PROJECT TITLE:	COMFORT ZONE PERFORMANCE EVALUATION OF ITESM'S SOLAR HOUSE PASSIVE ARCHITECTURAL DESIGN
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DURATION:	April 1979 to April 1980

JUSTIFICATION

Escalating costs of fossil fuel and electricity is a pervasive problem all over the world, even in those countries where oil resources are abundant. Therefore, solar energy research has become a very important component of energy conservation and renewable energy research and development.

At present, almost all of this research has been carried out in industrialized countries (U.S.A, France, England, Germany, etc.) and its applications for residential heating and cooling has been undertaken by private industry. So far, solar space heating has been efficiently developed, but solar air-conditioning is still being tested and it is not yet in widespread use chiefly due to its high cost and high temperature requirements.

> Since solar cooling requires further technical development before it can be used widely, it is likely to lag behind solar heating by several years. A market of over 200,000 units/yr is not projected until 1995... Efficient use for solar energy for air conditioning via absorption requires input temperatures of 180 - 280°F as compared to 120°F for hot water and space heating. Apart from the greater demands placed on solar collectors design for cooling applications, the major

technical barrier to the installation of solar air conditioning systems is that (3 ton) reliable and cost effective absorption refrigeration units are not yet commercially available[1].

In many developing countries the basic needs differ from those of industrialized ones, mainly because of milder climates due to their geographical location and because in general, demands for domestic use are fewer and must be strictly centered on satisfying first degree needs.

> In many of the so-called developing countries, often located in latitudes blessed with milder, less rigorous climates, the principal emphasis has been on water heating, agricultural applications, the cooling of buildings, water pumping using the sun, and the wind, biogas production for cooking and some power generation, with a lesser emphasis on heating of building and photovoltaic and power generation.[2]

Climatic stress varies, among other things, according to latitude. The farther north latitudes being the colder ones require energy for space heating. This being primarily the use and application of both passive and active residential solar energy in industrialized countries. On the other hand, in warm climates characteristic of developing nations, it is surplus heat remission the main concern; but even though this can be done by mechanical air conditioning with solar or

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[1] Joan B. Berkowitz, "Technology Assessment of Solar Heating and Cooling of Buildings". Proceedings of the Workshop on Solar Heating and Cooling of Buildings, Washington, D.C., June 17, 1974.

[2] T.A. Lawand and G.L. d´Ombrain, "Are all solar energy applications necessarily appropriate technologies?". SUn, Mankind´s Future Source of Energy, PRoceedings of the International Solar Energy Society Congress, New Delhi, India, Jan, 1978 p. 39.

traditional types of energy, it is an expensive unaffordable alternative. Firstly because of the high demands that it would impose on whatever the energy source may be, and secondly because it is a foreign dependent expensive technology out of the reach of many millions of people.

> Air conditioning for a small elite does not reduce the handicap under which the masses of the tropical countries have to labour. Their lot can be improved only by the design of houses that offer protection against extreme heat and take advantage of the more favourable features that exist even in the worst climates.[3]

It is thus important to enhance research and applications of solar architecture and passive principles, especially in developing countries where population growth imposes a drastic urge for mass housing in the urban areas. Most of the housing currently being built in these areas is minimized in size and poorly adapted to climatic conditions. Yet there is little research on the subject actually being carried out.

> Very little was discussed in either reference 1 or 2 on passive thermal design... This is a pity, particularly since it probably truly reflects that little is being done... In developing countries, in which there is a great incentive to make do with local materials since wages are low and manufactured materials expensive, this can be a promising approach[4].

Mexico, a developing country of Latin America,

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3 Department of Economics and Social Affairs, "Climate and House Design", United Nations, New York, 1971, pg. 15.

4 Francis de Winter, "Solar Energy Happenings in Other Countries", Passive Solar Heating and Cooling Conference and Workshop, Proceedings, New Mexico, May, 1976. Pg. 85.

has now become an exporter of oil. It is building two nuclear plants. Therefore, it has the possibility of not being affected by the energy crisis in the immediate future. However, the very particular characteristics of its geographical location and climatology indicates that solar energy might be an important energy source, in particular in the zones that have a dry tropical climate, to satisfy the basic needs of rural communities... Several research institutes which receive support from the National Council of Science and Technology (CONACYT), in some instances with the partial support of the OAS and other organizations, carry out feasibility studies as well as develop prototypes and demonstration projects.[5]

The previous source presents a table of "principal institutions carrying out R&D on solar energy in Latin America" and the Instituto Tecnologico y de Estudios Superiores de Monterrey (ITESM) is reported as one of the Mexican institutions working on solar architecture and space heating and cooling research. The institute's solar house at present under building completion (See Exhibits 1a through 2b), is one of ITESM's solar research projects which will be primarily used as a testing ground for different solar collectors and active solar systems. However the architectural design of this structure stresses and follows closely the notions of climatic architectural adaptation articulated in past decades by various designers and

[5] Marcelo Alonso and Miguel de Santiago, "Solar Energy in Latin America and Overview", Department of Scientific Affairs, Organization of American States, Sun, Mankind's Source of Future energy. Proceedings of the International Solar Energy Society Congress. New Delhi, India, Jan., 1978, Pp. 43-35.

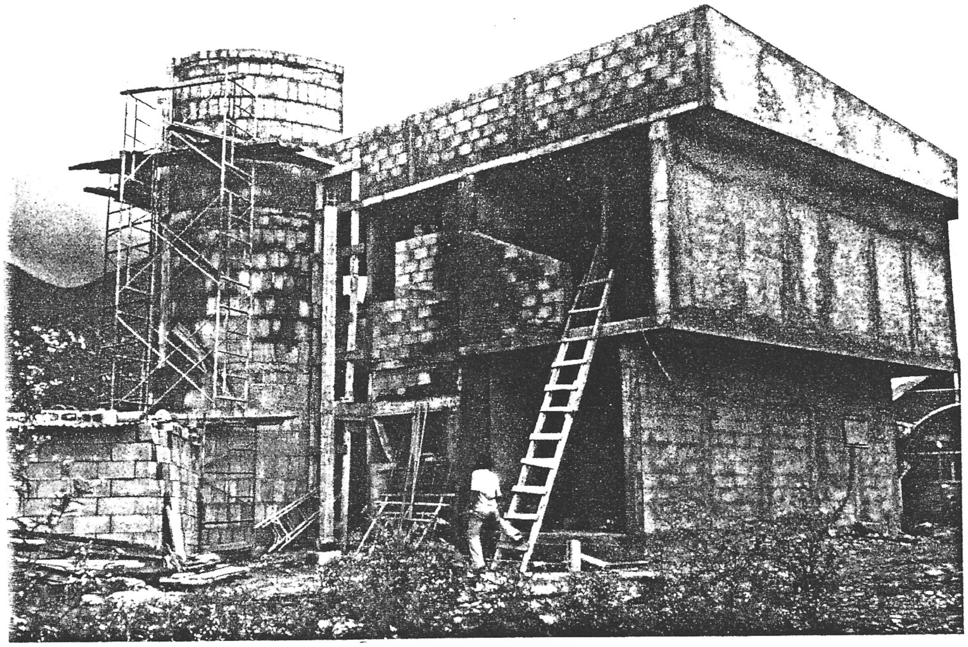

EXHIBIT 1a: ITESM´S SOLAR HOUSE UNDER CONSTRUCTION (NORTH VIEW). Monterrey, N.L.. Mexico.

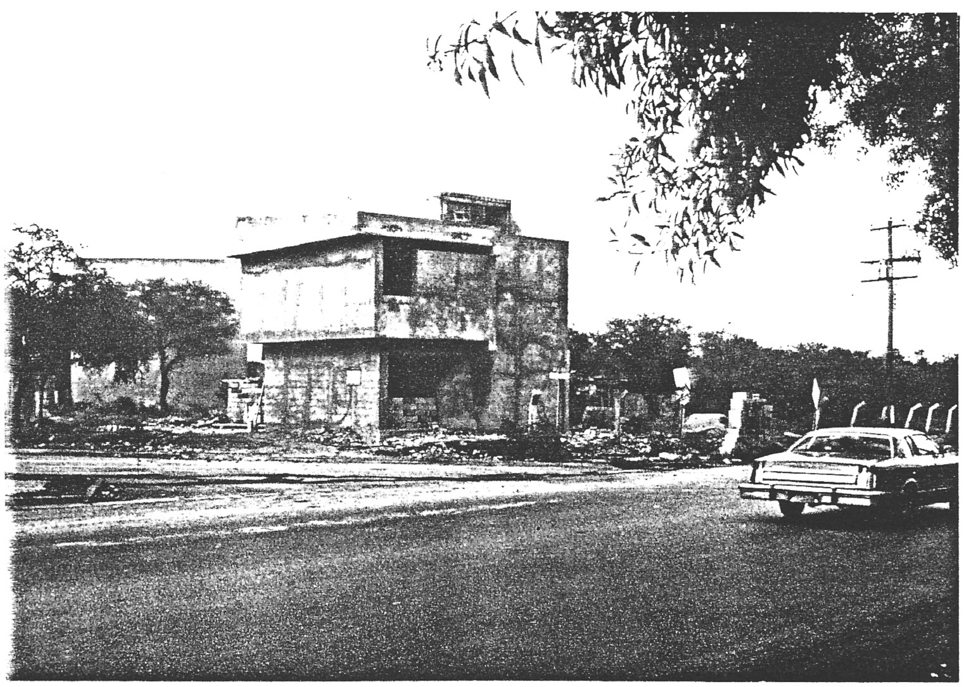

EXHIBIT 1b: ITESM´S SOLAR HOUSE UNDER CONSTRUCTION (SOUTH-WEST VIEW). Monterrey, N.L.. Mexico.

environmental researchers[6]. However, these notions, have only recently started to become common parlance among designers as a result of the oil crisis which prompted a renewed interest on the sun as an alternative sources of energy[7].

Notwithstanding the recent flurry of research and design of passive solar systems, these have been carried out primarily in northern latitudes for cool and temperate climates. However, there is a great need to evaluate the performance of some of these systems and principles as applied to hot-humid and hot-arid climates of developing countries. In many developing countries such as Mexico, appropriate architectural design technologies are required to meet the pressing housing needs of a growing population in which conventional and even solar powered forms of mechanical indoors climatic control, are simply not economically affordable, neither environmentally desirable.

Natural wind ventilation and sun penetration/protection techniques can be used by architects and home builders to the benefit and comfort of their clients, whether in the design of middle class suburban residences or low-income housing.

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6 Victor Olgyay, Design with Climate. Princeton University Press, 1963.
Baruch Givoni, Man, Climate and Architecture. New York, Elsevier, 1969.
Wladimiro Acosta, Vivienda y Clima. Buenos Aires, Ediciones Nueva Vision 1976.

7 Donald Watson, Designing and Building a Solar House. Charlotte, Vermont, Garden Way Publishing, 1977.

It is here proposed that given the passive architectural principles utilized in the design of ITESM's solar house, the structure can serve as a viable testing prototype of these techniques. Following, an overall description of the passive features of the project is presented, ensued by a tentative scheme of how the evaluation will be approached.

PROJECT DESCRIPTION

The Climate

The city of Monterrey is situated in the northern part of Mexico between a humid and an arid region transitional zone, because of this, climatic variations are extreme and frequent[8]. The hot season is the longest, with seven months duration from April to October. The cold season is only three months long, from December to February, and in between there is a transitional period corresponding to the months of March and November. The hot period is characterized by an increasing relative humidity of 65 to 70% that combined with high temperatures of 85 to 100 ^{o}F set weather conditions outside the comfort zone. The cold period is short and mild if compared to that of higher latitudes. Prevailing winds are easterly and south-east mostly all year long.

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8 Ivonne Audirac, "Estudio del Clima en Monterrey, N.L. para la Adecuacion del Edificio Laboratorio de Energia Solar ITESM". Departamento de Termica Fluidos y Control, ITESM, Monterrey, N.L., 1978.

The Structure

The housing needs are those of a suburban middle class home with two bedrooms, family room and bathroom in the upper floor; kitchen, dining and living area in the ground floor, and mechanical room, utilities and laundry area in the basement. (See architectural drawings). Total construction area: 1900 sq. feet. The house has a flat roof of approximately 800 sq. feet with 32 flat plate collectors destined to be the energy source of the mechanical cooling system.

Natural Wind Ventilation

A wind tower or wind scoop of Iranian inspiration[9] was designed to fit in the stair case of the house; thus assisting the ventilation requirements during wind and non-wind conditions. (See Exhibits 2a and 2b).

The architectural design emphasizes natural ventilation during overheated periods by creating high and low wind pressure zones with the form of the structure itself and adjacent landscaping. The east wall is slanted and elongated towards the south-west to increase the high wind pressure areas of the structure. Low pressure zones are created by a protruding stair tower in the north wall, and by the use of vegetation adjacent to the south wall.

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9 Mehdi Bahadori, "Passive Cooling Systems in Iranian Architecture", Scientific American, Feb., 1978, p. 144.

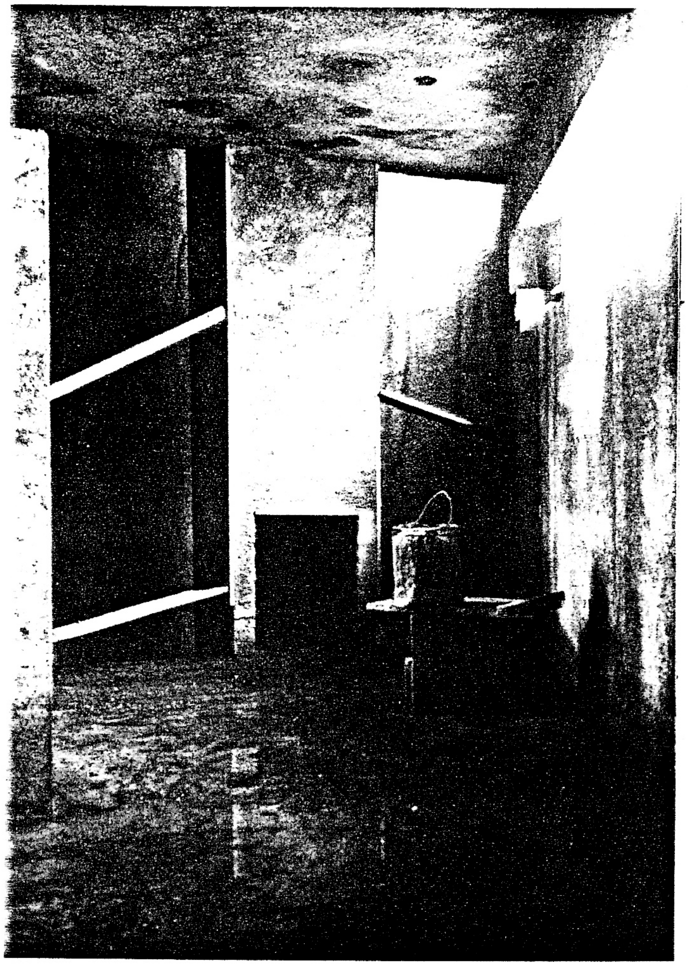


EXHIBIT 2a:

ITESM´S SOLAR HOUSE UNDER CONSTRUCTION. (2ND FLOOR INTERIOR VIEW). (In foreground wind shaft at center of staircase). Monterrey, N.L.. Mexico.

EXHIBIT 2b:

ITESM´S SOLAR HOUSE UNDER COMPLETION (SOUTH EAST VIEW) (Wind catch inlet visible in the upper right hand corner). Monterrey, N.L.. Mexico.

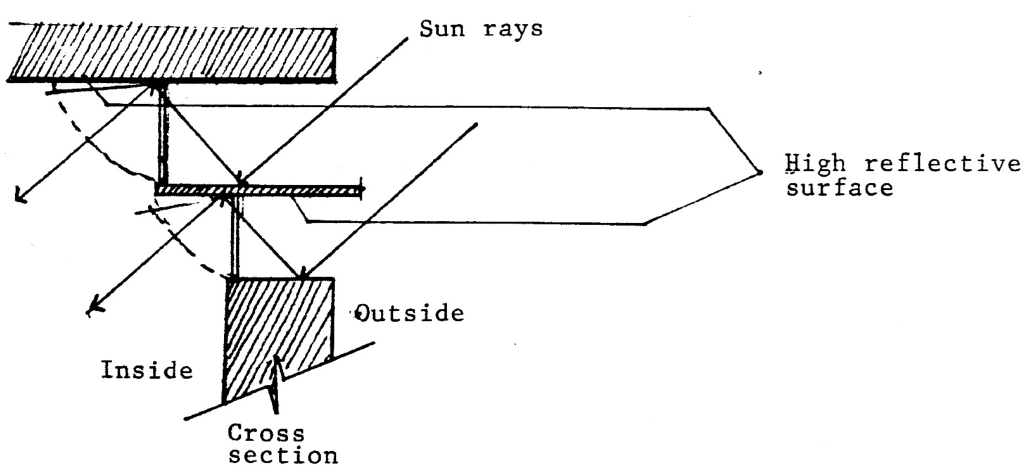
Models of the structure were tested in a two dimensional wind-tunnel (See Exhibits 3 and 4) to determine the best position of inlets and outlets as well as the best location of shrubs and vegetation, relative to the structure. The tested models showed that with the expected prevailing winds, adequate ventilation throughout the structure could be achieved.

Sun Protection/Penetration

The length of window overhangs were calculated according to the sun position during the critical months of summer and winter, so as to prevent sun penetration in the first, and favor it in the latter. South windows make special use of the above condition.

East windows were especially dimensioned for natural lighting and ventilation, as well as for sun protection. See figure below.

EAST WINDOWS



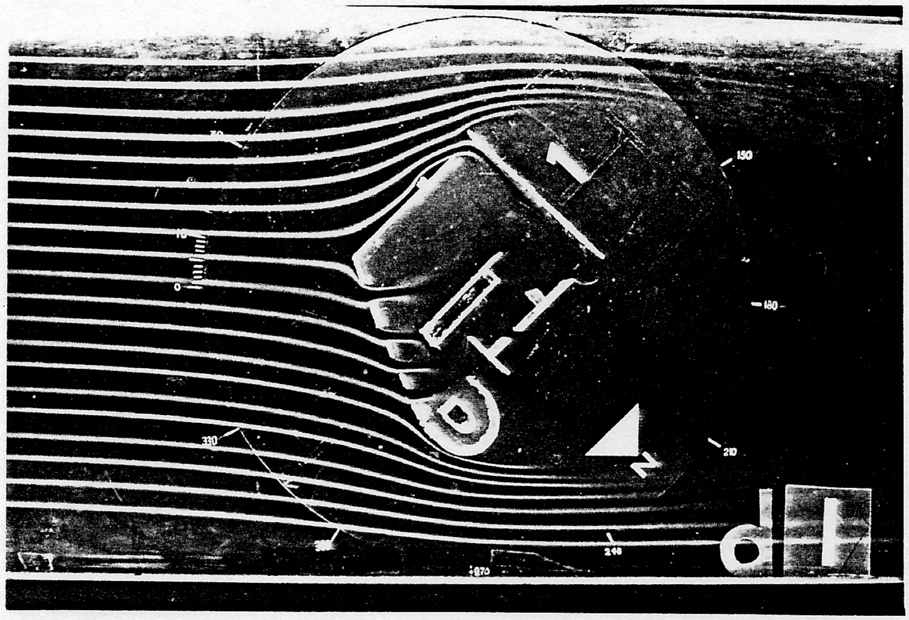
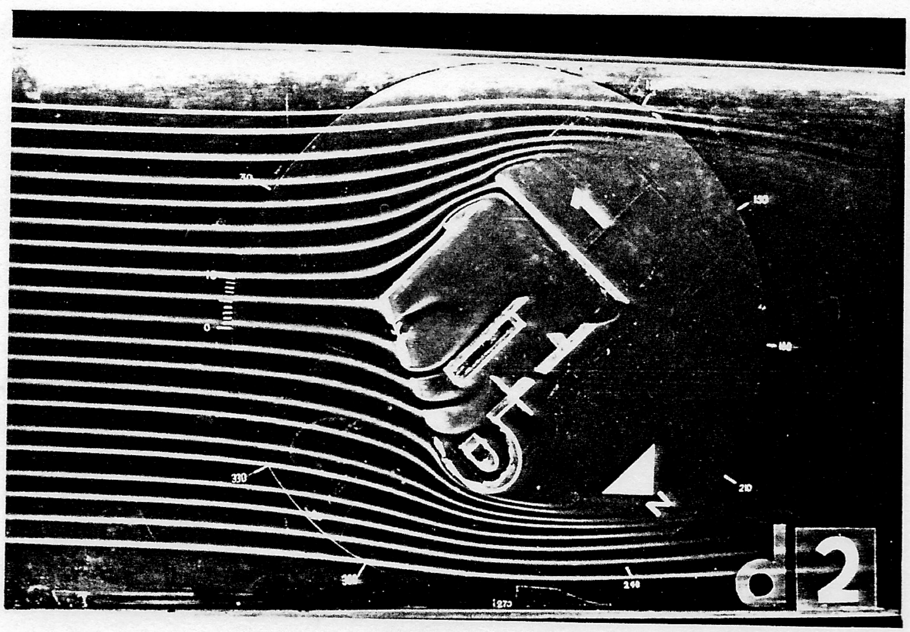


EXHIBIT 3: ITESM´S SOLAR HOUSE. NATURAL VENTILATION BIDIMENSIONAL MODELS (GROUND FLOOR). STREAM LINE PATTERN RESULTING FROM PREVAILING WINDS.



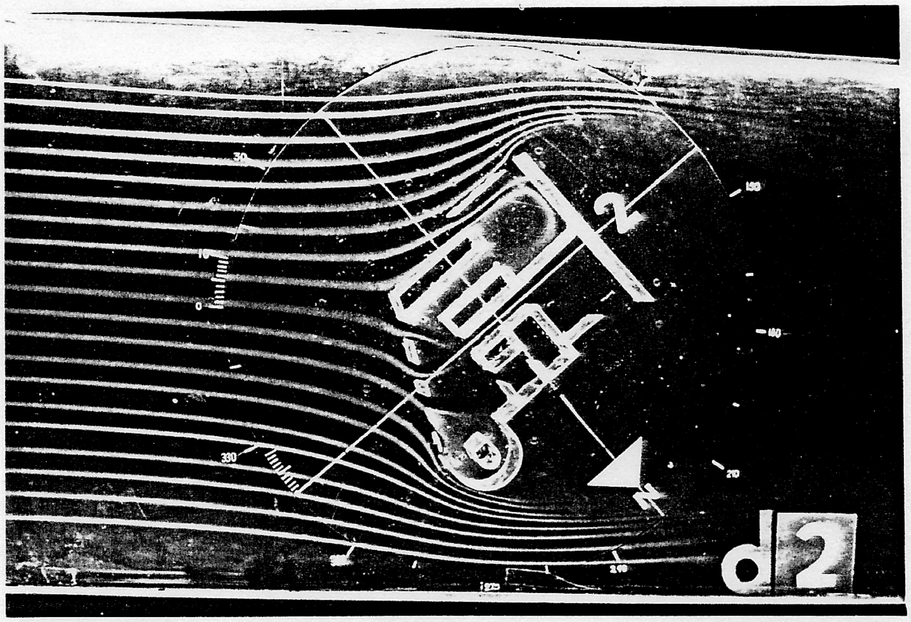
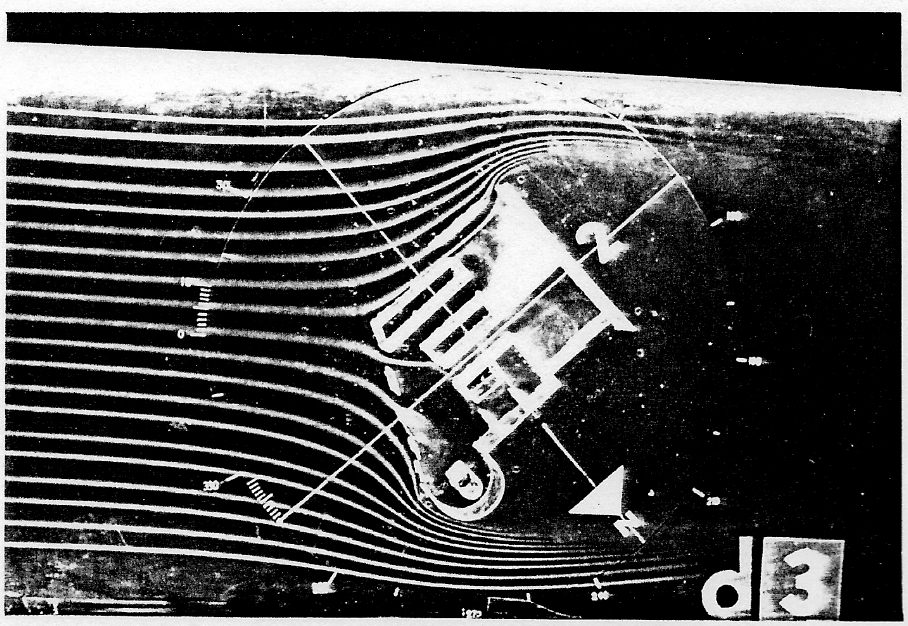


EXHIBIT 4: ITESM´S SOLAR HOUSE. NATURAL VENTILATION BIDIMENSIONAL MODELS (2ND FLOOR). STREAM LINE PATTERN RESULTING FROM PREVAILING WINDS.



There are no windows on the west facade so as to deliberately avoid the sun radiation penetration through glazed surfaces. Meanwhile the second floor and roof top are cantilevered in this side of the structure to act as overhang and protect the west walls from excess radiation during the afternoon sun. All the windows are double heat-resistant glazed and recessed.

Outside surfaces are all coated with a white high reflective material containing fiber-glass and white cement. Those floor surfaces where the sun is expected to impinge during the winter months are of high emissivity and low reflectivity. A floor tile with approximately 90% emissivity and 8% reflectivity, commonly used in Mexico was used for this purpose.

The ground floor near the south window has an extra feature. A tube coil embedded in the floor slab serves as a passive device for heat storage.

The use of deciduous vegetation strategically planted serves as shadow casters when needed in the summer period, and as mentioned earlier, to reinforce low wind pressure zones for natural ventilation.

PERFORMANCE EVALUATION OF PASSIVE DESIGN

The performance evaluation of the solar house's passive design will be carried out in terms of how constant are indoor comfort zone conditions achieved throughout the year.

For the above, the following instrumentation and procedures will be necessary:

Instrumentation:

a) Two dry bulb temperature recorders. Location: one outside the building, the other inside.

b) Two hair-hygrometers for RH (relative humidity) data.

c) Four hot-wire anemometers for wind speed data. Location: one outside, one at inlets, one at outlets, one at mid distance from inlets and outlets.

d) One radiometer.
Location: outside.

Definitions:

IAT Indoor air temperature

OAT Outside air temperature

WV Wind velocity I (inside), O (outside)

RH Relative humidity

Procedures

1. The above data will be collected by a microcomputer control data acquisition system and stored in disk on an hourly basis.

2. The data will be processed to obtain the following results:

   a) Daily graphs of time of day and:

      1. IAT and OAT

2. RHT

3. IWV and OWV

3. Frequency analysis of data outside the comfort zone for IAT and RH given for:

a) Hour of the day

b) Day of the month

4. Signals

A signal to open the windows will be given by the microcomputer IF:

a) IAT 85°F or

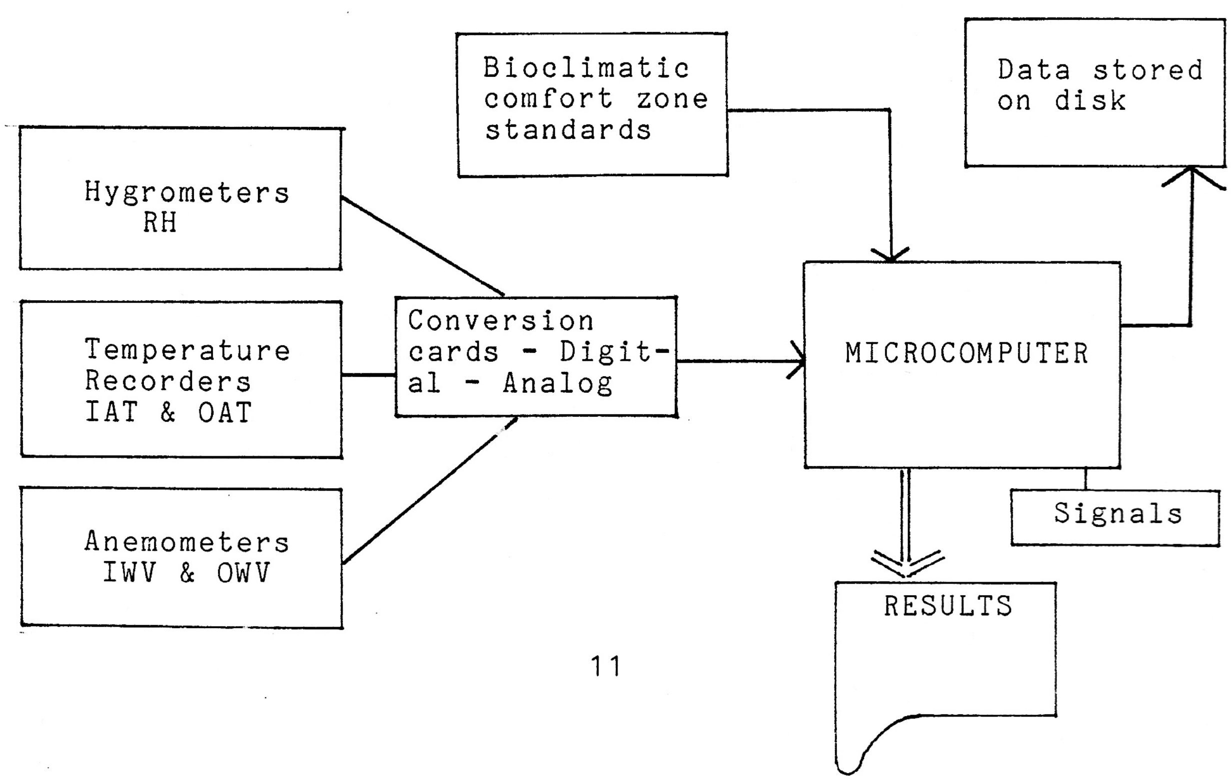
b) IAT 75°F and IRH 70% or

c) IAT 80°F and IRH 60%

A different sound will be signaled to close them when:

a) IAT 85°F and IRH 55%.

DATA GATHERING AND EVALUATION PROCESS



LIMITATIONS

The external validity of this study is limited by the number of similar type constructions in similar weather conditions. Although ITESM's solar house cannot be considered a low cost house if compared to the vast majority of dwellings in Mexico, the results and experience gained from its performance evaluation will serve to test the effectiveness of passive architectural techniques potentially applicable to a wide variety of housing cost situations.