasons. Therefore the double skin system is proved to be effective in energy conservation in residential buildings.


*Keywords:* Double skin façade; Energy conservation; Stack effect; Green house effect; Field experiments; Residential house

## 1. Introduction

With the improving requirement for indoor environment and variation of lifestyle, the energy consumption in the residential and commercial sector accounts for over 25% of the total in Japan in recent years. Furthermore, with the information technology revolution, the application of SOHO (small office and home office) leads to more energy consumption, especially the energy for household air-conditioning systems. Here a double skin façade system, which is one of the passive methods for energy conservation, has been introduced to a two-story house.

Double skin facades have been often used in office buildings. In the main building of Obayashigumi Technology Research Institute with the floor area of 3775 $m^2$ and height of about 13 m, Oka [1] measured that 22% of the energy for cooling could be saved during summer, while 24% could be saved when the ratio of area of windows was 50%. Hensen [2] made a study on the energy conservation performance of double skin system in a eight-stories building, and confirmed that 15–17% cooling load from second floor to eighth floor in summer can be cut down. The lower stories would have larger energy savings. And there are also many other implements in Japan. Matsushima [3] estimated that 240 Gcal of annual energy consumption would be cut down because of the double skin system in NTT Musasino Research and Development Building with the floor area of 8048 $m^2$ and height of 58 m [3] and Ito [4] measured the thermal environment in the seven-story Sendai mediatheque, with the floor area of 2933 $m^2$ and height of 37 m, in the winter. The largest temperature increase between the second story and the

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seventh story reached 32.7 °C in clear days, and the average increase reached 9.2 °C. The heating load is 10% lower than those in existing laboratories. The double skin system is quite efficient in energy conservation in public buildings.

The double skin space is similar to the traditional corridor space in the Japanese Folk House (Fig. 1), which is used as buffer space between the indoor environment and the outside atmosphere. The corridor acts as an exterior shading device in the summer, and at the same time it can introduce more sunlight into the house. If the ventilation openings are designed on the floor and ceiling, this corridor will turn to be a double skin space (Fig. 2).

Therefore, a double skin system is adopted in the experimental house in Kitakyshu Science and Research Park located in the south of Japan.

(a) (b)

Fig. 1. Outside view and inside view of a Japanese Folk House: (a) outside view, (b) inside view.

## 2. Outline of the proposed double skin system

### 2.1. Details of the experimental house

The experimental house is a two-story residential house with the floor area of 176 $m^2$ and height of 8.2 m, and it is 11 m long in the east–west direction and 8 m wide in south–north direction. Its exterior appearance is shown in Fig. 3(a), and the details of the double skin system are shown in Fig. 3(b). Both the SOHO room (1F) and living room (2F) have a 2.4 m-high window in the south, and there is a 6 m-high fenestration at 1.2 m to rooms. The exterior fenestration is made of flat glass with the thickness of 8 mm and interior slat-type sunshades, while the interior window is made of 6 mm flat glass. Therefore, space between the exterior fenestration and the south windows of SOHO/living room turns to be a double skin space.

In summer, the interior shades are completely shut down in order to shut down the solar radiation, while in winter, all shades are drawn up to take in solar radiation in the daytime. There are four openings on the floor, each with the size of 1.5 m × 0.1 m and there is one opening with the effective area of 0.6 $m^2$ on the roof. All the openings can be controlled automatically depending on the temperature difference between the outside and inside. As the floor is 0.5 m high above the ground, the air can be induced from under the floor during the summer. In addition, two auxiliary fans are equipped at the top of the east and west walls.

As for the air-conditioning system, the displacement ventilation system is used for cooling in this house. The supply diffuser is set at 0.3 m high above the floor, and the return air is set at 1.8 m above the floor. There is no special consideration for cooling in the space above the height of 1.8 m. While in the winter, the floor heating system is used.

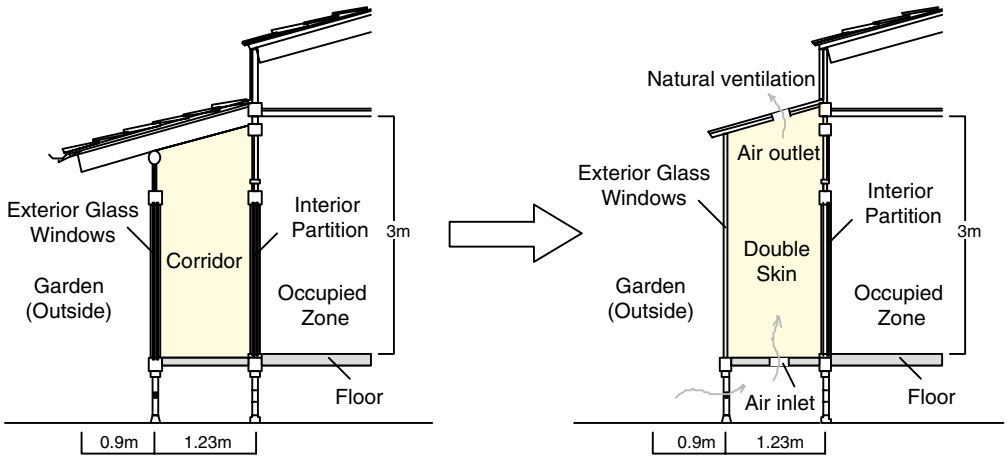


Fig. 2. Development from exterior corridor to double-skin space.