AVAILABILITY AND SPATIAL COINCIDENCE OF INDIGENOUS BUILDING MATERIALS

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A truly integrated approach to building responsively with the environment is a quickly disappearing art and science. When it does surface, such as at conferences dedicated to the craft of building with earth, we run the distinct risk of only talking about the techniques of earth building. Thus, earth building becomes a specialty, a technology divorced from its original purposes and inherent quality of offering people an affordable, environmentally sound, and energetically viable building option that is part of a continuing effort to build an overall environmental ethic.

This paper presents the subject of earth materials for building in a manner that enables them to be part of an overall environmental approach. This approach is called ecological land planning, developed in the sixties, and is presently used by every state land use office in the nation, and is able in a single medium to incorporate the expertise of a variety of disciplines from the natural and social sciences. In our appropriate technology work, we achieve a compatibility with these previous efforts by promoting one simple concept--mapping--which is the basic tool of ecological land planning. It is this recording tool whereby plant taxonomists record species, geologist study minerals, and soil scientists transfer their soil data to extension agents who in turn publish this information for use by farmers. Mapping is a statistical base for locating areas of poverty, jobs, skills, manufacturing, retail, etc. It is generally the basis from which plans are made, environmental impact statements presented, and, most important of all, it is a medium that enables you to know where you are relative to all the above.

As a tool for earth building, mapping tells us how far a source is, what area it covers, its general quantity, whether a local extractor, fabricator or mason exists, on whose land the material is, and whether it is publicly or privately owned. If many indigenous materials are mapped, the user can know how many different building components can be derived from a given locale. As a networking tool, depending on the information recorded, mapping can help someone gain access to someone else's experience in a similar region with a similar set of resources.

Below is a set of mapped area resources that represent a series of materials that can be used for earth building in Texas. Our Center has 40 to 50 such maps dealing with life support topics in general, including such areas as biofuels, windpower, low temperature solar, etc. We use this data base in many ways that may include such simple things as overlaying them in order to understand our options for purposes of guiding our work in any given region. This paper identifies, in general terms, a series of indigenous materials for building along with their spatial existence. We then demonstrate the tremendous richness offered through combining these materials by documenting some aspects of a prototype building for South Texas that uses a combination of these materials. This process enables us to calculate local job and business development potentials, initial and operating energy savings and, finally, general resource conservation in building.

These materials in mapped form can be utilized in many ways: Simple overlaying as mentioned earlier and demonstrated below where one finds areas of rich coincidence between volcanic ash mixed with caliche and lime for foundations, adobe for walls, and diatomaceous earth mix for light weight roof blocks.

MASSIVE MATERIALS

(1) Caliche is a high calcium carbonate soil characteristic of lower soil horizon in arid, semi-arid environments. It is estimated that these soils make up 14% of the Earth's surface, and over one-third of Texas' land mass. The mix for caliche block depends on the calcium carbonate content, with a good caliche giving a mix of 8 parts sand, 9 parts caliche and 1 part cement. Caliche can also be stabilized with a mixture of pozzolan and lime to replace the cement.

(2) Stabilizable Earth ranges from 10 to 60% clay and can be stabilized either chemically or by pressure. Earth with this range of clay content comprises about 60% of the Texas land area.

(3) Pozzolan is a fine grain, amorphous silica which, when mixed with lime, is called Roman cement. Typical pozzolan mixture is 5% lime, 25% pozzolan, and 70% sand/gravel aggregate. Pozzolan is 1,400 feet thick in Mission, Texas, and diminishes to 2 feet thick north of Houston. Pozzolan was the principal material used to build the Roman Empire.

(4) F1yash is very similar to pozzolan but is not really an earth material because it is derived as a waste from the stack of coal burning plants. If Texas energy policies continue as per present plans, we will be literally knee deep in the stuff in no time.

(5) Sand Lime is an autoclaved pressure molded mixture of sand, lime and water: 8 to 12% lime, 88 to 92% sand and 3 to 5% water.

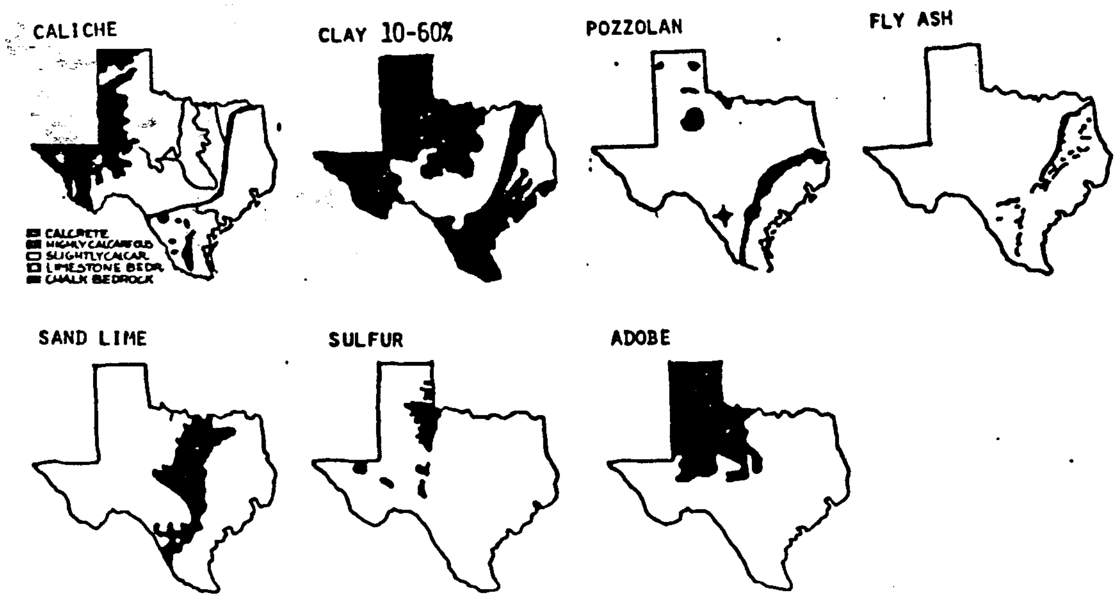
(6) Gypsum is not specifically mapped but usually occurs in parallel geologic formations to sulfur. It is first calcinated over fire and then ground and mixed with water (Plaster of Paris).

Sulfur is a subsurface mineral of which Texas possesses a reported one-fifth of the world's supply. Sulfur is mined by drilling, and presumably could be utilized from the well on-site in sprayed form, foamed form and as building block. Sulfur block are made by combining 65 to 70% sand and 30 to 35% sulfur.

BUILDING MATERIAL TYPES

(SLUMP BLOCK, RAMMED WALL, RAMMED BLOCK)

MASSIVE



(7) Adobe is a sandy clay soil contain virtually no organic matter and is characteristic of arid and semi-arid climates. At its best, adobe contains about 20% clay and 80% sand, but a wide variety of mixes are used with the resulting need for higher stabilizing requirements as one deaparts from this ratio composition. Adobe makes up approximately one-third of Texas' land surface.

INSULATIVE MATERIALS

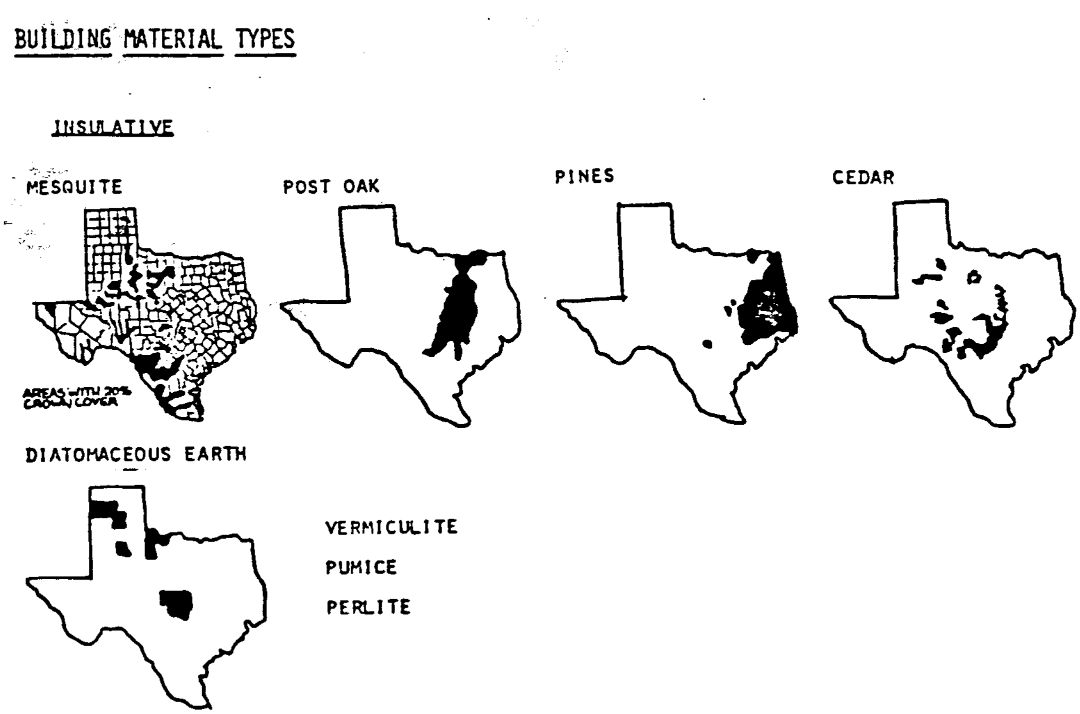
(A) Mesquite, Pine: Mesquite and Pine are a both usable in insulating block when mixed with cement and a base material such as sand. Mesquite sawdust must first be neutralized by soaking it in an alkaline solution of lime water and then mixed in a solution of one part cement to 8 parts stabilized sawdust. Pine sawdust can be mixed dry in proportions of 6 sand, 2 Portland, 2 lime, 8 sawdust. Both blocks must be protected from the weather with latex paint. These sawdust insulating brick are fireproof but have not been subjected to long term weathering effects.

(B) Oak & Cedar sawdust or chips can soaked in Boric acid for fireproofing land then used as an insulative fill in hollow walls.

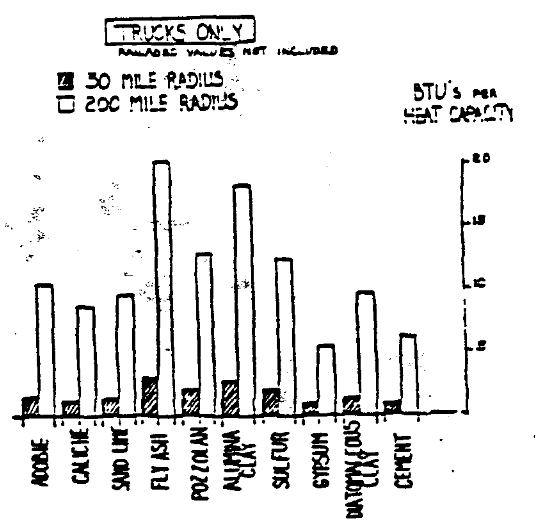
(C) Diatomaceous Earth is the deposit of siliceous fossils whose dry weight is 10 to 28 lb/ cu. ft. It is mixed with 3 parts sawdust, 3 parts shaving, 1 part cement, 1 part diatomite and 1 part clay.

(D) Vermiculite is micaceous mineral which expands upon exposure to heat of about 300°C. It can be used directly as an infill insulation.

(E) Pumice is a lightweight porous volcanic aggregate mixed with cement.



One important measure of the usefulness of an earth material is the energy storage work that can be accomplished once in place on a building site. This work is in the form of heat storage capacity, whose capacity per volume is a function of its density and specific heat. The energy cost for travel given a certain volumetric measure of a truck or railroad car will differ, as will the delivered product. These relationships are graphed below. It would seem from the viewpoint of transportation that adobe, caliche, sand lime, gypsum, Diatomaceous earth and cement are about equal. However, when coupled with the amount of energy in the production and building process, relationships change quite drastically. The list below indicates how some of this change might occur. Although these are all preliminary figures, the actual building process itself, when added on to the transport and production, should give the whole picture. A final chart showing this combination along with the amount of work done structurally and therally is soon to come.



BTU's NEEDED IN TRANSPORT RELATIVE TO DELIVERED HEAT CAPACITY

MANUFACTURING

Concrete Block	15.9×10^6 BTU/Yd^3
Fired Brick	13.8×10^6 BTU/Yd^3
Sulfur (recycled from soft coal burning)	$.18 \times 10^6$
Sulfur (Frasch Mining)	17×10^6
Flyash (when no stabilizer is needed)	$.12 \times 10^6$
Flyash (with stabilizer)	$.96 \times 10^6$
Pozzolan	$.90 \times 10^6$
Caliche	$.5\text{-}.9 \times 10^6$
Adobe	$.7 \times 10^6$
Gypsum	$.4 \times 10^6$

BUILDING ONLY

Slump Block	$.04 \times 10^6$ BTU/Yd^3
Pressed Block	$.07 \times 10^6$ BTU/Yd^3
Rammed Wall (assume 2.3 cu. yd./hr.	$.1 \times 10^6$ BTU/Yd^3

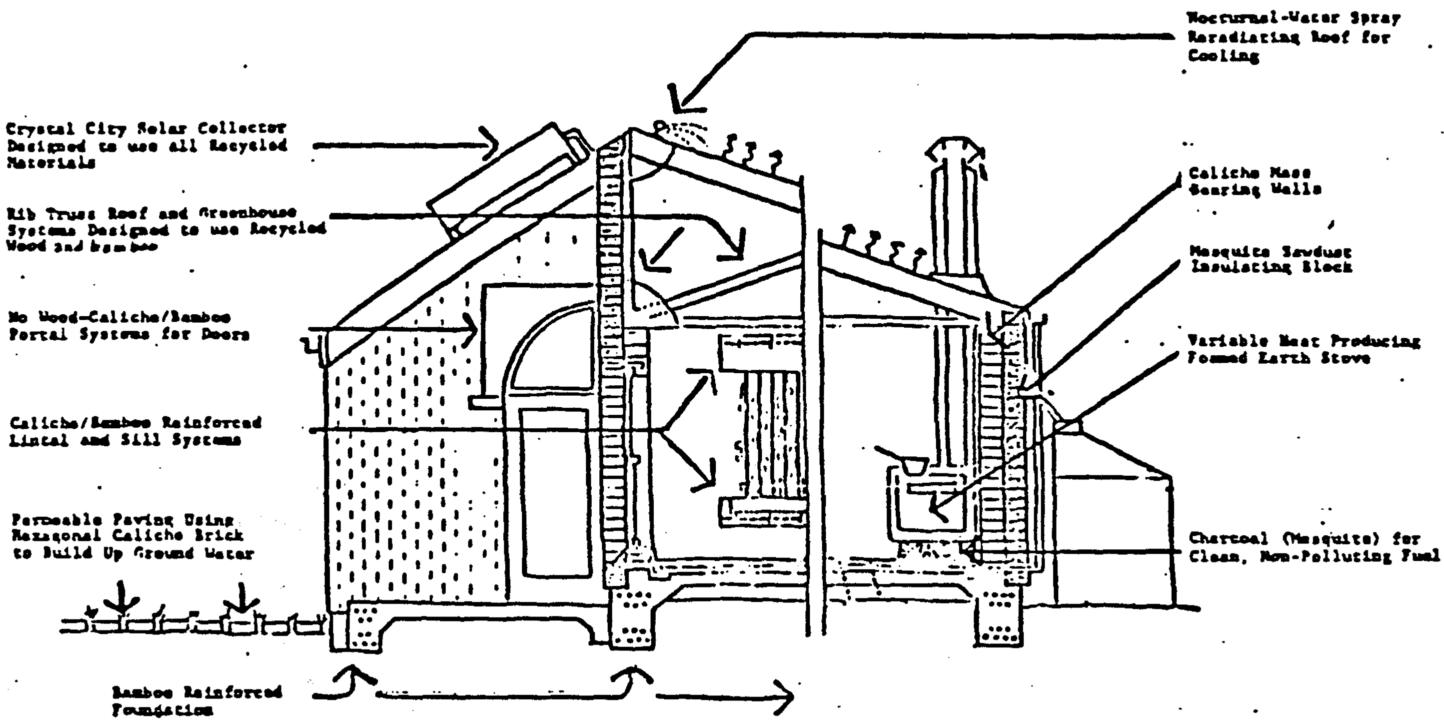
Now let us place ourselves into the reality of designing and constructing an actual building. Many materials and material combinations are required. If one were to study the headings and subheadings categorized in our paper entitled " Earth Block Manufacturing and Construction Techniques," one would realize the extent of questions which need to be asked. Remember, the main purpose of this building is to develop the use of a wide variety of local resources and to show what impact this approach could have on local energy consumption and job production.

The building diagrammed below describes in cross section some of these material systems. Drawings that follow describe such material combinations as well as utilities in more detail, and key these components into spatial maps. Let us first start with the building shell.

The building shell contains six (6) regional systems. They include a trickle-type reradiating roof, bamboo for reinforcing of foundation as well as for door and window lintels, caliche for use as mass and structural building block, and mesquite hardwood for hardwood tile floors and as a sawdust base for insulating exterior block.

The <u>Trickle-Type Reradiating Roof</u> is coupled to pipes in the heat absorbing foundation slab. The performance of the roof depends on the ability of white-painted corrugated roof metal to reradiate and evaporate the water trickling over it at night. This water is then cycled through pipes in the slab foundation. The performance also depends on how many BTU's/sq.ft. of roof area the night sky is able to absorb. In the building area, this roof is able to lose approximately 100 BTU's/sq.ft of roof, which is approximately equivalent to the heat gain of a well insulated building.

LOCAL RESOURCE INTEGRATED BLDG. SYSTEM

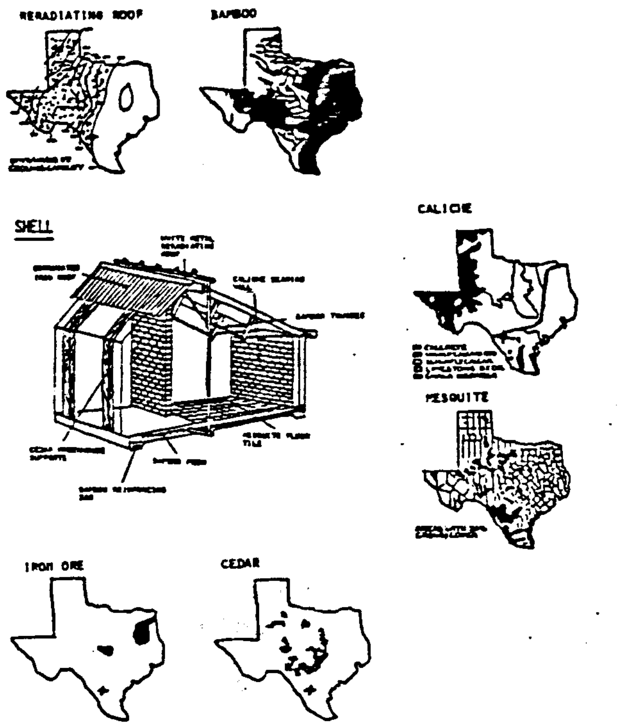


Bamboo in our demonstration area can be grown along the banks of rivers to make use of runoff. Planting bamboo in other locales would require water which is presently being used at five times its natural replenishment rate. Therefore, our map shows only rivers being used for growth areas in the study area. The bamboo must be cut as close as possible to its dormant season in order to reduce the amount of water in its stems. Bamboo is capable of withstanding 28, 000 lb/sq.in. in tension and is stabilized with asphalt emulsion before being placed in the cement or calcreete. No stems beyond 3/4" diameter are used. When the diameter is greater than 3/4," the bamboo reed is split.

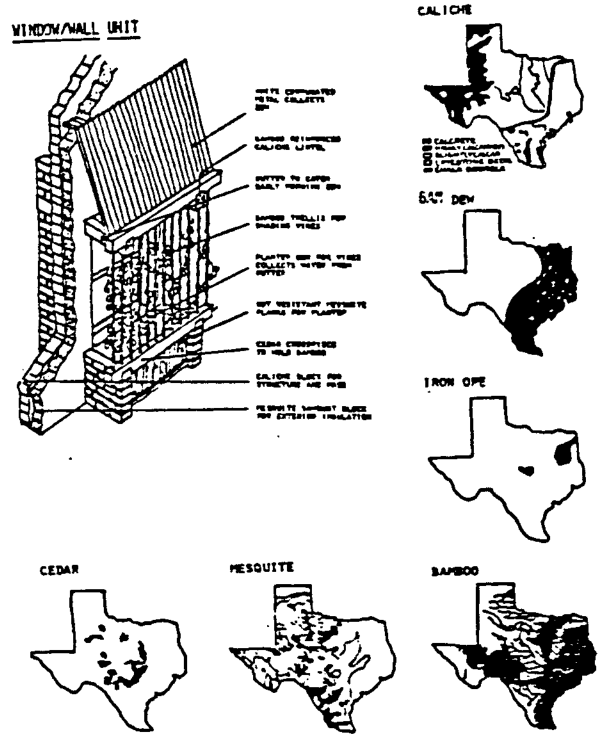
Mesquite is a hardwood that grows prolifically in this border region. Our organization has organized community-wide gathering efforts of mesquite to be used as firewood in six low-income rural towns in South Texas. At 13,200 BTU/lb., mesquite makes about the best charcoal in the U.S. and is an extremely hardwood, comparable to mahogany. We have incorporated this wood in two ways within this building: 1) as a floor tile and 2) as a material base for insulating sawdust block, since sawdust is a highly available waste material in the region. The tile are made by using the rough cutting capability of a local mesquite sawmill and a bandsaw that slices 6" x 6" x 2 1/2' pieces into 1/2" tile. The completed sawdust block weigh about one-third less than caliche block, which weigh about 20 pounds per 8" x 10" x 3 1/2".

Cedar is located outside our study area and would be considered a product that must be brought in from a neighboring bioregion. The cedar is required because the local mesquite tree rarely grows straight and does not produce good lumber, whereas cedar is the material in closest proximity which can be used to fulfill structural uses.

Iron Ore is another material requiring importation since it is crucial for the building's roof system to operate well. This metal drops temperatures quickly and then conducts the temperature efficiently to the water flowing over its surface.



The next building component, our window wall unit, has an area resource pattern generation similar to the building shell. The only major difference is our dew catchment technique over the vines which is used to water the plants for the purpose of shading the windows. This technology is useful only in coastal and near coastal regions where water vapor is high enough in the early morning hours to collect as condensation on surfaces that can cool to the night sky. This system could be considered not to be of particular significance until one calculates the heat gain on the east and west sides of a structure. The predictable use of a natural shade becomes very important. Other than this, there are minor changes in the use of materials; for example: mesquite is now the material for the planter box due to its resistance to rot; bamboo is used again as reinforcing materials now in cantilever lintels and also as a trellis for the vines.



Conclusion

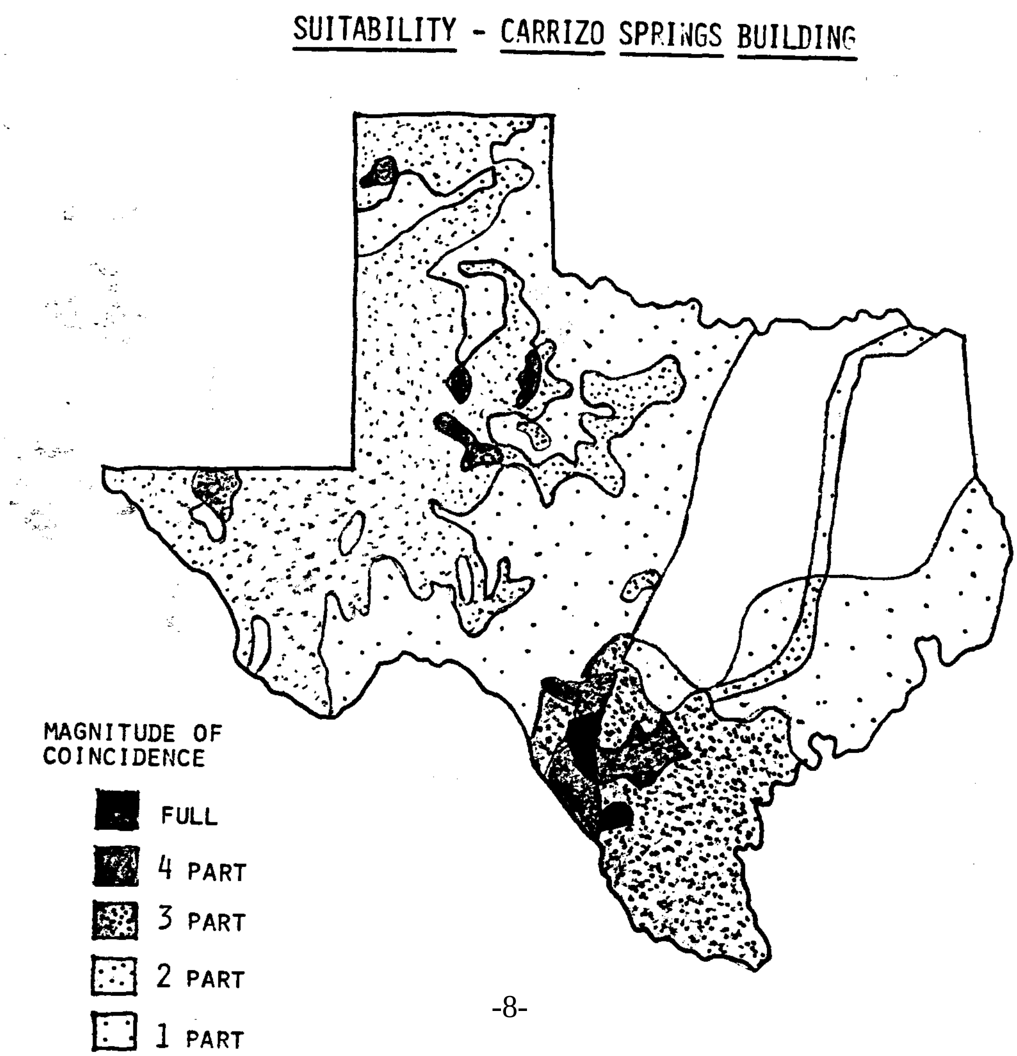
The two charts that follow, the first showing wall units and the next foundation, compare one indigenous building system with a conventional one in terms of initial energy cost, labor and operating cost. Please read the conclusion under the comments that follow.

The sophistication of indigenous construction methods come through when we compare the work accomplished (in terms of energy or structural stress) to the amount of energy put into the process in order to accomplish this task. We will use a structural example. Within our calculations, we found bamboo takes approximately 170 times less energy to produce than its equivalent steel reinforcing bar. If we can assume a life expectancy of 50 years (for which there is good reason to believe) if all fabrication methods are followed, we can expect the bamboo will take about 28,000 p.s.i. in tension. Our cantilevered lintels as well as our roof trusses are both under tension. Compared to common steel at about 20,000 p.s.i. tension, we have a material in bamboo which supplies a higher structural capacity by 40% using 172 times less energy! Other similar comparisons could be made, for example, in a wall's ability to store heat or cold, depending on your purpose, for a given season. The caliche walls are energetically better since they contain more heat capacity than conventional walls with only 25% the energy cost for fabrication.

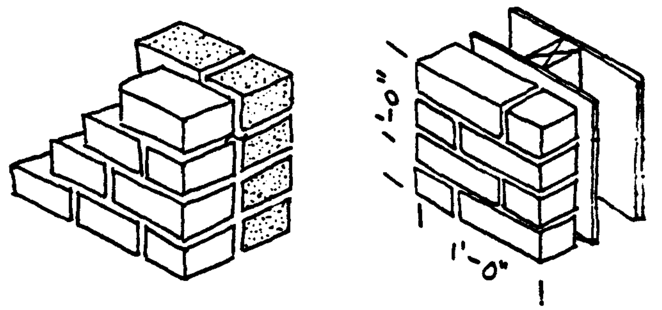
Our building form is a natural outcome of an adaptive effort for a species (in this case, homo sapiens) to learn better and better survival tactics. Energy use is one major criterion for natural selection. The more efficient a species can live given certain resources, the more likely it is for that species to continue on a survival path. In fact, it has been shown that those species who are able to allocate considerable energy for the purpose of valuable information storage in order to project this information to their young are the most survival worthy.

I wonder if it can also be demonstrated whether those species that are able to expand energy in their variety generation of alternative options for survival might not have the longest survival worthiness of all; A variety generator (called research at many levels) that does not make believe the future always is so predictable and that working options could be the best way for us to prepare.

The map below indicates where this building form is spatially applicable in Texas. It also might indicate a new way of organizing how we approach the built environment, whatever it is, in the same way that a plant taxonomist records the location of indigenous plant species. Just think if we could develop, as was achieved centuries ago, building forms that had some of the lasting powers of the plants around us.



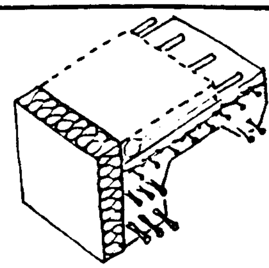
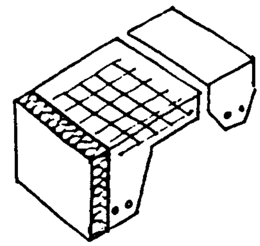
TOTAL WALL COMPOSITION	INDIGENOUS WALL	CONVENTIONAL WALL	COMMENTS



ENERGY COST			
-MASONRY	POZZOLAN CALCRETE BRICK 2,279.8 BTU/FT^2 WALL	FIRED BRICK 105,004 BTU/FT^2 WALL	INDIGENOUS 46 TIMES LESS ENERGY INTENSIVE THAN CONVENTIONAL
-INSULATION	MESQUITE SAWDUST BLOCK 11,217 BTU/FT^2	4" INSULATION 8,345 BTU/FT^2	INDIGENOUS 1.3 TIMES MORE ENERGY INTENSIVE THAN CONVENTIONAL
-OTHER (WOOD, PAINT, BUILDING PAPER, GYPSUM)	(EXTERIOR LATEX PAINT SHOULD BE INCLUDED)	OTHER WALL MATERIALS 34,699 BTU/FT^2	INDIGENOUS REQUIRES NO OTHER WALL MATERIALS
	TOTAL COST INDIGENOUS: 13,496.8 BTU/FT^2	TOTAL COST CONVENTIONAL: 148,048 BTU/FT^2	INDIGENOUS WALL TEN TIMES LESS ENERGY INTENSIVE OVER ALL THAN CONVENTIONAL WALL

LABOR TIME			
-MASONRY	POZZOLAN CALCRETE BRICK .28 H/FT^2	FIRED BRICK .16 H/FT^2	INDIGENOUS CREATES TWICE AS MANY JOBS AS CONVENTIONAL
-INSULATION	MESQUITE SAWDUST BLOCK .28 H/FT^2	4" INSULATION .013 H/FT^2	INDIGENOUS CREATES 21 TIMES AS MANY JOBS AS CONVENTIONAL
-OTHER (WOOD, PAINT, BUILDING PAPER, GYPSUM)		OTHER WALL MATERIALS .051 H/FT^2	
	TOTAL LABOR TIME: .56 H/FT^2 WALL	TOTAL LABOR TIME: .224 H/FT^2 WALL	INDIGENOUS CREATES 2.5 TIMES AS MANY JOBS OVERALL AS CONVENTIONA

OPERATING COST			
-COMPLETE INSULATED WALL	POZZOLAN CALCRETE BRICK W/MESQUITE SAWDUST INSUL. 1418.3 BTU/FT^2	CONVENTIONAL FIRED BRICK WALL W/4" INSUL. 2,870 BTU/FT^2	INDIGENOUS COSTS HALF AS MUCH TO OPERATE OVER-ALL AS conventional

BASIC FOUNDATION EXCLUDING RADIANT FLOOR	INDIGENOUS FOUNDATION	CONVENTIONAL FOUNDATION	COMMENTS
			
ENERGY COST			
-MASONRY	*POZZOLAN CALCRETE 43,797 BTU/FT^2 BLDG.	*CONCRETE 88,935 BTU/FT^2	INDIGENOUS TWO TIMES LESS ENER INTENSIVE THAN CONCRETE
-REINFORCING BAR	*BAMBOO 680.9 BTU/FT^2 BLDG.	*STEEL RE-BAR 8,772 BTU/FT^2 18,865 MESH 27,637 116,572 TOTAL	INDIGENOUS REIN FORCING BAR 17 TIMES LESS ENER INTENSIVE THAN STEEL
LABOR TIME			
-MASONRY	POZZOLAN CALCRETE .16 H/FT^2 BLDG.	CONCRETE .04 H/FT^2 BLDG.	INDIGENOUS 4 TIMES NUMBER OF JOBS
-REINFORCING BAR	BAMBOO 1.55 H/FT^2 BLDG.	STEEL .74 H/FT^2 BLDG.	BAMBOO REINFOR-CING GIVES 2.1 TIMES NUMBER OF LOCAL JOBS. EACH 850 FT^2 GIVES 86 H MORE WORK OFF BUILDING CONSTRUCTION SITE
MONETARY COST			
-MASONRY	POZZOLAN CALCRETE $1.45/FT^2 BLDG.	CONCRETE $1.74/FT^2 BLDG.	
-REINFORCING BAR	BAMBOO $1.58/FT^2 BLDG.	STEEL REBAR 73c/FT^2 BLDG.	

* INCLUDES ENERGY FOR LABOR

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Adobe

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