THE PRESENT AND FUTURE OM SOLAR SYSTEM

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ABSTRACT The OM solar system is one of various passive systems. As is in the general passive system, the technique in the OM solar system works with the designing and architectural space as a unity. In other words, the technique is a part of the designing. Nowadays a lot of new technique have been developed and all kinds of related technology are born. During the past nine years, the system has been already employed in about eight thousand homes and sixty public buildings all over Japan. This paper describes the followings: the principle of the system, the popular methods, the new technology, OM meteorological data, the computer simulation, and the prospects for the system.

1. HEAT COLLECTION AND VENTILATION BY THE AIR

In the earliest OM solar system which is being mostly used now, the roof acts as a heat collector and the air acts as the medium for transporting heat collected on the roof to the heat storing sectors of the building. The roof collector is ordinarily composed of two sections as shown in Figure 1. On the lower part of the roof near the eaves is the sheet metal roofing with a space underneath, functions as the pre-heating section of solar heat collection. The upper part on the roof is a high-temperature collecting section which consists of a metal roofing covered with a sheet of glass, and there is a space of stagnant air under the glass sheet.

Fresh air from the edge of eaves or attic space enters the air layer under the roof and flows upward. At the upper end of the high-temperature collector, the air is led to pass through the ridge duct and accumulated in a roof-top air chamber. Then the heated air from the ridge duct enters the fan-box which is an air handling unit equipped with dampers on two sides to regulate the direction of the airflow (Figure 2). In the wintertime, the fan forces the air to flow through the vertical air duct down to the space under the floor. A thermal sensor installed in the roof-top air chamber controls the on-off switch of the fan and the volume of air supply.

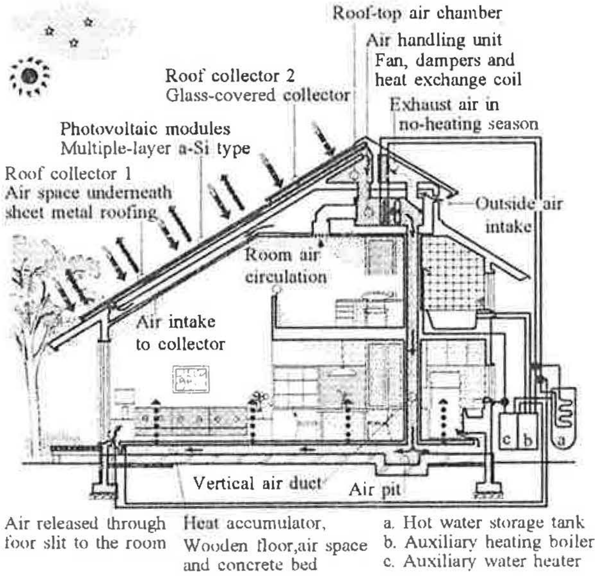

Figure 1. The OM solar system.

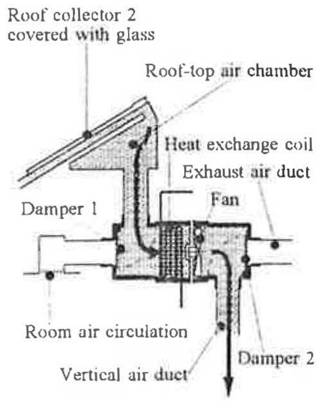

Figure 2. OM handling box.

The heated air from the vertical duct firstly diffuses in an expanded pit-like space, and then moves in the air layer between the floor and the concrete bed. Due to the difference in thermal conductivity and thermal capacity for the floor and the concrete, the most part of the heat in the air is transferred and stored into the concrete bed. Finally, the heated air is diffused inside the room through the outlets located generally near the windows. Once the heat is no longer available on the roof, the fan stops and the damper situated at the front of the fan-box shuts down, so that the way of airflow from the roof collector to the room is cut off. The heat stored in the concrete bed continues to radiate a gentle warmth through the floor. Not only does the system provide ventilation while the heat is being collected , but also maintains a positive air pressure inside, helping to keep the draft from entering. Moreover, the internal air pressure causes an outflow of air through tiny cracks for a hand in air ventilation.

2. HOT WATER SUPPLY AND AUXILIARY HEATING SYSTEM

Inside the fan-box, there is a heat-exchange coil connected to the hot water tank with a conduit. When the room temperature rises above a set temperature in winter, the sensor gives a start signal to the pump. Then the pump circulates the water which acts as the medium of heat exchange with the hot air, so that overheating is prevented. When it does not need heating inside in spring and summer and autumn, the damper situated in the back of the fan-box opens toward the exhaust air duct connected to the outside. In these seasons, the hot air is exhausted outside after being used for producing hot water. At PM.2:00 on a clear or cirrostratus day, hot water of 40-60 ℃ in a tank of 300 litre can be obtained by heat exchange. In general, hot water of 300 litre is enough for a family to consume in one day.

When the room temperature drops below the set degree, the auxiliary heating boiler heats the water which flows through the coil in the fan-box. The air from the room is heated and the heated air is circulated through the space under the floor. This process also takes place whenever collected heat on the roof is not enough to heat the room and no auxiliary heater is available. In addition, there is various kinds of auxiliary heating system such as fan convector, soot exhaust heat exchanger, heat pump air-conditioner, etc.

3 . NOCTURNAL RADIATION COOLING AND DEHUMIDIFYING

In summer, it can take advantage of the radiative cooling at night by selecting the system's mode. When outdoor temperature goes below the room temperature, the fan runs, first to get rid of the heat remaining under the roof and inside the ridge duct through the exhaust duct. Once the temperature inside the ridge duct goes lower than the room temperature, the back damper turns up and the air cooled under the roof is directed to pass through the vertical duct down to the space under the floor. Because the glass sheet does allow the long-wavelength radiation to escape, the pre-heating collector plays a leading role in the radiative cooling. Except the most northern island (Hokkaido), the summer in Japan is hot and humid. When the temperature of the roof goes below outside temperature by the radiative cooling, vapor condensation takes place in the space under the roof. Therefore, the air from the roof becomes cooler and drier than outdoor air and the room is cooled and the humidity is removed. In daytime, the system turns on the mode of air-exhaust+hot-water-supply, moisture and dew drops under the roof are exhausted outside. To obtain a more effective dehumidification, an attempt is being tried to use a sheet of desiccant material in the air layer under the roof.

4. PV POWER GENERATION ON THE ROOF COLLECTOR

By sticking amorphous solar cells on the metal collector, it is possible to generate electricity without substantially bearing upon the amount of heat collection. In this case, the air passageway under the heat collector is used for the wiring. An idea of using PV power to run the fan has been proposed, a new type of DC fan and a small self-supporting DC/AC inventor are being experimentally produced. Simultaneously obtaining one's own supply of heat and electricity presents a definite advantage in terms of the construction and the expenses involved, as well as from the standpoint of design.

It is said that a PV generation system with a power of 3kW is able to supply a general home for electric consumption in a year. The latest amorphous PV system with a power of 3kW occupies about 60 m^2 area of the roof. Connected to the utility power terminal with a protective relay, the surplus power from the PV system is sold and electric power is bought from the utility power when the PV power supply is not available.

5. UTILIZATION OF PCM AND RAINWATER

Figure 3 gives an example that the system is used for exhausting smelly air and removing airborne particle in a hospital. The airflow is one way in the hospital room so that indoor air pollution can be prevented. A layer of PCM (phase change temperature is 27 ℃) is used to store heat for preventing overheating. After heat collecting finished, the heat radiated from PCM is transported to the room.

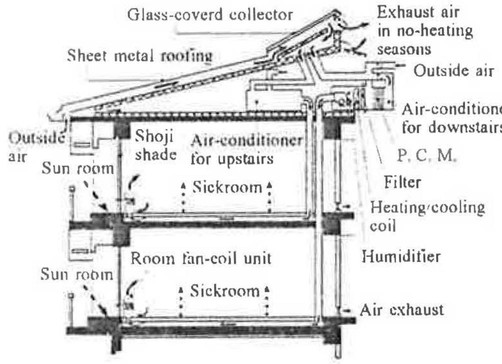

Figure 3. The OM solar system in a hospital.

In a two-storied wooden house where a living room is upstairs, a vertical layer of PCM is placed in the joint between the first and second floor. The latent heat released from PCM is used as the power to circulate the indoor air at night.

There is an increasing number of using rainwater collected on the roof as reclaimed water or garden water. To determine the volume of water tank, it is necessary to know the local pattern of rainfall. The computer simulation with AMeDAS (Automated Meteorological Data Acquisition System) data is effective in discussing such cases and the relationship between reclaimed water consumption and capacity of water tank.

6. DESICCANT COOLING

All of the newest technology in the OM solar system has been applied to an exhibition building in which floor heating, nocturnal radiation cooling, hot water supply, PV power generation are included. Rainwater falling on the northern roof is collected as toilet washing water and rainwater on the southern roof flows down to the pond.

The cooling system in the reception room is a desiccant cooling system in which non-fluorocarbon silica gel is employed. The airflow in the cooling system is shown in Figure 4. Indoor air mixes with outdoor air and moisture of the mixed air is absorbed as the air is passing through the half face of the circular rotator which is made of silica gel and rotating slowly. Meanwhile, silica gel on the other half face of the rotator is dried by the hot air heated on the roof. As the rotator is operating, the processes of absorption and restoration for silica gel are repeating and moisture in the room is continuously removed outside.

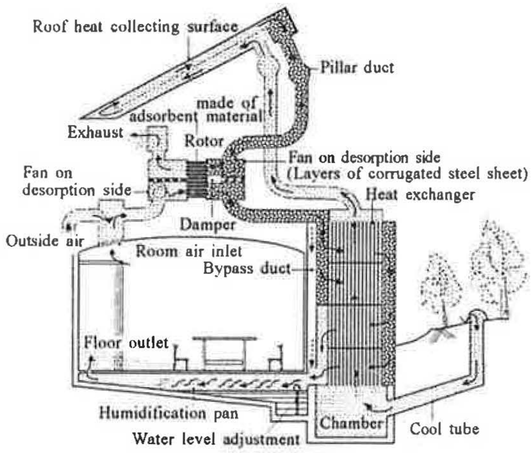

Figure 4. The desiccant cooling system.

The dry and warm air is cooled to the temperature of outdoor air by the air from the cool tube in a sensible heat exchanger which is composed of corrugated steel sheets and made to be the northern exterior wall. The cool and dry air is cooled again and humidified in the space under the floor as flowing above a humidifier which is a 'pan' with water. The cooled air cools the space under the floor and returns to the room. The humidifier itself is an OM pit and has a gentle slope. The surface area of water can be changed by adjusting the level of water.

7. OM METEOROLOGICAL DATA BASE

It is without saying that the first step for designing a passive solar house is to understand characteristics of the local climate. Japan straddles a number of climatic zones from the subarctic to the subtropical. Ocean currents and seasonal winds combine with a complex mountainous terrain to create a wide diversity of climates. In the whole of Japan, there are 159 weather stations and 839 AMeDAS unmanned observation stations to gather the meteorological data for air temperature, sunshine hours, wind speed, wind directions and precipitation.

However, the data from this observation system can not be employed directly as is in the passive solar system designs and in computer simulation. Therefore, the meteorological data for the OM solar system has been produced from the AMeDAS data for the past 10 years. The basic method of data processing is that the days of a month are divided into three groups (three representative days for the month) according to the daily sum of solar radiation received at each of 839 stations, and one-hour average values are given for each group. The values of absolute humidity calculated from 159 weather stations are also included in the data base.

In the present OM computer simulation, the data extracted from AMeDAS data is used rather than the hourly average data for the three representative days mentioned above. For proposing the new methods based on the comparison of calculated values with measured values, the 'experiments' on the desk are being carried out. In addition, it is being prepared to make a national edition of OM meteorological data base in which the hourly and daily and yearly data such as cloud amount and vapor pressure and sky radiation, etc. are included.

8. COMPUTER SIMULATION FOR DESIGNING

Though the principal of passive solar system is simple, to make clear the responding characteristics of the building in the changeable surrounding environment, computer simulation is indispensable. The OM simulation system consists of the following programs: (1) List meteorological data, (2) Manage the files, (3) Input the building data, (4) Calculate overall thermal transmission for composite material (including the heat bridge), (5) Check the input data, (6) Estimate thermal performance, (7) Output the calculated results, (8) Options.

The simulation has already been used as a designing tool for all of OM solar houses at the stage of designing. Now is being developed new simulation programs which are user-friendly to use in designing, data input procedure being simpler and calculation time being shorter.

9. CONCLUSIONS

In Japan, the OM solar system has been applied to about 8,000 homes and 60 public buildings in which there is a diversity of technology. For the use of the OM solar system, architects and the builders take the local climates and the purposes of the building into account, proposing new ideas case by case. As a passive solar technology, the OM solar technology is an open and boundless technology, developed by a large number of architects and researchers and local construction companies. The technology not only serves for the utilization of natural energy but also for the designing based on the lifestyle and regional characteristics.