SURABAYA ECO-HOUSE
An experiment in passive design in a tropical climate.
Part 1: outline of the project and design of the experimental building

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1 Background and objective of Surabaya Eco-House

Entrusted by the Ministry of Construction, the Infrastructure Development Institute Japan conducted an experiment on energy- and resource-saving collective housing jointly with the Institute of Technology Sepuluh Nopember (ITS), the Republic of Indonesia, for the purpose of making contribution to improvement of living environment and energy conservation in developing countries.*1

In order to build a sustainable and recycling-based society, it is essential to improve performance of buildings themselves in the light of regional climate and to create favorable indoor environment with less dependence on energy-consuming technologies. This requirement must be fulfilled at an early date in developing countries, where energy consumption is expected to rise sharply.

The latest project is a case study designed to build future energy- and resource-saving collective housing in developing countries featured by tropical climate with high temperature and humidity.

2 Eco-house passive design

Architectural and mechanical methods are available for creation of favorable indoor environment. The former, called passive design, is a designing and systematic method to utilize natural energy, such as sunshine, changes in temperature, winds and terrestrial heat, while considering regional climatic conditions. The latter is a method relying on air-conditioning equipment.

Dependence on air-conditioning is growing in developing countries under tropical climate. It□s important to develop and apply passive design, particularly passive cooling technology, not only in view of global environmental problems and possible energy exhaustion but also with a view to building a resident-participating community with consideration given to regional characteristics (Fig.1).

3 From Rumah Susun Sombo as a model for post-KIP period to Surabaya Eco-house.

KIP (Kampung Improvement Program) which started in the late 1960's is supposed as one of the most significant programs for housing improvement in Indonesia. The main purpose of KIP was to provide infrastructure to achieve better sanitary conditions in the Kampungs. As KIP, by the latter half of 1980's, obtained sufficient results in Surabaya, it came up with the further task to find a solution to high-density residential district i.e. establishing new housing model..

Fig. 1 Overall view of "Surabaya Eco-House"

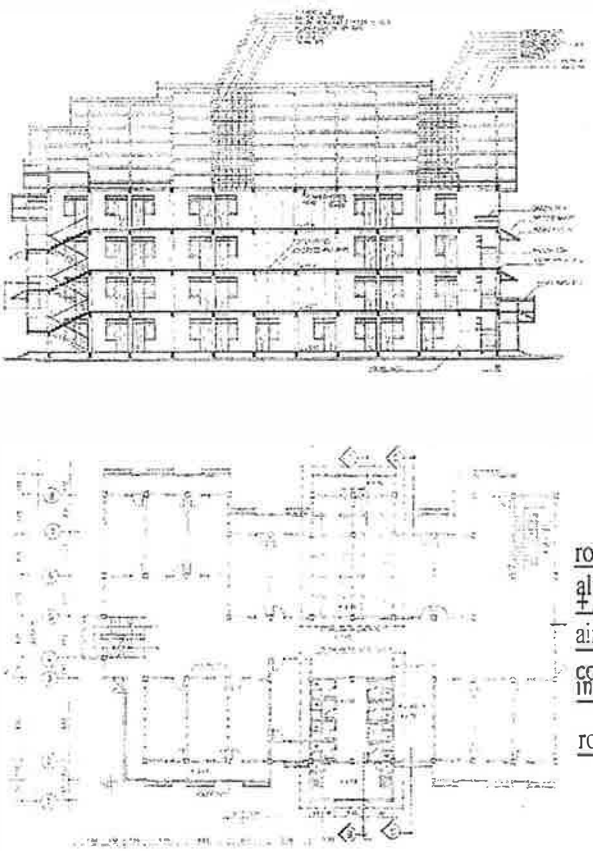


Fig. 2 Planning (below) and elevation (above) of Rusun Sombo

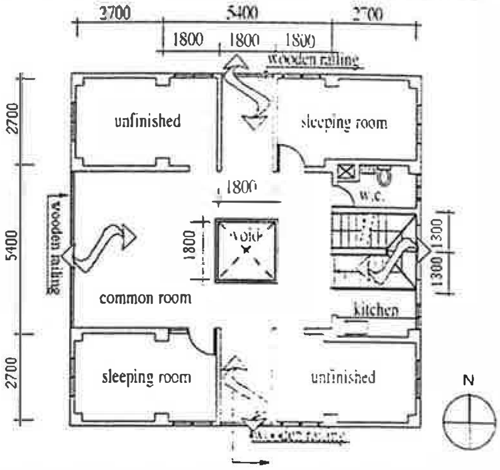


Fig. 3 Planning of Surabaya Eco-House 2Fl

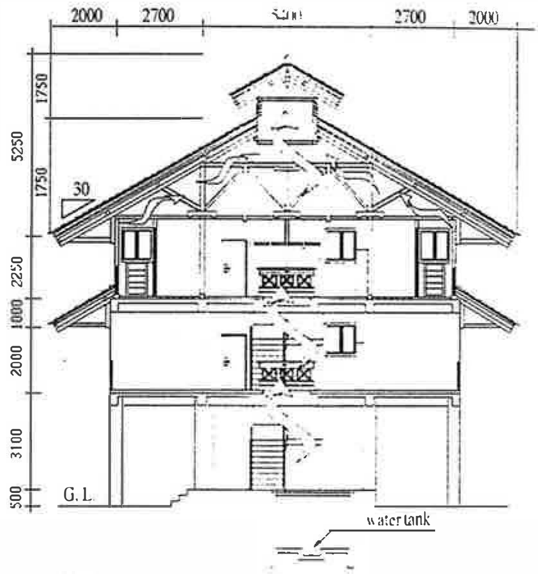


Fig. 4 Section of Surabaya Eco-House

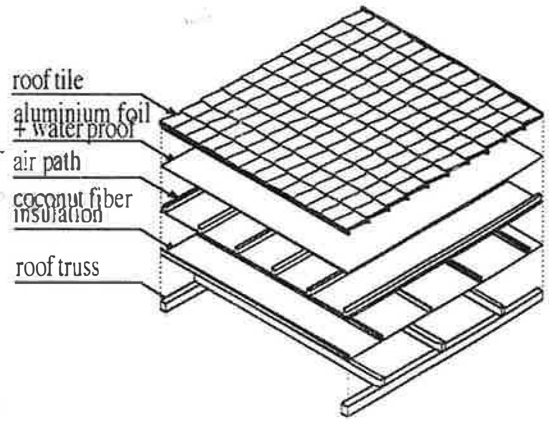


Fig. 5 Diagram of "Double Roofing"

One of the successful solutions was the construction of the Rumah Susun Sombo (called as "Rusun Sombo" in short) which was designed by Prof. Silas from ITS and Surabaya city planning board (Fig.2). This project is based on the principle so-called "On Sight Development". Therefore special attention was paid to former residents of "Kampung Sombo" who were to move into the Rusun Sombo after its completion, so that residents would not be forced to move out as a result of the improvement itself. For instance, its wide double-loaded corridor with open-air edge plays quite an important role for maintaining resident's way of living, because normally, for people living in kampungs, open-air space is indispensable in respect of providing places where variety of activities take place.

While designing Surabaya Eco-house, it was decided that we would adopt Rusun Sombo as a basic model and combine it with the ideas of passive design for further improvement. This is because, in our point of view, providing a model with regards to the existing local way of living is quite important for the building to be accepted by the residents.

4 Characteristics of the Surabaya Eco-house

As mentioned above, Surabaya Eco-house is designed as a prototype collective housing model that is appropriate for the local conditions in Surabaya. The research group under Prof. Silas from ITS has been working on collective housing based on social and environmental conditions of Indonesia in cooperation with the group led by Assoc. Professor Funo at Kyoto University.

On the basis of the results of the long-term research, the project is intended to build collective housing which incorporates passive cooling technologies conforming to regional natural conditions and to promote use locally produced building materials. It should be regarded as a prototype of the Indonesian-type of collective housing in a sustainable society.

4.1 Skeleton-infill-type construction

The fundamental structure of a building (skeleton) is of concrete construction with long-term durability, and partitions and exterior (Infill) are subject to needs of residents for their participation in deciding-making process.

4.2 Floor plan fit for regional lifestyles

With importance attached to regional lifestyles, common corridor of collective housing are wider in comparison with conventional collective housing, giving a feeling of spaciousness. In the meantime, maximum privacy is ensured in parts for exclusive use (Fig.3).

4.3 Passive cooling technology

1) Commonly Shared Open Space Arrangements, Ventilation and Natural Lighting
The commonly shared free and open air space has been utilized to secure horizontal and vertical ventilation channels. Windows have been installed on the top roof to facilitate ventilation and heat discharge, and to get natural lighting. And a 3-story high void space has been built at the center of the building (Fig.4).
2) Double-roofing
To effectively break sunlight heat, the roof has been designed as double-layered-roof with heat-insulating and air layers. The heat-insulating materials have been developed of local products, coconut fiber. The air-layer is placed on the outer-side of the heat-insulator, intending quick spontaneous discharge of sunlight heat (Fig.5).
3) Windows and outer-walls for insulating sunlight heat
A bigger roof and deeper eaves have been built to cut the sunlight and wooden outer-walls system not to absorb sunlight heat. (The outer-walls system will be introduced in a future plan.)
4) Ventilation channels in private sections
To facilitate cross ventilation in the private unit, an arrangement of openings and operating system have been designed. Two openings have been installed on the outer-wall, and a vent

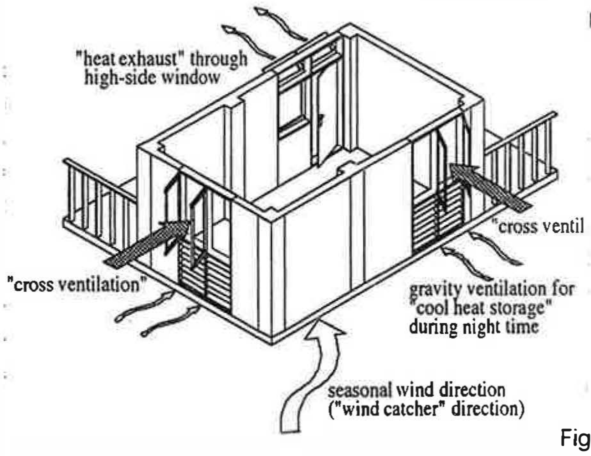


Fig. 6 Ventilation Channels in Private Sections

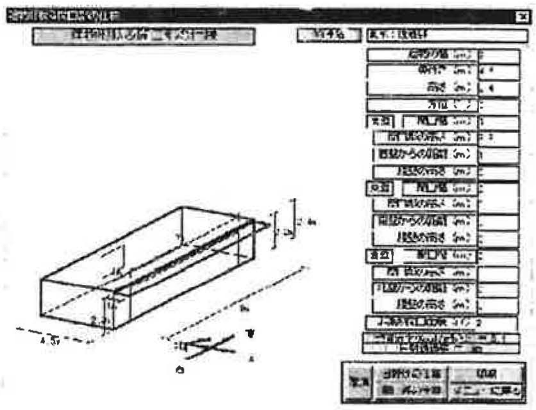


Fig. 8-1 "Solar Designer Ver.4.1", Data input on Openings/ data on dimensions, orientation and location

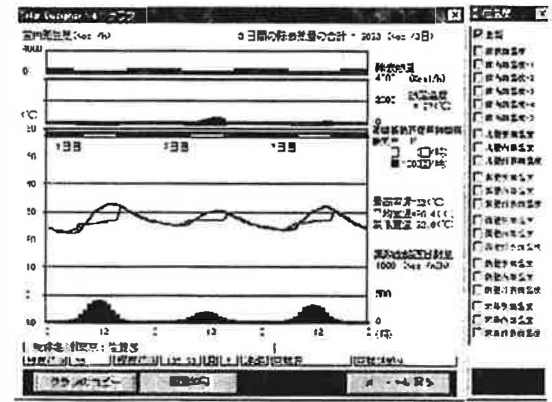


Fig. 8-2 "Solar Designer Ver.4.1",Final result with the graphs indicating temperatures of chosen elements

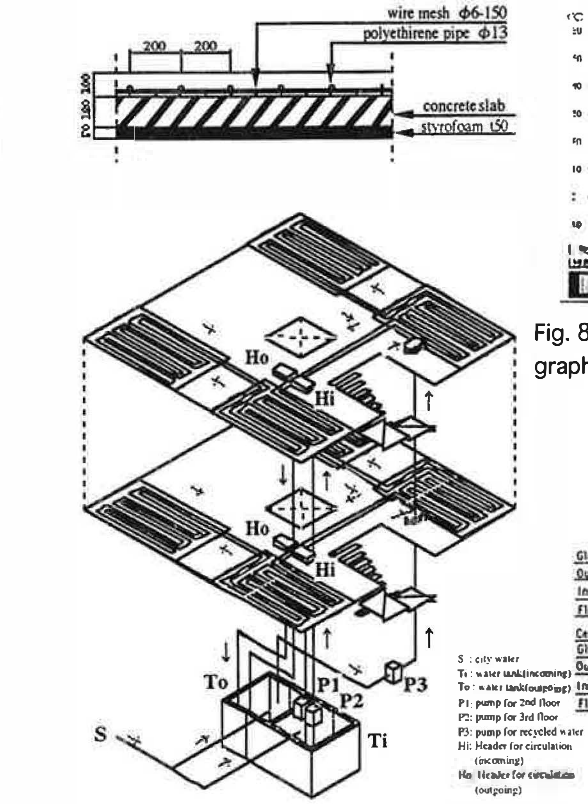


Fig. 7 Section of slab (above) and Diagram of Radiant Cooling System by Circulating-Water (below)

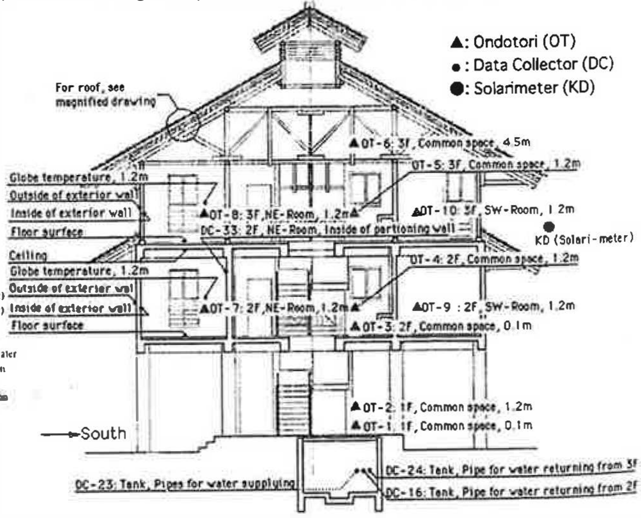


Fig. 9 Monitoring equipment and measurement points

window onto commonly shared open space. The operating system has been designed to allow ventilation not only during daytime but also at night (Fig. 6).
3-5) Cold Storage by Night Ventilation
Concrete floor slab with big thermal capacity is utilized as a cooling system. Cool air is led into rooms by the night ventilation to store the coldness in the concrete floor. This provides a coolant for the next daytime.
3-6) Radiant Cooling System by Circulating-Water
A polyethilene pipe is buried in the concrete floor slab to circulate well water for radiant cooling effect. The well water is kept in an underground tank beneath the ground floor and is circulated by a solar-driven pump. The circulated water is re-used for flushing toilets or sprinkling (Fig.7).

5 Personal computer simulation

The simulation software we used is " Solar Designer Ver.4.1". This software is based on the program called "Passwork" which was developed by Building Research Institute, Ministry of Construction, Japan. This software can calculate the indoor temperature of a certain room that is basically closed by walls and slabs. *2 Influence from rooms surrounding the target room both horizontally and vertically is also taken into account by adding its approximate value to the thickness of the walls and slabs of the target room. *3 Below is the procedures for executing simulation quoted from the manual whose original explanation is in Japanese.

a. Input data on physical settings of the building

1 Openings/ data on dimensions, orientation and location (Fig. 8-1)
2 Specification of openings/ data on heat transmission coefficient, solar-radiant transmission coefficient
3 Shadings/ data on dimensions, locations
4 Slabs/ data on thickness of concrete and insulation parts, finishing, solar-radiant absorption coefficient, thermal conductivity
5 Walls/ data on thickness of concrete and insulation parts, finishing, solar-radiant absorption coefficient
6 Ceiling/ data on thickness of concrete and insulation parts, finishing, solar-radiant absorption coefficient
7 Air conditioning, louver, number of air changing, indoor produced heat

b. Setting climate pattern

8 Loading registered climate patterns
9 Input and change climate patterns/ latitude, longitude, temperature, albedo and so forth.

c. Calculation and estimation of the performance

10 Calculation
11 Final result with the graphs indicating temperatures of chosen elements (Fig. 8-2)

6 Monitoring equipment and measurement points

There are mainly three kinds of equipment that were used in monitoring. The first one is temperature and humidity data collector called "Ondotori"(Pic. 1). "Ondotori" has a special sensor that can measure temperature and humidity of the air at the same time. The second one is the temperature data collector called "Data Collector"(Pic. 2). This equipment has so-called "T type thermocouple" for a wider use. The sensor can measure almost any kinds of temperature including air, surface and even water. The last thing is the solarimeter with which we can measure the amount of solar radiation by recording an integrating voltage(Pic. 3-1, 2). The recording interval for all above-mentioned equipment was set 10 minutes.

There is another equipment used in the monitoring called Assmann thermometer. Assmann thermometer can measure dry-bulb and wet-bulb temperature, so that the relative humidity can be figured out with the conversion table. The data was compared with those from "Ondotori" and "Data Collector" to confirm if the error range would be acceptable.

Measurement points are indicated in Fig.9 (In Fig.9 , "OT" means Ondotori, "DC" for Data Collector and "KD" for Solarimeter). There are mainly four parts to be measured, namely Double Roofing, Open Common Space, rooms and water tank. On each floor, there are two rooms to be measured with intensive data collection on "northeastern room". This is because of Surabaya's geographical location in the south latitude. Normally rooms located on the northern side have severe condition in terms of thermal environment. In the northeastern room, Globe temperature is also measured(Pic. 4). If the normal and Globe temperature do make difference, it could be concluded that Circulating-Water Radiant Cooling System has been successful.

Footnote

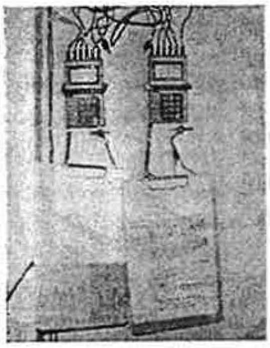
*1 This project was implemented in cooperation with Department of Architecture, Faculty of Technic and Civil Engineering, ITS. Those who made special contribution to this project from ITS are Prof. J. Silas, Ir. Dipl. Ing Sri Nastiti NE and Irvansjah ST.

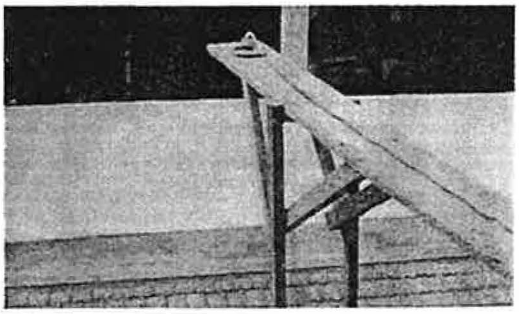
*2 Practically there are two ways of approximation. One is to consider whole building as one box; another is to consider each room respectively.

*3 The guideline for conversion is still being discussed.

Acknowledgements

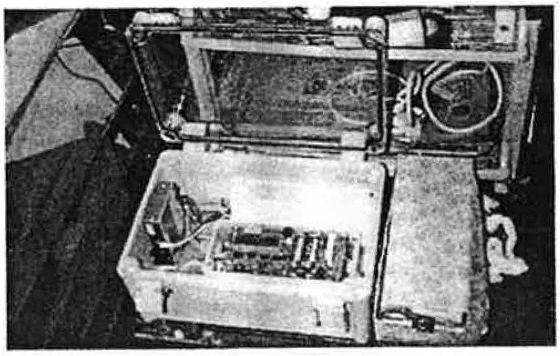
We would like to express our special gratitude here by mentioning two companies' contribution, which was indispensable to our project. Mitsubishi donated devices for radiant cooling including polypropylene pipe especially for this project. Solar cells that generate electricity for radiant cooling are donated by Sharp Cooperation. We greatly appreciate assistance provided by both companies.



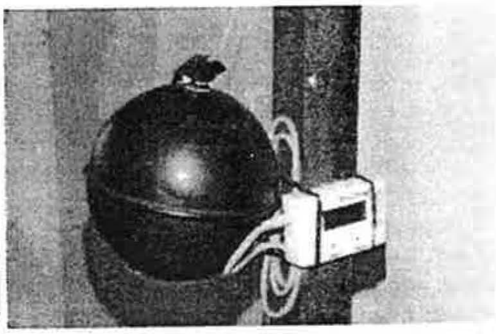


Pic. 1 "Ondotori" (left: Temperature Data Collector)
Pic. 2 "Data Collector" (right: Temp. and Relative Humidity Data Collector)

Pic. 3-2 "Solarimeter, KADEC" (Sensor)



Pic. 3-1 "Solarimeter, KADEC" (Recorder)



Pic. 4 Measurement of Globe temperature