## *Earth Materials*

*Fired*

In the section on “Playing With Fire” there are kiln ideas that could produce bricks and tiles. Some of these could be produced one or a few at a time incidental to cooking meals or heating homes – without requiring any additional energy. Consider creating specialized blocks with a slight radius of about 5 feet. These could serve to make fairly earthquake-resistant cisterns. A cistern 8 feet in diameter by 8 feet deep would be able to store 3008 gallons, or 11,386 liters.

*Civilization*

The use of earth-materials (mud, brick, and cement) unavoidably defines a permanent lifestyle. Such structures have survived in use for centuries, and indeed, they are he only structural survivors of ancient civilizations. Ironically, these materials are by far the most abundant, and serve some of the poorest of populations. One drawback is that you don't want to be caught dead under such materials during earthquakes.

Of all the commodities, this single element will have the most far reaching effect. If certain things are not established and maintained at the beginning stages, the potential of building locally sustainable community is forever lost. It is time to design the future.

In much of Latin America, it is a standard practice to use the walls separating the lots as walls of the homes themselves. The walls are impervious to sound, and give the home a very solid and gracious feel. The eight-to-ten foot walls bounding the back yard provide complete privacy, and survive for generations.

If applied in the USA, it would consolidate the 5-foot-wide “burglar-access” strips on the sides, and the front yard setbacks commonly required in the United States. These spaces would become part of one big yard for the private use and enjoyment of the resident.

The massive front door opening on the sidewalk itself completes the sense of security. This single portal to the outside world would have two sections and open to a patio entry area. The smaller section would be for people, and the other side – normally latched – would allow the passage of a vehicle. When both were open inviting access could be provided to a home-based business.

Homes may be of modest size, but very comfortable and convenient. Because of these structural principles, there would be very little external difference between the homes of the poor and the wealthy. Internally however, they may live in very different worlds.

The village must be designed ahead of time so that the number of residences would never exceed a pre-set level. The surrounding agricultural land must also be established, and never be encroached upon for development. There are numerous other features that must also be considered.

The carrying capacity of the land should be adequate to serve the maximum population of the village under the worst of climatic conditions. Beyond this, reserve capacity should be added for:

- Emergency aid to others
- Failed crop experiments
- Park and recreation areas

- Planned transportation corridors
- Agriculture-related features such as processing sheds, paths, and water systems
- Future recycling and waste-processing facilities
- Trees and other crops for energy and petrochemical replacement
- Garden space for those receiving welfare benefits
- Anticipated animal husbandry operations

Within the village itself, adequate space must be reserved for:

- Transportation terminal
- Retail
- Light industry
- Community meeting, dining, and entertainment
- Utility production and distribution
- Research and education

The most ancient and standard earth material (besides caves and excavations) is dried mud blocks. These only survive if they are coated with plaster to keep them from washing away during rain storms. Alternatively, they can be fired as bricks to last for the duration.

In relatively recent times “rammed earth” has come into use. This material uses earth with just enough water to clump it together, with just enough cement (typically about 10%) to hold it together in wet weather. The mixture is forced into forms with significant pressure. I have made rammed earth components by using a three-pound sledge hammer to literally beat it into place.

A kiln can be used to drive the water molecules out of things like limestone and bones, which can then be ground up to make cements and plasters.

*An Earthen Saga*

Sometimes when I feel I have too many problems to solve all at one time, I attempt the mental exercise of developing solutions that will meet more than one need.

A few years ago I dug out an extra room in the basement. After dealing with the hernia I had received from pushing dirt-laden wheelbarrows up a stairway (for real), and giving away what I could, I still had this huge pile of dirt that now needed to be moved somewhere else.

I envisioned building it into terraces, but not being able to afford a mountain of railroad ties at the time, I had to keep thinking. I came up with a chicken-wire bag lined with plastic. The chicken wire would hold the tension and the plastic would hold the earth.

I have found it extremely important to commit ideas to experiment, no matter how confident you may be that they will work. The principle being that if you don't, you can wind up kidding yourself about having solutions that are non-functional, and thereby build a false sense of security. I remember disagreeing with an old man about the merits of a rope I was planning to use for a particularly dangerous application; His response was "That's a great rope – till you pull on it." Never wait to experiment until you can't afford to lose.

Anyway, I was sure that the wire would be strong enough in this application, and was right, but I had overlooked the structure of the mesh. After having built a twelve-foot diameter by three-foot high enclosure of chicken wire, lined it with plastic, and having filled it with earth, I had the weary satisfaction of a tough job well done -- until it started growing.

The problem was that the hexagons that make up the chicken wire have points that run the long axis of the wire. If you pull on two opposing corners of a hexagon that is free to collapse, you will extend it to 150% of its original length while decreasing its' width to zero. This is exactly what was beginning to happen to my terrace. Pressure from the dirt was free to stretch the perimeter while lowering its' height, and soon I had the same tonnage of earth to manage all over again -- only this time it was mixed with

chicken wire and plastic.

Failures tend to make one philosophical, and this is not really without merit. It's healthy to occasionally lift your vision above the cobblestones of life and remind yourself of where the road leads. I maintain that I have never had an experiment that failed. If an experiment does not go the way I expected it to, then its' value is actually enhanced. It has provided information that would otherwise have been overlooked, and that is what experiments are for. The corollary to this however, is that when you desperately need a solution, don't experiment. It is for this reason, by the way, that any of the projects described here that you might anticipate really needing, should be constructed and experienced before such a need arises. They all worked for me of course, but I can make anything work--except chicken wire.

So back to the chicken wire. If you pull evenly on the opposite sides (as opposed to points) of a hexagon, it will stop stretching when it becomes a rectangle that is as wide as one of the sides and twice as long. This amounts to narrowing a network of hexagons by 50% and lengthening it by less than thirty percent. So, I tried a less ambitious experiment by cutting a couple of short lengths of chicken wire to about 30% longer than the desired finished height of the "tank", and wiring them together along the edges. I also pre-stretched the wire to minimize the amount of adjusting that would take place after it was filled with earth.

I made several structures about 5 feet high by about 2 feet in diameter. The structures were stable, as far as earth containment was concerned, but they were dangerous in that they tended to tip over easily, and weighed over 1000 lbs apiece.

A major refinement I would suggest at this point is that you don't make this type of structure more than 50% taller than it's diameter. I would also suggest that you don't use clear polyethylene for the plastic, because within a few months the sun will deteriorate the plastic and leave you with bare chicken wire trying to contain earth. I know you'd believe it if I told you how I found this out.

One other technique which I read about but never tried (here we go again), was the development of terraces from earth-filled tires. I saw some pictures where each course was set back half-way from the layer before it. The exposed earth was planted with nice weeds and things so that the whole effect was that of an exceptionally beautiful pile of trash.

As far as applications go, wires and tires are cheap ways to build terraces. Although the circular format of the wire limits its' use in a downtown city lot, I can see it as being a handy technology for a homestead of even very limited acreage. Here are a few ideas:

1. Build a wind-break just north of your house.
2. Use as a structural member for a primitive shelter, root cellar, greenhouse, or barn.
3. Build a graduated series of rows that optimize exposure to the south, for planting a terraced garden.
4. Use up excess dirt left over from digging out your basement.

By-the-way, do you happen to know anybody who needs some dirt?

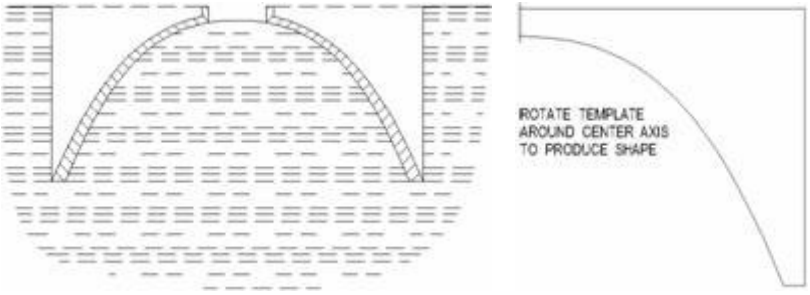
### *Underground*

I've given a little thought to underground structures. Basically, they are very stable temperature wise, and they leave more of the surface available for growing things. I considered making a parabolic shape and using heliostats (see "Energy Tree") to blast sunlight in through the top. You would be able to have a tropical garden underground in the severest of winters. I was thinking I could grow the largest avocado orchard in the state of Colorado – assuming one tree would do it.

One down side some people have experienced in underground homes is in dealing with humidity. So seal things carefully from both above and below, and have a good supply of external air available.

If I were to attempt an underground structure, rather than dig all the way down and then set up forms for the concrete, I'd sculpt a parabolic dome in the earth and use it as a form. I would leave a reinforced

opening at the top for access, so that the earth could be removed after the concrete was well set. I would also add an access at the outer edge a little later on.




There would be a number of advantages to such a technique.

- Most obvious is that forming would be simplified – although cement would have to be applied as a coating, rather than poured.
- The outside of the shell would be backfilled as you dug out the center of the dome.
- If you didn't mind having a raised terrace, you could have the insulating advantages of a subterranean structure without having to dig so deep. You could use earth removed from the perimeter to build part of the parabolic form above the original grade. This portion of the shell would then be covered by earth removed from the center to develop the terrace. Such an arrangement would place the perimeter access closer to the original grade.
- A parabolic shell would have a very high strength for the amount of materials. Think "egg."
- Properly engineered, the dome could later be expanded from the inside by excavating and casting support pillars to greater depths. Such structures would of course follow the ever-widening curve of the original parabola, and then be connected by a surface shell. Since the concrete would be leaning inward in this case, internal forms would be required.