Rural Economic Development through Building Energy Efficient Houses for Under $3,000

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Abstract

This paper looks into creating community-based economic development through materials development and building small energy-efficient housing for the rural areas of the Eastern Province of South Africa. This is a student exchange project between Tuskegee University and the University of Fort Hare, Republic of South Africa. With students and faculty visiting both campuses researching materials developing the design and finally assisting in building the demonstration house in Alice.

In 2002, Tuskegee University and the University of Fort Hare were awarded a USAID, ALO grant to provide training in building low-cost energy-efficient housing to provide healthier living conditions in the rural areas of South Africa, which are suffering a severe shortage of affordable, clean, warm, and durable housing. It has been demonstrated that not having clean and vermin-proof housing and safe water are the major contributing factors to the very short life expectancy in developing countries. The intent is to develop a program using the approximately $3,000 South African Government housing grant to create a viable grassroots industry in small-scale building and backyard manufacturing in depressed rural communities while providing appropriate affordable comfortable housing. There are many reasons for this lack of suitable housing; these include lack of materials, lack of experience and skills to build the housing, lack of appropriate and suitable designs, and lack of funds to build the normal modern house.

The housing goal of this project is primarily to develop more appropriate housing and materials that meet the current needs of the people and then to train designers and workmen in the skills necessary to make the materials and to build the housing.

This project has several phases. The first is to build on the base of existing methods and materials and to develop building uses for currently unused and underutilized materials (such as, but not limited to, using coal ash to build lightweight insulated building blocks and more effective and durable application of the indigenous mud construction) and to design a small energy-efficient house that is acceptable to the intended user. The second phase is to develop and dem-

onstrate the use of transferable skills (small-scale building, backyard manufacturing, and entrepreneurship) in using these techniques to build appropriate affordable and durable housing (this paper).

Introduction

This paper will first give a little background on the country and the housing problem being addressed. It will then discuss an alternative community-based housing proposal, which not only provides energy-efficient healthy housing for those who now live in the informal villages but also has the side effect of providing a steady source of income and local employment.

The idea behind this project is to use the R21,000 (US$3,000) South Africa housing subsidy to provide a job and income source to the local community. Typically, developers use standard, readily available materials and skilled workers build the homes that qualify for this subsidy, a very sound business plan that, when operating efficiently, produces the lowest cost house. This business plan, however, means that any economic benefit from the development, other than the actual housing, goes elsewhere. The idea behind this project is to develop a way for some of the economic benefit to stay in the local community.

A basic economic principle is that income from sources outside the community has a multiplying effect when the income is spent in the local community for goods and services needed by the people with the income. The typical rule of thumb for export income[1] is for every actual dollar spent in the community, the community receives four dollars of economic benefit. This economic gain is the result of the money circulating through the community to provide the goods and services needed to provide the export product.[2] This is why countries always want more exports than imports and the ratio of exports to imports is one of the measures of determining the health of a nation's economy. This formula works whether the situation is a country exporting goods abroad or a community selling goods to the community down the road. The underlying idea for this project is to maximize economic benefits for the community by keeping as much of the subsidy in the community through the community providing as much of the labor and materials needed to build the house.

To gain maximum benefit for the community, the export income needs to continue over an extended time. Even if most of the labor and materials come from the community, the typical housing development---where all the housing is built in a short time---does not serve as real economic development for the community; the project must last for years for it to have any long-term impact on the community. This project is an attempt to introduce into the housing equation the concept of using the construction of housing as a seed for viable development of a community. The model proposed is not for all subsidized housing projects, but rather for those located in the rural areas and the rural edges of urbanizing communities where the unemployment rate is high.

Therefore, the first goal is to develop appropriate housing that is passive solar, energy- efficient, comfortable, healthy, and durable, and that can be built out of locally made materials that meet the needs of the people. To be most effective the process must not require expensive machines,

supplies, large volumes, or specialized skills to work. This aspect is described in the paper *An Energy Efficient House for Under $3000*, also being presented at this conference.

The second project goal is to train the local community workers with the skills necessary to control and manage the project, locate the house, make the materials, and build the housing. This gives control of the construction process to the local community, making it possible for under-financed rural communities and small groups with limited skills to develop a viable economic base through making the major materials and constructing energy-efficient, comfortable, healthy dwellings.

Background

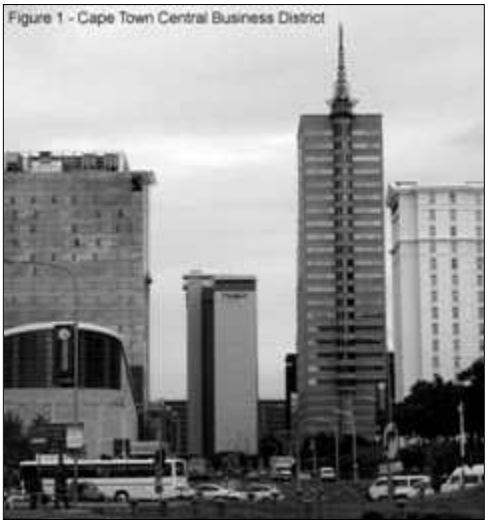


Figure 1 - Cape Town Central Business District

The Republic of South Africa, located on the extreme southern tip of the African Continent has a diverse and dramatic landscape, which ranges from mostly semi-arid highlands to subtropical costal areas. The country has a relativity mild climate in the project area, East London, where the temperature ranges in summer are 12-34C (54-93F) and in winter are 4-24C (38-76F).[3] The population is 42 million (52 percent are women) and 50 percent of the population lives in rural areas. Racially, blacks, at 77 percent, constitute the majority; whites (11 percent), coloureds (9 percent), Asians, and others makeup the rest.[4] Even though the country has a literacy rate of 80 percent, some 11.2 million women and 9.8 million men have little or no formal education at the secondary school level. The major languages spoken are English, Afrikaans, Zulu, and other tribal languages, with most educated persons fluent in two or more. The major religions are Christian (60 percent), Hindu (20 percent), and Islam (20 percent).[5]

"South Africa is the primary hub of Africa with the region's best transportation linkages, banking facilities, health facilities, communications infrastructure and trained personnel. It has one of Africa's most extensive manufacturing sectors, which includes motor manufactures, food processing, and production of textiles, cement, metal products, paper, and chemicals. Minerals, such as gold, diamonds, and processed aluminum, and various cash crops are South Africa's largest foreign exchange earners with tourism fast catching up as a major income earner. Although South Africa has one of the most vibrant economies in Africa, unemployment and underemployment are serious problems. Some 63% of all South Africans earn less than R1500 [US$200] per month with 45% earning less than R500 [US$70] per month."[6] (See Figure 1.)

During apartheid, the black majority was kept out of the viable economy, was provided with little schooling, and was not allowed to own land or housing until 1994. Typically in the urban areas the majority in this sector lived in hostels (barrack-type worker housing) or in informal towns, which sometimes had one or more water taps for thousands of residents. (See Figures 2 and 3.) Some lived in the black townships; Soweto, a suburb of Johannesburg, being the most

famous, has somewhat more substantial housing. Nelson Mandela's Soweto home, which appeared to be rather typical of Soweto, was a small brick house of about 50sm (525sf).

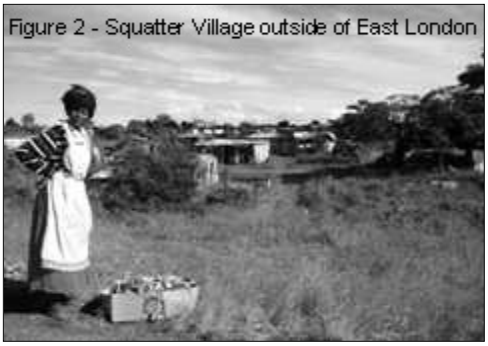


Figure 2 - Squatter Village outside of East London

One of the ANC government's important promises to the people was to build one million new homes under the Reconstruction and Development Program (RDP). In 2002, South Africa was facing a 2.2-million-unit shortfall in low-income housing[7]. The RDP houses are built by private industry using a government grant of about R16,000 (US$2,300)—not very much money to build a house when one also has to buy and develop the site, including the streets and utilities. It is not surprising, then, these entry-level houses are very small and unfinished, typically 30-35sm (310-370sf)---smaller than a double small-car garage. The houses typically have two rooms with minimal plumbing—a toilet, a sink, maybe a shower—with no heat or hot water (the climate varies, but in most locations the houses need some form of home heating.) The houses are built out of 8x8x16" cinder block with a shed tin roof lacking any energy or sound insulation, and with only two or three windows and a single door. The typical government house does not have heat or any insulation, nor is any thought given to free heating through passive solar techniques and orientation. Heating---when affordable---is achieved by burning coal in an open bucket filled with sand. (See Figures 3-6.).


Figure 3 - An early RDP Housing Project Outside of East London


Figure 4 - Interior RTP House in Bisho


Figure 6 - Typical Construction - 60 Meter House


Figure 5 - Room Heater burns coal

About 500,000 houses have been built and are mostly in urban areas. As would be expected with any major program, there are good and bad housing projects. In the better ones, one can see housing being well taken care of, with improvements and enlargements being made to the original house. RDP houses meet minimum standards; however, most significant, they come with tenureship, and are a quantum improvement over a squatter shacks constructed of discarded materials.

To qualify for the housing grant, now about R21,000, the house has to be the applicant's first house and the applicant's family needs to have an income between R800-2,500 (US$100-300) per month. The applicant can add other resources to the grant to build a more substantial house. It is beyond the scope of this program to provide housing for those below this base income. Also,

experience has shown that because it costs to maintain a house, providing a house that the owner cannot afford to maintain---which then deteriorates and become unusable, is a waste of the limited resources and is not economically viable for the country. An example of how limited the resources are for some families is the experience of providing household water taps; since 1994, of the three million low-income households that had water taps installed, 90 percent have been cut off because the family could not afford to pay the water bill.[8]


Figure 7 - Traditional Housing Near Alice.

Study Area Housing

The study area is in the Cape Province of South Africa near the town of East London. Traditionally in this region, variations of adobe construction have been used, ranging from mud brick construction to building a frame of branches and infilling with straw and mud with thatch roofs. (See Figures 7 and 8.) The traditional houses are loosely arranged small round structures with minimal openings; a separate building is erected for each use rather than constructing connected rooms. The newer structures are mostly small rectangle buildings similar to RDP housing, built of either concrete blocks or mud bricks with corrugated zinc roofing. A small number of octagonal blockhouses that mimic the traditional house exist in the villages. Corrugated zinc is the preferred roofing material even on the traditional round structures and it appears that the preferred housing type is a variation of the brick houses built by the European settlers.


Figure 8 - Building Showing a Traditional Form of Adobe Construction


Figure 9 - A New Housing Development - 60 Meter Houses


Figure 10 - Housing Association Condos - 45-60 Meter Units

The Eastern Cape Province has an active housing program building 40-square meter versions of the RDP houses. There are various housing developments in the province. The most interesting are “housing associations” or “cooperates” that are adding to the government subsidy to build larger improved housing, see Figures 9-11. These associations develop the land, put in streets and utilities, and build the houses for their members. The intended clients do not have a credit history (typical for most black and colored citizens emerging from apartheid) and cannot obtain a standard mortgage, so the houses are typically rented to the client for four years for the same rate as a mortgage would be. After four years, the client has a record of payments to present to the building society to show that they can handle a mortgage. The association then uses the mortgage payout to construct additional housing. In the suburban areas, the housing types are simple two-or-three bedroom, one-bath single-family houses; in the


Figure 11 - Living Room of House Shown In Figure 9

urban areas, townhouses and condominiums are typical. Fifty to sixty-five square meters appears to be the typical unit size for these projects.

Housing Construction to Serve as a Base for Community Economic Improvement

Because half of the population lives in rural areas and most of the subsidized housing is in the urban areas, this project was conceived to develop a small energy-efficient house for rural areas and the rural edges of the urbanizing areas and to use this to provide an economic base for further community development. This involves developing both a house and suitable building methods that meet the following guidelines:

- the house has to be acceptable to, usable by, and wanted by the intended user;
- it must make the most of the small amount of money available;
- it should use passive solar heating to eliminate the unhealthy indoor environment created by the burning of coal in un-vented open containers in the house for heating;
- it can be built using a modernized version of traditional building techniques and materials;
- building materials should be developed that are durable and can be readily made locally with minimal equipment, material purchase, and skill,
- the amount of material that must be purchased outside the immediate community is minimized so the government housing subsidy can provide economic development to the community;
- local community employment is increased through making the materials and construction of the housing;
- training is provided in small-scale business financing and management to empower the local community and entrepreneurially motivated individuals to successfully take control of the project or parts of the project; and
- community members are trained in material making and house construction using these materials

This is a lot to ask for. Currently the material is being researched and developed, and a 40sm (420sf) three-bedroom passive-solar house design using these materials is being presented to the proposed clients for their critique. Construction of the prototype house is scheduled to be underway when this paper is being presented. The development of the demonstration training programs and the actual training are scheduled for the next phase of the project.

The Materials

Our research indicates that an air-dried stabilized enriched mud brick with straw is the best choice. A non-stabilized mud brick has several problems---the major ones being absorption of moisture leading to eventual failure if not corrected and erosion from rain. The addition of a stabilizer to the mud mixture minimizes these problems and strengthens the brick. The choice between using asphalt emulsion, cement, or fly ash to stabilize the brick is largely a choice of economics—the cost of the material in the specific location. For the current project asphalt emulsion is the best choice.

The rest of the structure uses standard, easily available components—low-cost single-pane window units and door units and the ever-present corrugated zinc roofing. Plans for insulation have not yet been completed, though clearly some form of roof insulation is needed to assist in controlling the temperatures in all seasons and will be installed. Currently, a borax-treated straw appears to be the best roof-insulation choice for the first house. The borax is to control insects. Thatch roofs were the traditional roof and still exist. For climate and sound control, thatch is superior to a non-insulated tin roof.


Figure 12 - Current Mud Brick Construction


Figure 13 - Making Mud Bricks

Energy---Heating and Cooling the Structure

The house is being design to be a passive-solar structure with natural heating and cooling through design, material choice, shading, and ventilation, requiring little if any additional energy to moderate the temperature in both summer and winter conditions in the target locations. The use of the passive solar design of the house and the use of a modified traditional material for construction are the major factors that separate the housing in this project from other housing projects in South Africa.


Figure 14 - Improved Unvented Coal Room Heater

In South Africa, there is almost no effective passively heated and cooled housing for the low-income sector and what we have seen of the current attempts is not successful. In the low-cost housing subsidy, there is no budget to provide properly vented heating stoves; the normal way for the poor to heat their homes is by burning coal in an open. unvented sand-filled bucket, which is both very unhealthy and a fire hazard. An improved bucket burner has been developed; however, it still produces so many harmful gases that researchers find it hard to understand how anyone survives exposure to the toxic gases it produces. If the structure is improved to be less drafty, burning coal in such an unvented stove could be lethal. (See Figure 14).

The House

The house proposed is a forty-square-meter (425sf) variation of the now standard 30- to 40- meter low-cost house. The major differences from the standard RDP house are to make it a passive solar house and a more functional arrangement of the inside. (See Figures 15-18.) The house has all the elements of an efficient, attractive, and acceptable home—it's light filled and feels spacious, while still giving privacy to the occupants, which is not normal in this housing. One of the

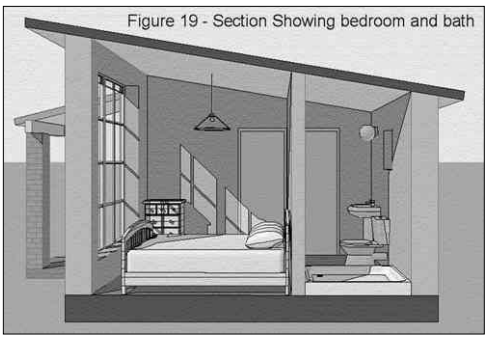
authors built houses with a similar floor plan that were very popular with the occupants in a South Pacific country.

The proposed house is slightly more expensive than a standard design due to the additional glass required by the passive design. Also, there may at first some be resistance to the larger windows on security grounds (improvements potentially conflicting with custom); traditionally the houses have a few tiny windows at most. There may also be operational problems should the occupants keep the shades closed during the day, as the sun must be able to heat the floor during the daytime for the passive design to work. The design is under review by the prospective clients and changes will be made to adapt the house to their needs and perceptions and still make the house work as a passive-solar structure.

The Building Process

The building of the house has a two-fold purpose. The first is to provide suitable, durable, passively solar-heated and cooled, affordable housing that is easy and affordable to maintain. The second purpose, possibly the more important, is to develop the processes and train local communities and individuals in the entrepreneurship skills necessary to develop small-scale community-based housing material manufacturing and construction. Therefore, all material development, housing design, and construction is focused on this goal, not necessarily on the more standard goal of providing the most housing for the least money.

After the prototype house has been constructed, the process will be evaluated as to how well the materials work, the house will be monitored to see how well it functions in moderating the temperature throughout the year, and clients will evaluate how well they like the design. Each of these aspects will be fine-tuned for production. The goal of this phase of the project is to set up a demonstration community-based system. For this to happen, many things have to come together; some are:



- community members must to believe that it is possible, so that the effort becomes theirs rather than that of the research team;
- training must be developed that gives the community members the financial, entrepreneurial, and management skills to manage and direct the process;

- techniques and training must be developed in how to test the soil to determine its suitability and what and how much stabilizer to add;
- trainees must learn how to make and dry the mud bricks;
- instruction must be given in passive solar design – orientation, location of windows, building mass, insulation, and operation of the building;
- workers must learn how to construct the buildings;
- follow-up support and training must be provided as needed.

For long-term effectiveness, the training must be to a large enough group that as members come and go the community knowledge base is retained and the project can continue. Once individuals are trained in the various steps, small independent businesses could be set up to do any part of the process, as happens in the typical construction business, and the homes built on an ongoing as-needed basis.

It appears that in the typical informal villages visited there presently exist small businesses supplying the various needs of the residences, including distributing building materials. This project aims to formalize that process and provide better-quality housing, building on existing economic infrastructure. For an individual to receive the government subsidy, the building has to be built on land to which the resident has some form of secure title. Secure land tenure is important for the success of any housing program.

Summary

A very important feature of this housing demonstration project is that it gives control of the construction process to the local community and makes it possible for underfinanced rural communities and small groups with limited skills to make the major materials needed to construct an energy efficient, comfortable, healthy dwellings. The money that would go outside of the immediate community to purchase the building components stays in the community, providing jobs for those who have none. The project also provides flexibility in that, if it is desired, the wall components—concrete blocks—could be purchased and filled to meet the required mass for the solar aspects of the house to work, thus providing a major improvement to the existing low-cost housing.

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[1] Any income that is earned from sources outside the community for services or goods provided can be classified as export income for the local community.

[2] This multiplying effect is valid only for the labor and goods that come from the community; it is reduced by any goods and services that the community imports.

[3] South Africa, Encarta, www.encarta.msm/encyclopedia_761557321/South_Africa.html

[4] South Africa Facts and Figures, Encarta, http;//Encarta.msn.com/fact_631504863/South_Africa.html

[5] Facts and Figures, Habitat for Humanity, www.habitat.org.za/facts

[6] About South Africa, Habitat for Humanity, www.habutat.org.za/aboutsa1.html

[7] US Department of State Fact Sheet, South Africa Housing Initiative: US Contribution, www.state.gov/g/oes/rls/fs/2002/17004pf.htm

[8] South Africa Housing Fiasco, www.socialisterna.org/rs eng/texts/sahousfi.htm