SUSTAINABILITY IN A SUBTROPICAL CLIMATE

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ABSTRACT

The author purchased 5 acres of land on the Bayou Teché in south Louisiana some 22 years ago. The property was over grown with vegetation and contained dump sites from many years of neglect and abuse. This allowed for the purchase of the property at a lower price, and the opportunity to follow the advice of architect friend Malcolm Wells - "buy an ugly piece of property and make it beautiful, while usually we do just the opposite" [1].

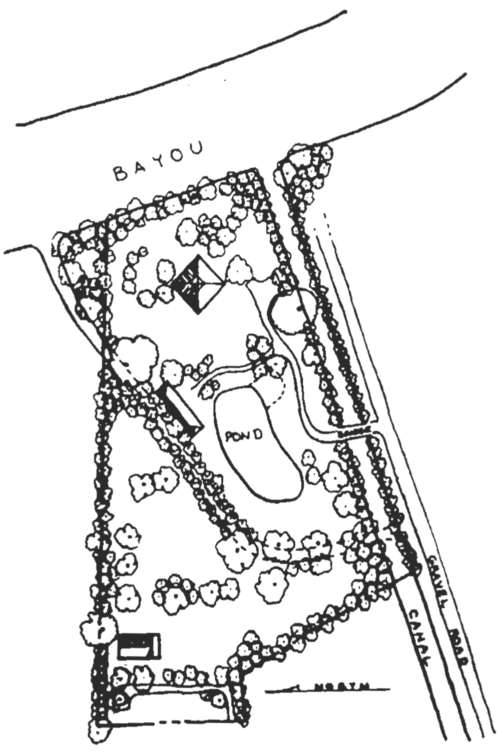

Fig. 1. House Site.

An old house, doomed for destruction, was purchased and moved to the property. After a year of part-time renovation the author and his family moved into the structure. For the next 17 years, time was spent cleaning up and selectively clearing the property. Also during this time research on local vernacular architecture and sustainability continued along with the collecting of materials to be recycled into the design of a new home.

About 5 years ago the design was finalized, the property was cleaned up, and construction started on a new house. Construction, on a part-time basis, lasted for the next 4 years. Some of the major considerations for human comfort were shading, ventilation, and thermal grounding along with concerns for infiltration, insulation and solar radiation. Sustainability considerations were energy efficient design, local materials, recycled materials, indoor air quality, and Feng Shui.

RESEARCH

With an interest in building an appropriate home for the hot-humid climate of south Louisiana, the author investigated the vernacular home designs of native Americans and early French colonist of this area [2]. This was to act as a springboard or a foundation to provide human comfort. Both native Americans and French colonist had to design and build to combat the natural climate for comfort without the convenience of any kind of mechanical equipment.

The Mississippian Mound Builders who inhabited this area were the oldest culture on this continent. There is documentation showing that they were in Louisiana at least some 1500 years bc, and were in existence when French colonists starting settling the Mississippi River valley. These earliest people, before the bow and arrow was invented, built pit houses - merely a hole in the ground covered by a steep thatched roof. They understood the thermal comfort of being surrounded by earth. Later when they started building above ground, they brought the earth up with them in the form of wattle and daub.

The French colonist who first started settling in south Louisiana built the same type of architecture they had built for many generations in France. However, this design for a colder climate did not work in hot-humid south Louisiana This architecture went through a climatic adaptation to provide human comfort [3]. Here lies tremendous insight as how to build appropriate architecture for this area.

HOUSE DESCRIPTION

The house is square with the corner points oriented to the cardinal directions. The house is shaped like a chimney with a mechanical core at the center which extends up to a cupola at the apex of the roof. The wood frame structure sits on an underfloor (crawl space) plenum. The knee walls of the plenum are used or seconds of 8"X8"X16" concrete block stacked four high. They are tied to a continuous spread footing with a reinforced bond beam with reinforced cores at 4'o.c. and all other cores filled with insulation. The exterior of the block was waterproofed. Polystyrene rigid insulation, recycled from insulated metal door cutouts, were placed horizontally on the ground tapering out about 8' from the knee wall. This was backfilled to 8" from the exterior siding with a good slope away from the home in all directions. (The sheet metal removed from the door cutouts was used as termite shields.)

A large double pitched hip roof extends 3' beyond the exterior walls and porches. The rafter ends are exposed and shaped away form the edge in the French colonial style. The center 40' square has a much steeper pitched roof. It is layered with insulation (sprinkled with borax), two vented air spaces and a radiant barrier. The interior surface of this roof (cathedral ceiling) is wrapped with an air barrier and finished with a v-grove cypress channel rustic. It has a very light white pickle to help reflect the daylight down from the cupola.

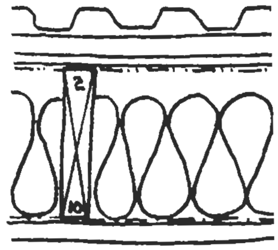

Fig. 2. Roof Section

The outer 8' from the center 40' square is covered with a lower slope lean-to roof typical of the early 18th century French colonial style. The beams supporting the porch roof are connected in a Z-scarf joint typical of this same era.

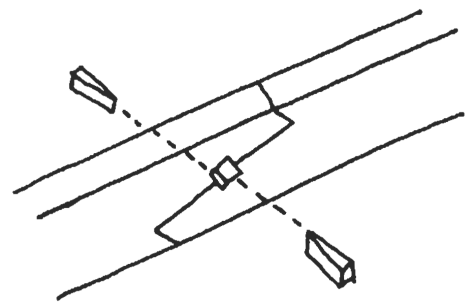

Fig. 3. Z-Scarf Joint in Beam.

A 7' square cupola caps the roof. The copula has two 2' square windows on each side. The windows on the SE and SW sides are casement, and NE and NW sides are awnings creating a negative pressure at all 8 windows when the prevailing breezes from the Gulf are predominate from spring through fall. The cupola windows, which are located at the 3rd floor level, are motorized for ease of operation from the 1st floor. A dormer is placed on both the NE and NW side of the roof to aid in exhausting air from the house. The author calls it "*suculation*" [4] - provide openings high in the structure on the leeward side creating a negative pressure on the interior. The cooler air is brought in as low as possible. The large verandah to the SE and SW is designed to scoop the southern breezes. Casement and awning windows throughout the house allow for a variety of air circulation options.

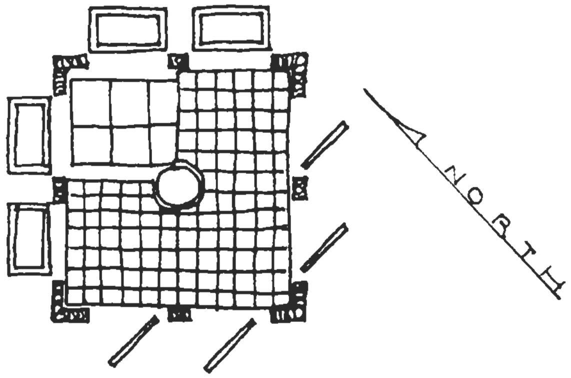

Fig. 4. Cupola Plan-Windows.

A continuous louvered vent encircles the cupola between the bottom of the windows and the roof. This ventilates two air spaces in the roof with air intake as low as possible at the roof eaves. The eaves have no gutters. Instead, brick gutters are located on the ground along the drip edge. All bricks are recycled old brick.

The exterior walls are sheathed with a 1/2" rigid R-board and the 2X6 stud cavity filled with blown cellulose. All exterior corner post and wall T's are designed to accommodate more blown insulation. Below the floor, cellulose insulation is also blown between the joist above the knee wall and about 3" thick on the interior face of the block wall.

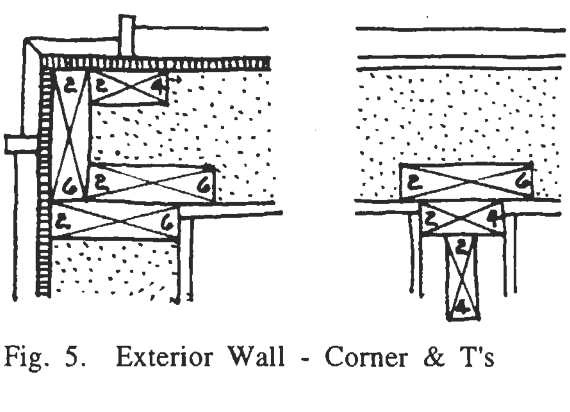

Fig. 5. Exterior Wall - Corner & T's

Steel bar-joist were placed on top of the bond beam being welded to steel anchor plates the author made with recycled scrap plates. Recycled metal building siding and roofing was welded down to the top of the bar-joist along with a 3"X3" steel angle around the perimeter. A 3" concrete slab was poured with some small rebar reinforcing, but no mesh. Wood blockouts were placed along the exterior of the slab for floor vents at each window and a few other locations. A hard steel trowel finish was used, the concrete scored and an acid etch stain applied and sealed.

The two major walls in the great room, one to each side of the heat-circulating fireplace, are of *bousillage* construction - the 17th & 18th century French colonial wall construction of a *colombage* (half-timber) frame being infilled with a mixture of mud (heavy clay content) and retted Spanish moss. It is made into little loafs called *tauchés* and laid over a lattice of wood sticks called *batonniérs*. The face of the walls are smoothed over, by hand, and left exposed and unsealed to act as a desiccant when the air is too humid. It has a wonderful hand finished look and the natural color is a reddish-brown. The dirt for the *bousillage* was recycled from the hole that was dug for the septic tank. The *colombage* frame of recycled cypress is also left exposed. Typically the colonist would have plastered over the *bousillage* and the frame. Even the poorest settlers would have white-washed the wall as a finish.

Most of the wood interior finishes and cabinets are recycled old cypress. All paint used on the interior contains no volatile organic compounds. All interior ironwork and center exposed structural frame are recycled metal. Some of the recycled ironwork is hand forged by the author.

Because of the large overhang and porches, close attention was paid to tying the structure down due to possible hurricane winds of this area.

SEPTIC SYSTEM

Septic systems in this rural area are required to be motorized tanks. This pumps air into the tank for aerobic bacteria to breakdown the solids, and provide effluent that is supposedly 90% pure and allowed in streams and lakes. This type system is required because the soils in this area are heavy clays and the typical leaching field or absorption trenches do not work to percolate the effluent back into the soil.

An extensive leaching field was constructed for the first house that was moved to the site. It was twice the size required for a family our size. It worked fine for 10 years. After that we had problems, especially during the winter with shorter days and less sunlight.

For the new house a wetlands type system was used that required no energy to run. A large three compartment septic tank overflows into a trench 4' wide by 1.5' deep by 80' long. The trench is lined with a heavy plastic pool liner. The trench is filled with large, 1.5" to 3" diameter, rocks. The effluent is introduced at one end and an overflow at the other end that keeps the water a few inches below the top of the rock bed. A variety of water succulent plants are grown in the rock bed to disperse the liquid through evapotransporation. It also provides a beautiful, colorful rock/water garden.

THERMAL COMFORT

The mass floor is used for radiant cooling and heating for human comfort. The floor is tempered by passing cool or warm air below it in the plenum. A plenum is also created overhead by lowering the hallway ceiling. From this overhead plenum, a triangular shaft that encloses the fireplace flue extends up to the floor of the cupola. The floor of the copula is an open aluminum grate (recycled) allowing air movement and light to pass.

The geothermal heat pump is located in the center of the house just behind the fireplace. The HVAC system room also contains the water heater. A heat exchanger in the heat pump provides hot water to the water heater during the air conditioning cycle with waste heat. The mechanical room is a return air room that has controlled openings to both the overhead plenum and underfloor plenum. A short run of duct work from the heat pump connects to both plenums. With simple flaps, either plenum can be used to return or supply air to the house.

During the short winter, wood is burned for heating. Warm air from the top of the cathedral ceiling is pulled down with the fan from the HVAC unit. This fan is set at a low speed and runs constantly. The warm air moves form the center of the floor plenum to the exterior walls and enters the rooms from holes in the floor by each window. The slow movement of air transfers most of the heat to the mass floor and some to the exposed ground in the plenum. The ground is covered with a vapor barrier.

As the winter wanes and the weather warms, the outside air is brought in during the middle of the day to warm the floor and the house is closed for the cold nights. When the days become hot and the nights cool, the home uses the outside night air to cool the mass floor and the house is closed during the warmer days. During this time of the year the air movement in the two plenums are reversed. Cooler night air is returned through the floor plenum and pushed up to the copula where it ventilates back to the exterior. This process is reversed in the fall. The house can be opened to just ventilate(suculate) for long periods during the spring and fall. At some point during the summer the air

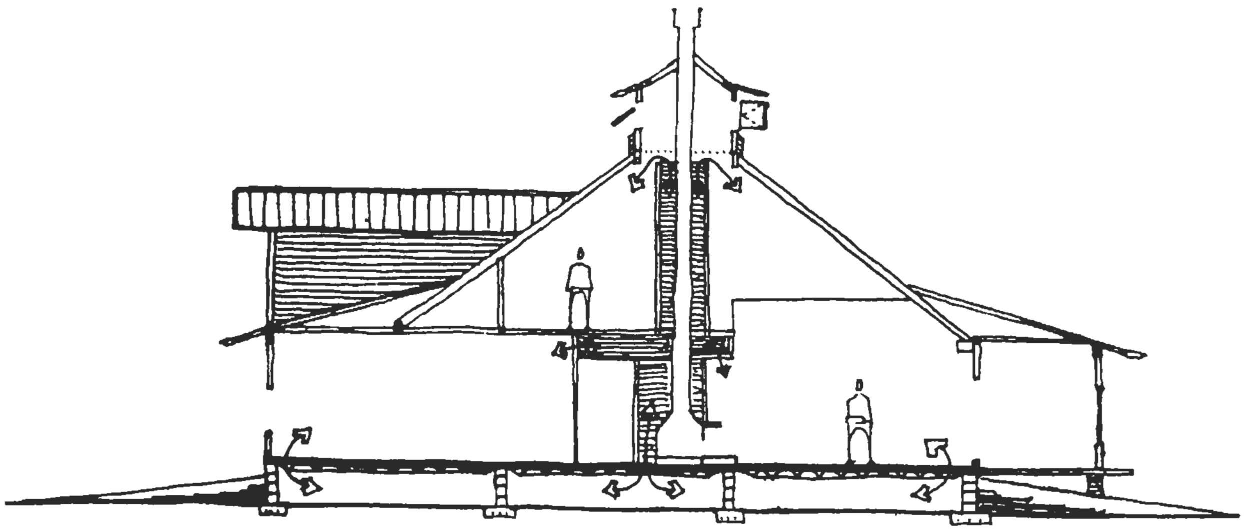

Fig. 6. House Section

becomes too humid to bring in - it reaches 100% relative humidity almost every night. The house is closed at this time and the air conditioning used mainly for dehumidification.

The design of the plenum and the horizontal exterior ground insulation is for thermal grounding. It is designed to bring the constant underground temperature closer to the ground surface in the underfloor plenum. The constant ground temperature in this area is 69°F at 30' below ground. However, the normal ground temperature at 15' below the surface of the ground is warmer than this in the winter and cooler in the summer. This is due to the thermal lag of the mass of the earth.

CONCLUSION

The all electric house has been lived in for all seasons now and performs well. The radiant thermal comfort is much more enjoyable than that of heating and cooling with air. Table 1 shows that the home uses less than half the energy used by the local utility company's all electric high end energy homes.

	Bronze Design	Silver Design	Gold Design	Author's Design
KWH	.96	.94	.89	.47

Table 1. Energy use per sq. ft. per month with one person at home.

Month	Conditioning
FEB	Open
MAR	Open
APR	Open
MAY	Open
JUN	Air Condition
JUL	Air Condition
AUG	Air Condition
SEP	Open
OCT	Open
NOV	Open
DEC	Wood Heat
JAN	Wood Heat

Table 2. Human Comfort Mode

Historically we have been told not to use mass in hot-humid climates. However, historically that is just what the native Americans and the French colonist of this area did. Building with mass seems to work well if it can be tempered naturally and with minimum energy use.

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