THE FUTURE OF PASSIVE SOLAR DESIGN: REGIONALISM AND APPROPRIATE TECHNOLOGY

P. Fisk III
Center for Maximum Potential Building Systems, Inc.
Austin, Texas 78724, U.S.A.

ABSTRACT

The contextual framework within which passive solar design occurs is rarely if ever looked at. Questions of water use, material availability, and the overall ecological and social impacts seem paramount only when the topic of passive solar technologies occurs in conjunction with another newly formulating discipline--that of appropriate or intermediate technology or older and more accepted methodologies, such as those contained in ecological land planning. This paper borrows from several of these adjacent disciplines in hopes of measuring the tremendous potential of passive solar through a truly regional understanding. Based on work at our Center, we find that this approach achieves the following:

(1) Enables the various technologies in the passive solar field to become major determinants in the future of a new, more relevant architectural and community form;
(2) Extends through combinatorial possibilities and pattern generation, the wide application of passive solar;
(3) Demonstrates through mapping that this relatively new concept can be incorporated and utilized into the more accepted disciplines, such as ecological land planning, regional analysis and economic development strategies, and micro-climatic and site analyses;
(4) Becomes an excellent educational, user and research approach to enable one to understand the field in terms of what passive solar does and does not do.

INTRODUCTION

This paper is organized into two general categories: <u>One,</u> the potentials in physical form of generating relevant climatic solutions by combining passive solar form envelopes; and <u>two,</u> the important overall resource saving features when passive solar is regionally incorporated into other form determinants that derive from regionally understood technologies. The latter has not only lower cost implications, but lower overall embodied energy use, more local job potentials, and potentially higher acceptability by a far wider range of disciplines by virtue of its rich regional derivation.

Fisk, 1972

The Internal Potential of Passive Solar

Much of the work done in the passive solar field has dealt primarily with the optimization and testing of one system as opposed to another. Much frustration has resulted by one group's determination that theirs is the solution to a given problem. If we look at a different order of problem definition and concentrate on the overall scope and objectives, we find that at least some unnecessarily asked questions disappear. Let me describe such an instance using some examples from passive and hybrid cooling.

Trinity University's excellent work in testing and climatically mapping the use of reradiating and evaporative systems shows a potentially high use for this technology. (Figure 1) Existing conditions in the arid southwest, however, tell us that any additional water use is unacceptable in many communities. Texas A&M University has recently tested a system that accomplishes the same end, i.e. dropping the temperature of a ceiling or slab, but this time using a dual water well heat exchanger. By utilizing a porous strata within the ground water regime, water can be pumped from one input well to another output well and back into the building. Both systems have their advantages and disadvantages. One cannot be utilized where there is no water; the other where no porous subsurface layer exists. Both depend on what final Delta T. is possible and thus the economics of the system. We should perhaps set the limit of reradiating water systems at that point in a region where natural evaporation occurs at a greater rate than precipitation and set a limit of the well water heat exchanger to non-calcium, highly porous soils.

More subtle differences arise when one looks more closely at questions occurring between more adjacent research questions. For example, questions as to the use of air as a heat transfer medium versus water in radiant cooling systems have developed due to the obvious poor conductivity of the former. Yet, we find that both systems, when located within their proper contexts, work. In Texas, the night sky sink ranges from 100-1,600 BTU/Ft^2. Two air systems, one old and one new, have been working at the upper end of this heat sink range(1) in our part of the country. Beyond the fact that these systems work and save money is the fact that they also do not use water.

If we consider the four systems of radiant water roof, radiant air roof, earth water heat exchanger, and earth air heat exchanger, listed in Figure 2, together under ecologically viable conditions we find they cover a substantially large part of our state; yet, if taken individually, their impact is not nearly as great and their environmental "fit" not very relevant.

Pattern Generation

Now that we have used mapping by overlaying in developing regional blueprints of several passive systems and recognized the usefulness of each, let us now look at the richness in climatic form and climatic pattern that combinations of these can begin to indicate. Figure 3 illustrates a climatic form generated into form patterns. Each of the basic forms has been climatically generalized previously. When combined, these forms can accomodate various climatic needs. The obvious cases are basic heating and cooling; i.e. utilizing a lag time thermal chimney in summer (breeze occurring in the structure during night time hours when outside air is coolest) and connected to a trombe wall, (Figure 4.) for heating. But more subtle combinations become possible.

For example, the simple combining of east/west desiccant walls originated by Dannies in Germany operates in a geometry that very specifically meets climatic need; i.e. east wall, when hit by sun, acts as a thermal chimney dehumidifying the air through the regenerated west wall, and vice versa during the evening, thereby nicely meeting what the climate is often already telling you: mainly that it is humid in the morning and afternoon. When this system is placed on two separate halves of the roof, it is regenerated at midday, and could be used all night for humidity during this period. Thus, these two systems together, geometrically and operationally, (a fan would have to be used with the roof system) can fulfill a slightly more humid climatic need.

As we combine more systems, similar discoveries can be made, i.e. a quick gain thermal chimney working at midday could be used to dehumidify off regenerated flat surfaces located on the ground instead of on the roof. A lag time thermal chimney could do the same at night using no fan. One can now recognize the potential importance of combinations and permutations brought about by some of the interrelationships of the passive systems we already know about within the literature. The potential for truly indigenous building forms and even indigenous community forms can be developed out of this simple realization. (Figures 5 and 6.) The buildings used in these examples have been designed and in some cases constructed by the Center for Maximum Potential Building Systems. Jon Hand of Night Sky Systems, Ft. Worth, developed the final building near Wichita Falls from our schematic.

It is now time that some of the richness in these forms is fully studied in depth to help guide us to the next most sensible steps for research and demonstration.

Regional Resource Patterns - The Determinants of Form and Function in Passive Solar

Now let us take this simple methodology one step further to include various parameters as they effect a passive building. As an example, we will use a demonstration building (Figure 7) which our Center is currently constructing through training a local crew in a low income community in South Texas, The building's basic climatic form was developed from our first map presented (Figure 1) on radiant and evaporative systems. The other regional resource patterns have been developed from some 50 maps on file at our Center (soon to be on computer to better serve our constituencies in Texas.)

Within this building, most all systems and attitudes toward construction techniques are derived from a thorough understanding of the region. For example, since it is a demonstration building, we are incorporating both a water radiant system and an earth/water slab heat exchanger. The reasons for using both systems are as follows: (1) the radiant capacity using the night sky is just on the borderline of being useful; (2) the wet bulb temperature expected off the roof is about the sane as the ground water temperature; and (3) there is a chance of utilizing the aquifer sands below as a heat exchanger.

Regional Resource Determinants

Other features of the building are equally if not more regionally relevant than the obvious passive solar aspects. Bamboo, for example, is used extensively as structural members, since the material can be locally grown, can produce up to four times the number of local jobs than commonly used steel, and in some cases actually works better than conventional materials.

Specifically, the bamboo is used (1) as reinforcing bar and welded wire mesh, saving 170 fold the energy as would be used for steel reinforcing materials; (2) as the tension member in the roof trusses which hold up the reradiating roof. The tension capacity of bamboo is approximately 28,000 p.s.i.. vs. common steel which is 20,000 p.s.i.; (3) in the door and window lintels which makes them lighter than if steel were used; and (4) Carrizo Springs, the name of the town in which the building is being constructed, is a region where bamboo species naturally grow, Carrizo meaning reed-type species in Spanish.

Another locally derived building material is mesquite--a hardwood which is the common tree species of the region. In one town nearby, the Center helped retrofit 1000 homes with woodstoves following a total gas shut-off to the town's 8200 residents, and organized a mesquite collection and distribution network. An obvious byproduct of this system was a tremendous amount of waste sawdust. Utilizing our earth block development lab in Austin we developed a light weight insulating mesquite sawdust block to be used on the outside of our mass structural block. In the case of the Carrizo Springs demonstration building, the mass structural block is made from caliche, an earth material which, according to the United Nations, makes up 14% of the Earth's surface. Both the caliche block and the mesquite sawdust block are made in slump-form from the same machine. The resulting caliche/ mesquite block walls are 10 times less energy intensive than conventional, well weatherized passive solar walls using the materials combinations shown in (Figure 8). Moreover, as with the use of the aforementioned indigenous materials, the caliche/mesquite wall produces 2.5 times the number of local jobs than a conventional wall.

By the brief descriptions of the components of this integrated building, we can see what the environmentalism of passive solar could really be about. We can also see how a tracking and information sharing system can be used to aid the process of designing and constructing low energy buildings, and how quite different disciplines can work together at a level that could have far reaching effects in how many of us could really glean the benefits of these "new" technologies.

References

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Falls and Bliss. U.N. Conference on New Sources of Energy, August 1961.

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6. Knowles, Ralph. Energy and Form, The MIT Press, 1974.

7. McHarg, Ian L, Design with Nature, Doubleday & Co., 1969.

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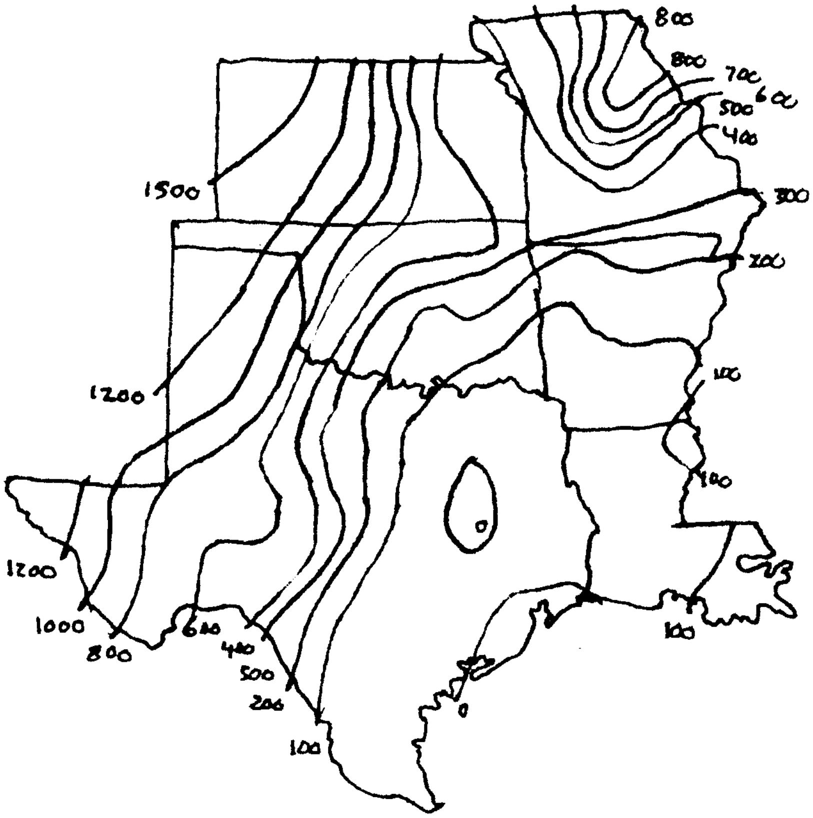
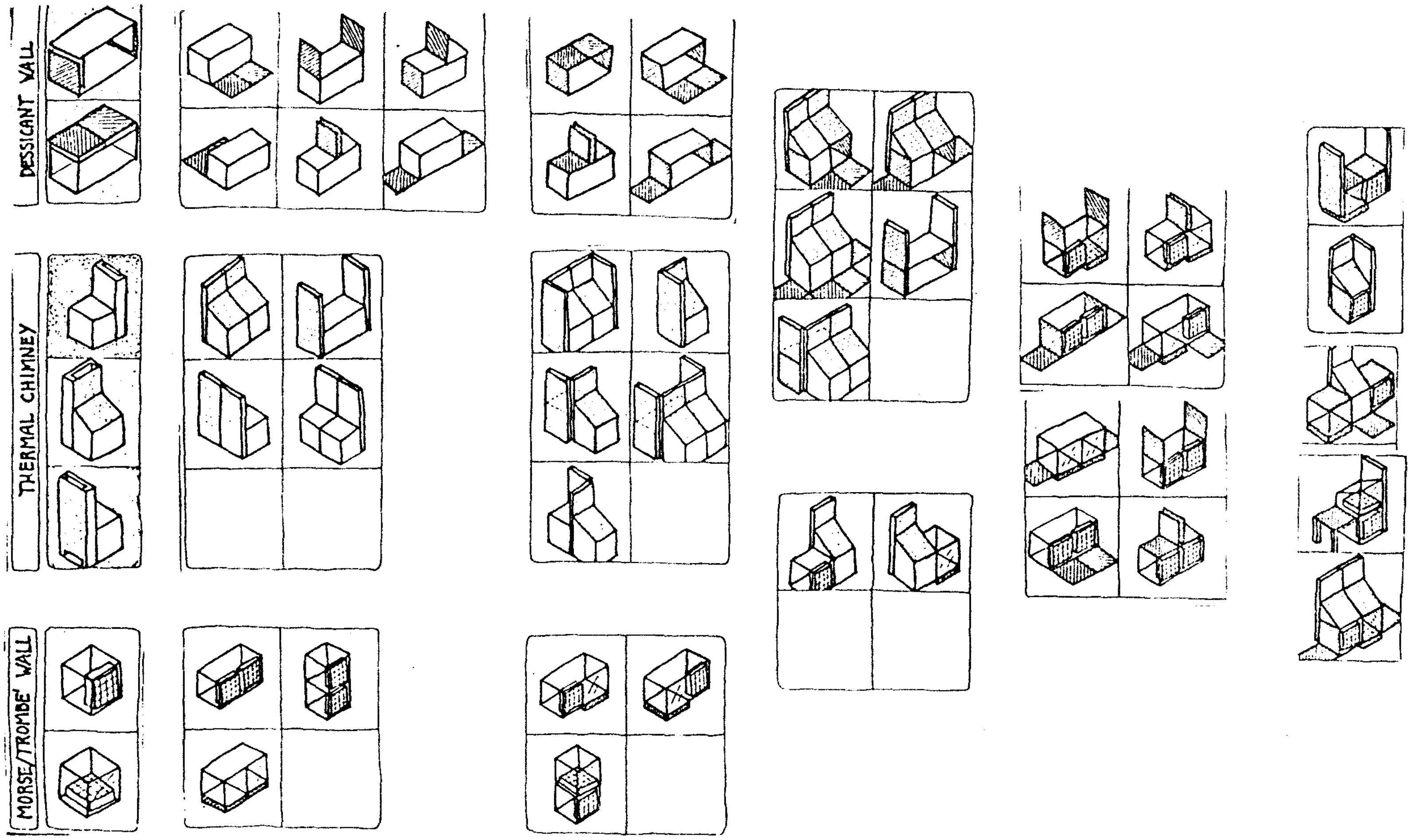
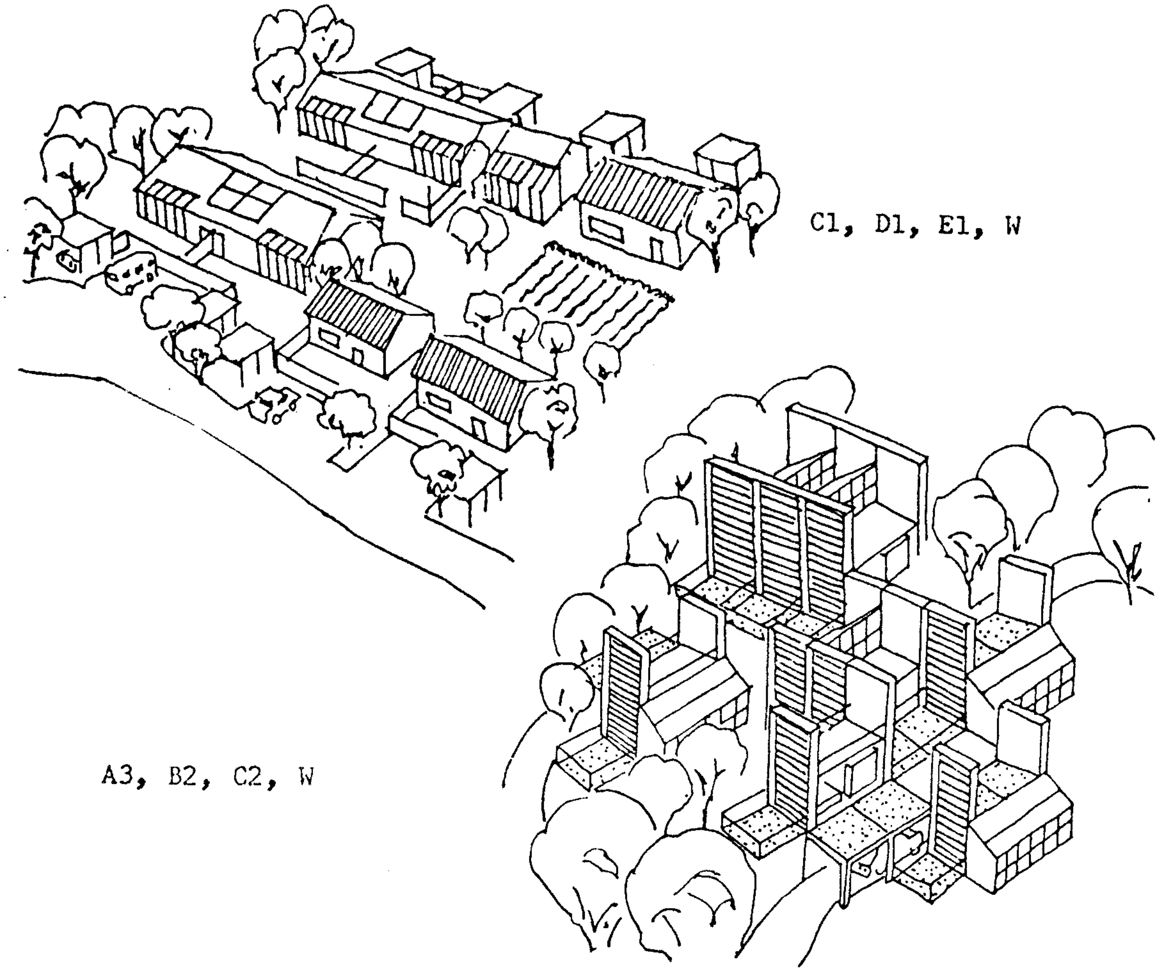
JULY NOCTURNAL NET COOLING RATE FOR WET SURFACE AT 70°F (BTU/SQ.FT/DAY)



EVAPORATION
RADIATION
AND CONVECTION
TYPICAL JULY
HOURLY DATA
77 CITIES
HORIZONTAL SURFACE

PATTERN GENERATION 1ST 2ND 3RD ORDER



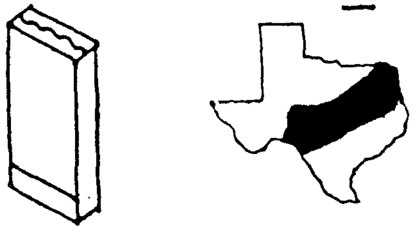


C1, D1, E1, W

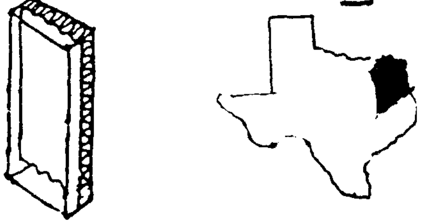
A3, B2, C2, W

PASSIVE SOLAR

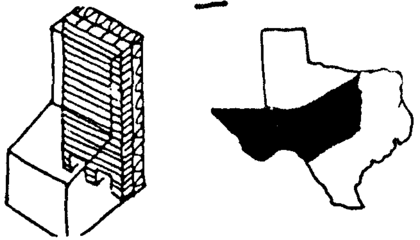
EAST THERMAL CHIMNEY A1



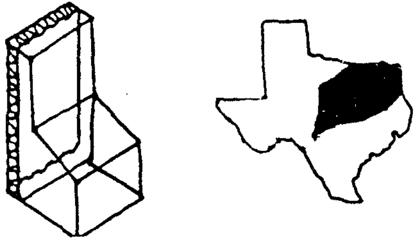
WEST THERMAL CHIMNEY A2



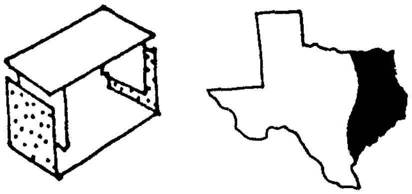
WEST THERMAL CHIMNEY WITH BUILT IN LAG TIME A3



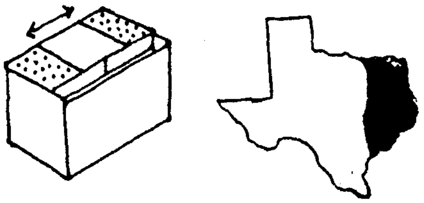
SOUTH FACING THERMAL CHIMNEY A4



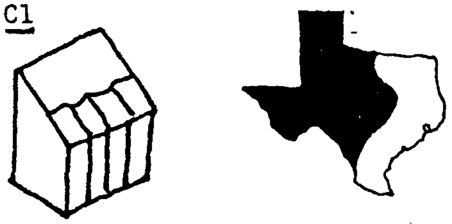
EAST WEST DESSICANT B1



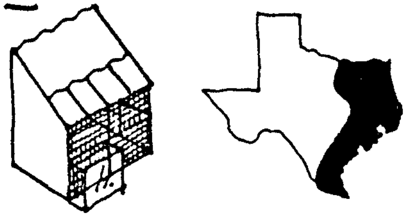
ROOF DESSICANT B2



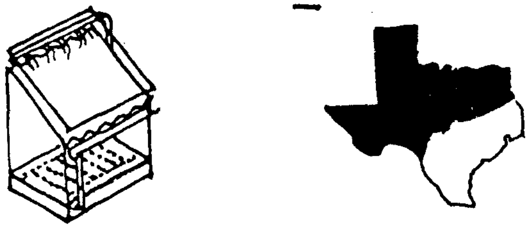
ATTACHED SOLAR GREENHOUSE C1



SOLAR GREENHOUSE/SCREENED PORCH C2

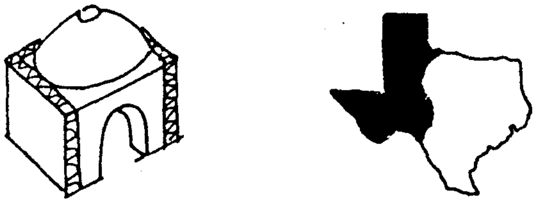


TRICKLE COLLECTOR D1

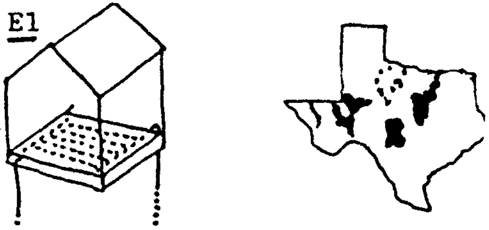


MORSE/TROMBE WALL D2

NOCTURNAL MASS D3

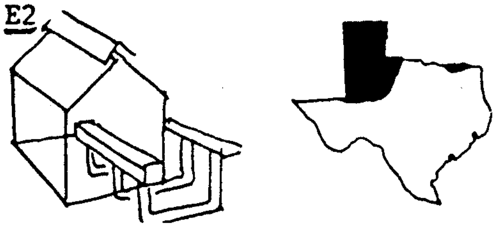


EARTH WATER HEAT EXCHANGER E1

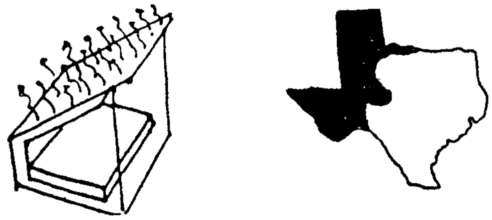


EARTH AIR HEAT EXCHANGER

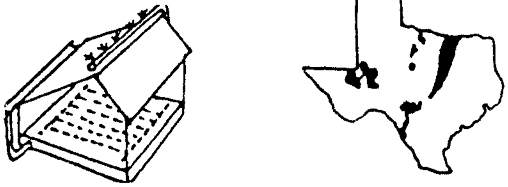
E2



RADIANT AIR F1



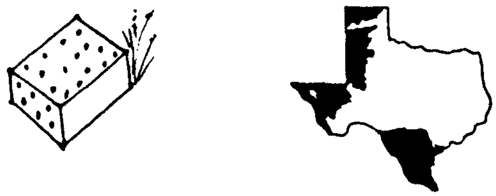
RADIANT WATER F2



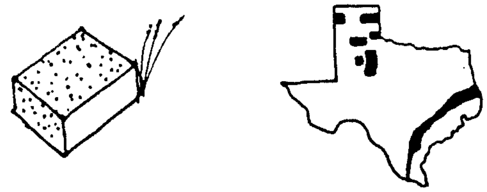
INDIGENOUS MATERIALS

ALKALINE WEED SULPHUR BLOCK V

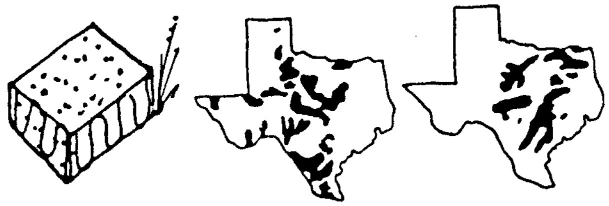
CALICHE BLOCK W



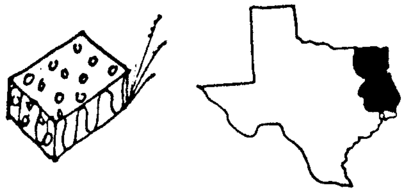
POZZOLAN BLOCK X



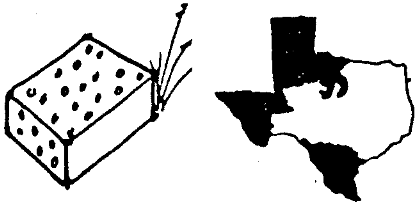
HARDWOOD SAWDUST BLOCK Y



SOFTWOOD SAWDUST BLOCK Z

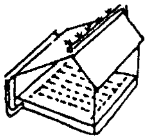


ADOBE BLOCK U

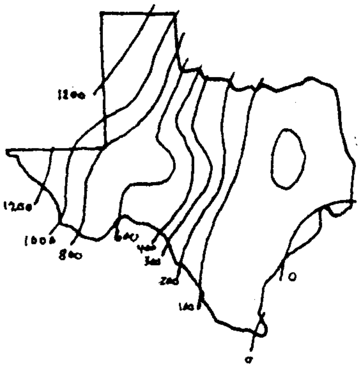


PASSIVE SOLAR SUITABILITY STUDIES

RADIANT WATER F2



RERADIATION POTENTIAL



MEAN EVAPORATION RATE

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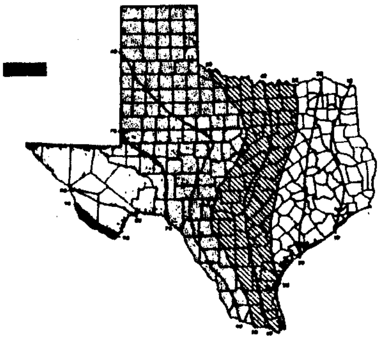

MEAN ANNUAL PRECIPITATION

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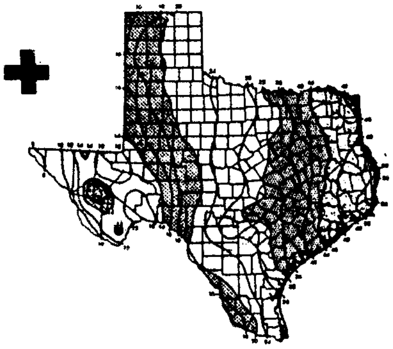

USABLE FRESH WATER AQUIFERS

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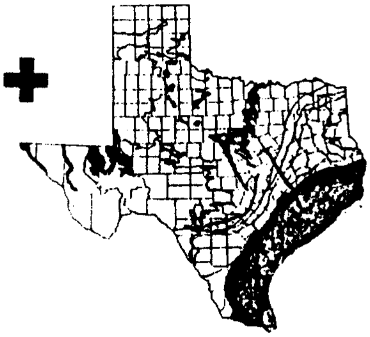

RERADIATION SUITABILITY

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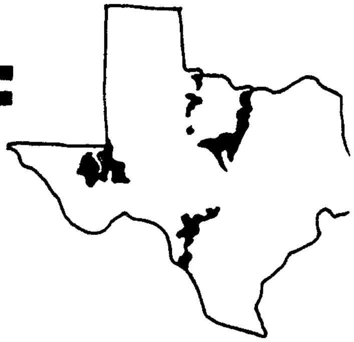
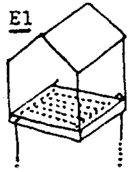


EARTH WATER HEAT EXCHANGER E1



MEAN ANNUAL TEMPERATURE

USABLE FRESH WATER AQUIFERS

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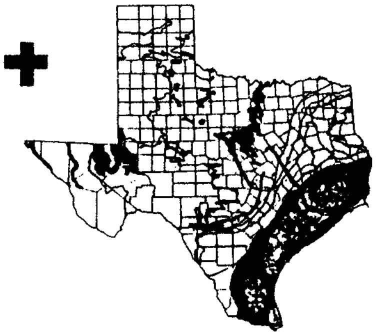

WELL HEAT EXCHANGER SUITABILITY

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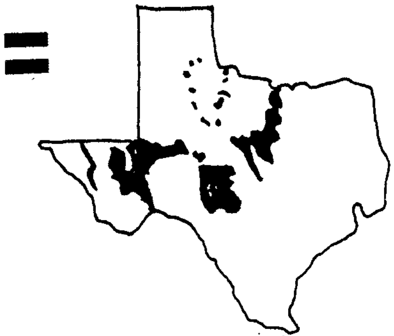
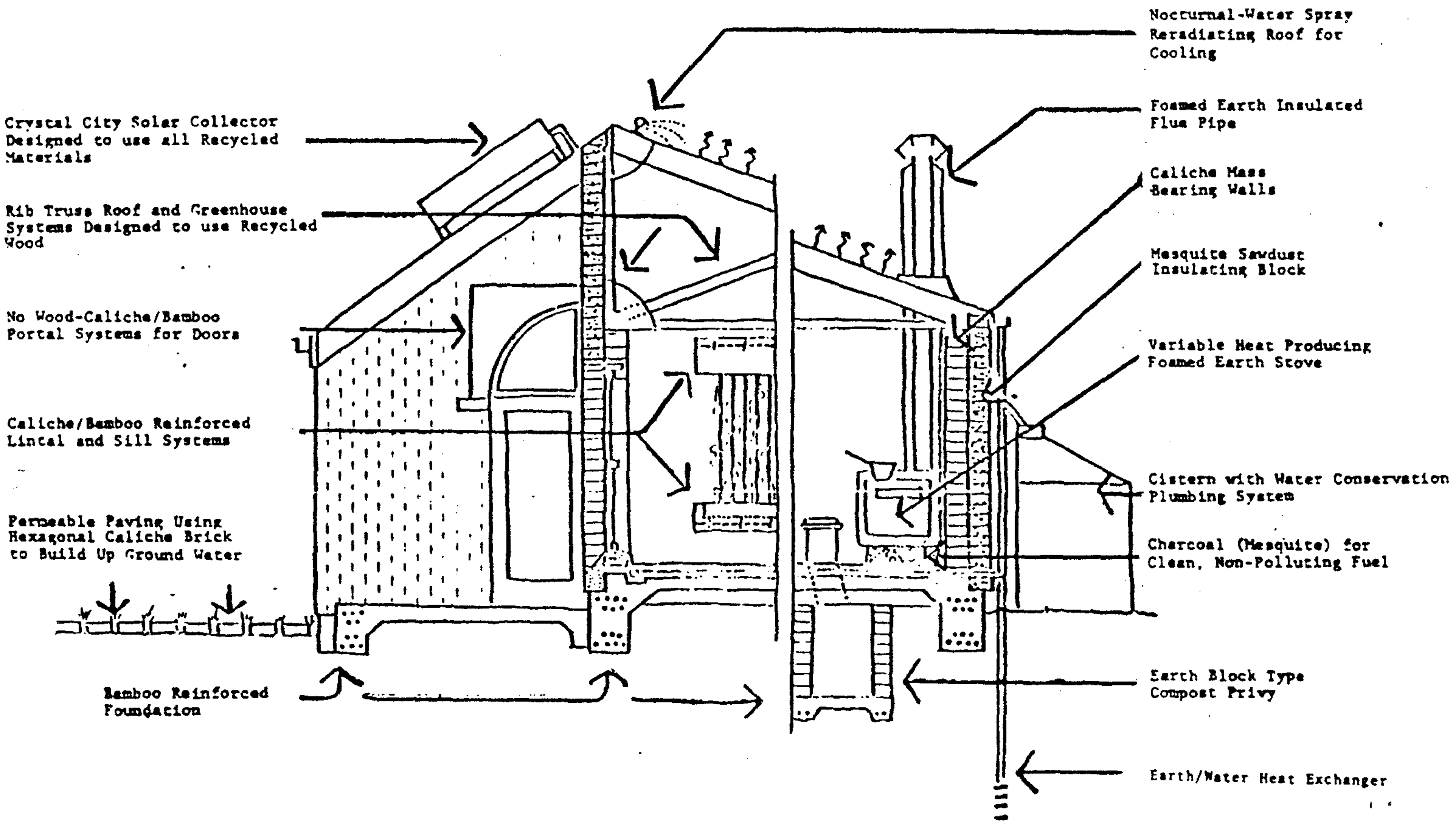


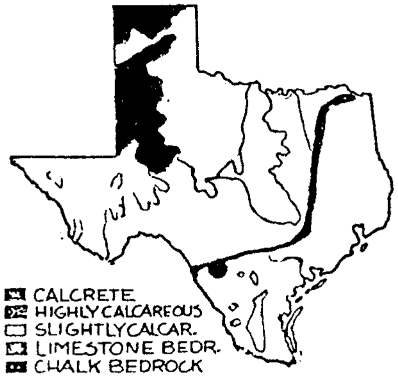
LOCAL RESOURCE INTEGRATED BLDG. SYSTEM



AREA RESOURCES

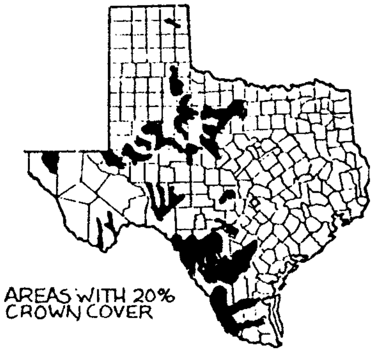
RESOURCE INTEGRATED BUILDING SYSTEM

CALICHE



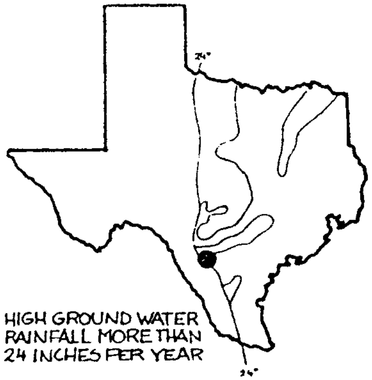
■ CALCRETE
▨ HIGHLY CALCAREOUS
□ SLIGHTLY CALCAR.
▧ LIMESTONE BEDR.
▪ CHALK BEDROCK

MESQUITE



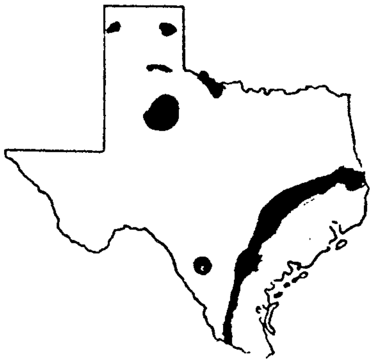
AREAS WITH 20% CROWN COVER

BAMBOO

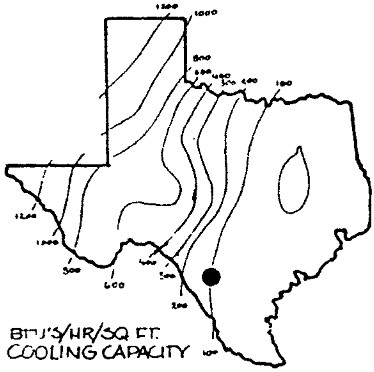


HIGH GROUND WATER RAINFALL MORE THAN 24 INCHES PER YEAR

VOLCANIC ASH

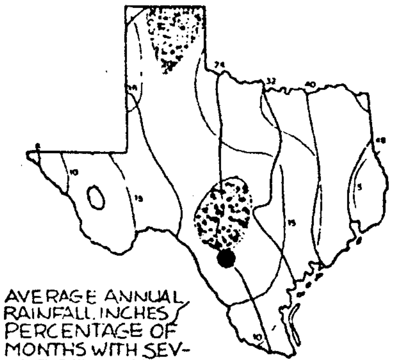


RERADIATING ROOFS



BTU'S/HR/SQ FT. COOLING CAPACITY

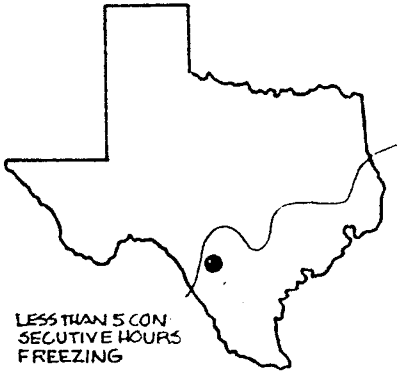
CISTERN WATER CATCHMENT



AVERAGE ANNUAL RAINFALL INCHES PERCENTAGE OF MONTHS WITH SEVERE DROUGHT

■ ▨ ▧ □ □

CRYSTAL CITY SOLAR COLLECTOR



LESS THAN 5 CONSECUTIVE HOURS FREEZING