THE WORK ON EARTH STRUCTURES IN THE DOM. REP. PAST AND PRESENT

David S. Luther
Foundation for Community Development
(Fundacion para el Desarrollo Communitario)

ABSTRACT: With a brief introduction the history of earthen buildings in the Dom. Rep. is described, with its uses and problems, both structural and socio-economic.
The main text deals with the work of the Foundation in adobe and rammed earth structures. Described is the soil stabilization technique, innovative formwork, design, roof structure, preservation methods, etc. and finally the future of earth construction in the Dom. Rep.

The Dom. Rep., in actuality, does not have a broad history of earthen structures. The original inhabitants were the Arawak (or Taino) Indians who were rarely known to live in earth houses basically because the island was so lush in vegetation. They had no need to use earth as a building material since there was always wood available. The island also had a high degree of rainfall which, according to the Spaniards, discouraged them from using earth since the rain tended to damage it. The Arawaks, in general, built their dwellings of wood and palm leaves.

TEJA - MANI

Around the middle to the end of the sixteenth century the Indians had all but disappeared creating thus a vacuum in the labor force. The French soon began to import African slaves to fill that shortage and at the same time importing their culture which still persists to date. At the same time, though much slower at first then accelerating rapidly in the last century and still more in this, the country was being deforested creating thus whole regions of dry hot climate. It was through necessity then, that certain people, not having the wood that was once very common, turned to earth as a building material. This change was accelerated by the fact that earth was a traditional building material of the original Africans. The techique that grew out of this necessity to use earth is called " teja-mani" and is now used im all of the Southern arid regions of the Dom. Rep. and in almost all of Haiti.

The method of construction is similar to "waddle-and-daub" and "bajareque" of Central America. The construction process begins with standing posts, approx. one meter on center, that become the structure's columns. These are connected at the top by a wood tie beam. Between the posts a panel of a weave of strips of small size wood (almost the size of twigs) is placed and to this panel wet dirt is applied. Their criteria for selecting the soil has more to do with the color of it than with its resistance to weathering. Upon examination we have found it to be a white silt with between 10 to 20% clay, just enough so that it adheres to the weave. There are no stabilizers used of any sort and no preservation techniques so naturally maintenance is high, and the life span short The Foundation, that I represent, is working on ways to improve this system for future construction and on ways to rehabilitate existing structures.)

COLONIAL BUILDINGS

The other early example of earth construction in the Dom.Rep. are the buildings of the Spanish Colonial Era. During this period all the important structures were built of earth and lime, and although after the middle to the end of the seventeenth century it was rarely used, today it is becoming the focus of a lot of attention. It should be noted that not long after the Spanish occupation of the Dom. Rep., began that the seat of the Viceroy was moved to Havanna and the country was largely ignored. During this period this method of construction using earth fell into disuse and wood construction replaced it.

However, the fact that these structures have stood almost five centuries withstanding tremendous hurricanes and earthquakes has begun, as recently as ten years ago, to impress the Dominicans. Because of their general lack of familiarity with earth construction their receptivity to it has been poor. The recent attention given to the colonial buildings has done much to help sway the public opinion in favor of earth structures.

The term given to this method of construction is "tapia", and it basically is a composite of clay, rubble, lime and bricks loosely compacted into a wall of approximately one meter thick.

CINVA - RAM

Recently there have been several attempts to implement housing programs using the CINVA — RAM to make earth blocks, and many of them have failed due to several reasons. One of the reasons of which I will talk more of later is the cultural taboo associated with earth structures. Another has to do with hurricane San Zenon of 1930 which literally devastated Santo Domingo with over 10,000 deaths. Most of the buildings of the Capital City were made of wood with roofs of zinc sheets, and these were precisely the structures that suffered the most. As a result of it, Rafael Trujillo, who came to power one year before the hurricane (1929) and remained there for 32 more years, instilled the idea in the Dominican mentality that cement and concrete block were the only building materials that could resist high winds and therefore the only materials worth building with. This erroneus concept has been the most difficult obstacle to change that we have had to overcome. The concept is so ingrained that for the average Dominican to have a house of concrete block is a status symbol, a measure of his position in society. In other words, cement is synonymous with progress. To try to convince the average Dominican of the necessity of using alternate construction materials has not been easy, but the economic situation is such that the price of a bag of cement went up 33% the last time it was raised.

Another problem with a couple of the CINVA - RAM programs has been the lack of thorough training so that what happened in some cases where the earth walls were not made to be water resistant the rains caused considerable damage. This has created a serious credibility gap

Still yet another factor against earth construction has been the very color of the earth which in almost all cases has been red, the color of the most common clay on the island, laterite clay. According to the common misconception anything that is the color of dirt cannot have any structural value. (The obvious remedy in this situation is to finish the earth structure with lime or paint it thereby changing its color).

However, there have been several institutions successful in the past couple of years with the CINVA-RAM both of them on a small scale. One of them is the Institute for Development of the South (Instituto para el Desarrollo del Sur-INDESUR) which basically has worked at the leved of individual buildings, houses, schools, etc. Their program is very new and so it is difficult to assess its re-

sults as of yet. The other organization working with the CINVA-RAM now is a group of catholic priests in San Jose de Ocoa headed by Father Luis Quinn. They are constructing letrines, kitchens, sheds, etc. etc. with pressed earth block. The success of their program is due both to the receptivity of the population of San Jose de Ocoa, known traditionally to be very progressive, and to the dynamism of Father Quinn. As their structures are small and of minor importance their program has not yet really been put to the test. It will only be after they begin constructing larger buildings and living spaces that the full impact of what they are doing will be known. The success of their program, and really of any other program, will be measured more in terms of social acceptance than technical quality.

ADOBE

Adobe block construction has also been tried very little and when it has the results have been disastrous. On one well known occasion a housing program was tried in a region close to Haiti and rich in timber. This region is in the north where "teja mani" is not common. The result was that it was rejected because the houses resembled haitian houses, in that they were both made of earth, and the average Dominican rejects anything Haitian as being primitive and anti-progressive. Also the region, being rich in timber, had no demand for earth structures simply because wood was so readily available. Perhaps if the project had been located in a deforested region the results would have been more positive.

Several universities also have experimented with adobe block construction but never have the results been implemented in the field. This situation is very familiar in the Dom. Rep. Too much has been done under laboratory conditions and too little (if anything) has been done in the field. Presently, adobe block construction is not being used by any major group or organization, to my knowledge, except the Foundation for Community Development, which I represent.

THE WORK OF THE FOUNDATION FOR COMMUNITY DEVELOPMENT

The work of the Foundation is concentrated primarily in the western part of the country close to Haiti in two areas, one of which is in Las Matas de Farfan to the South central and the other is to the north in Loma de Cabrera. The whole frontier is an extremely depressed and largely ignored region. At each of the two locations we selected, we are building schools for organic farming and appropiate technology (Centro de Agricultura Organica y Tecnologia Apropiada para la Comunidad- CAOTACO).

The principal buildings at both centers are being built of rammed earth, which I will discuss further on; out the interior partitions, letrines, sheds, and other minor structures are being built of adobe blocks. At first our only intention in using two different systems of earth construction was to enrich our own experience and also to expose the people to at least two types of construction. As it turned out the experience served as a basis for comparison demostrating both the pros and cons of each system.

Based on this study we decided that any future extension work of the center would employ adobe or pressed earth block instead of rammed earth, of which we have more experience. The reason for this is that it resembles much more the method of construction of concrete block which is the most common and used everywhere in the Dom. Rep. We have found that rammed earth is too different from the systems used here and therefore it takes more time to train personnel. It also is easier to convince the people of the value of earth block construction than it is of rammed earth. As of yet there is only one extention project, that of a school in La Matas de Farfan, that we intend to built with earth block.

The center at Las Matas is in a semi-arid region. The people's reception here has been very positive because the system of construction of "teja-mani", that was described earlier, is common and wood is becoming difficult to obtain. In the year we have building the center we have detected no cultural problems that inhibit the acceptance of these earth structures, either rammed earth or pressed earth block.

The center in Loma de Cabrera is a different situation. As it is in a mountainous region rich with wood the people there have not yet accepted earth construction with the same zeal as in the South. Even though the cutting of trees for wood is against the law in the Dom. Rep., the inhabitants of that area do it constantly and use it to build their houses. We expected this; and though there probably will not be much extension building in the next six months, the goverment is becoming very strict with the anti-deforestation laws. This will obligate individuals, groups or organizations in that area to seek alternate building materials. Those who cannot afford the spiraling cost of cement, and there are many, will turn to earth structures.

RAMMED EARTH

The main buildings of both schools, six in each school or twelve in all, are being built of rammed earth. In neither case did we encounter problems in finding sufficient clay though both sources were found under the top soil. We selected clayey soils mainly because we found that was easier to add sand to clayey soils than it was clay to sandy soils. The proportions used were 3 parts clay, 3 parts sand, and 1 part lime. One of the basic ideas behind this project was that to design and build everything so that it would have a high degree of replicability in the field by the farmers. Immediately this made us discard cement as a stabilizer because of its cost, which at the frontier is about $5.00 a bag. Instead we used lime which is very common in almost all regions of the country. In Las Matas there is a lot of limestone, so we simply cooked it using a traditional technique taught to us by the inhabitants of that region. In this fashion we had an abundant supply of lime and at very reasonable prices. We found that although the 3:3:1 proportion was the guide,small variations did not considerably alter the quality of the construction.

What we were always careful to control was to add the correct amount of water to the mix,because if it were too dry it would not

compact well and too wet a mix created a mud. In the preparation of the mix we took great care to screen the clay, eliminating any balls of clay or gravel, them add the lime and wet it lightly. We found that by letting it sit for awhile the lime broke down the clay and thereby mixed with it better. After a day or so we added the required amound of sand, mixed it again and then again added water. At this state it was ready for compaction.

A good rule of thumb we established to help the workers determine the amount of mix they should compact at one time is that it should be about the height of a fist when they emptied it into the form. The height of a fist is about 4 inches which when compacted reduces to 2½ inches. The idea was to relate as many of the rules of thumb to elements they were familiar with such as a fist or as in another case we told the workers to raise the tamper to at least knee height before dropping it. In this case the rule of thumb was related to the knee which is something easily identifiable to them.

We found that the best type of tamper was one built of iron tube (6 ft. high and with and outside diameter of 2 in.) soldered at its base to an iron plate ½in. thick and 4 in. square. The 2in. diameter tube is optimun for long periods of time. If the weight of the tamper did not reach 20lbs. we would fill the handle with wet cement until it reached the desired weight.

At no time did we use any electric powered equipment such as air tampers or automatic mixing machines even though our work would have been easier because the intention in all cases was and is to enable even the poorest farmer to replicate what we were doing.

Our foundations were of cement and stone, using in both centers the abundance of field stone found on site. The soft terrain necessitated a strong foundation but in one experimental house built prior to the schools the rammed earth was set directly on a base of solid coral requiring thus no foundation. In effect the porous coral rock acted as the foundation for the house.

Our windows and doors were well braced using first a permanent frame of 1"x10" wood for the jambs and sill and a 2"x10" for the lintel. Inside this permanent frame was a temporary and reusable frame of heavier wood to prevent the collapsing of the 1"x10" 's. This bracing was essential as we discovered quickly that the ramming created tremendous pressure that on many occasion damaged not only the window and door frames but also the forms. The pressure also threw the window and door frames out of plumb.

FORMS

The forms we used to build the structures were totally our design and were determined by the system of construction we wanted. We decided that it would be best to ram a whole wall, from corner to corner, at one time thereby creating one whole monolithic section much stronger than if the wall were tamped in several parts. This decision was due in part to previous experience where we found that the only joint problems we had were vertical ones; and if the forms were short then the wall would have several vertical joints

between the tamped sections thus increasing the weakness of the wall. So we designed a form work system that was composed of sections that would fit together to create any length we wanted. In other words we designed a modular form system capable of creating any size space. This form can be put together so that it connects two corners of just about any distance from one another. At the same time it can subdivide the total wall or building into smaller spaces or rooms of any desired dimension by simply introducing a corner form at the desired location. From this corner form, in the shape of a "T", an interior wall, also of rammed earth, could begin.

Each full module is 90cms. (or three feet) long by 90cms. high and they are set 25cms. apart (or 10 inches") which is the thickness of the wall. A half module them is 45cms. (or 18 inches) long by 90cms. high. This creates a module of 18 inches and there are few activities not capable of being satisfied by multiples of such a small module.

There are several advantages to this type of system other than the fact that one can tamp a whole wall at the same time. One of these is that when one wall, from corner to corner, is finished one of the filled corner forms can be removed and located at the corner of a new wall and the rest of the forms can fill in the space between the two corners, one filled and one empty, thus creating a continuous system of forms. It is difficult to go wrong with such a system because it is versatile, and all the forms attach to one another. Another is that the individual modules are easy to handle because they are relatively small and light so that one can lift it up to the top of a wall two meters up.

The individual section along the same side of the wall are connected by metal hooks. The sections on different sides of the wall are held together at the top by an easily removable metal hook that prevents movement in either direction, and at the bottom by a metal rod that holds the forms together with the use of a nut that screw on one end of the road. The sections on one side of the wall are held in a straight line by guide bars.

The full height of the wall, to ceiling height, is achieved by tamping three rings around the structure. Considering that each form is 3ft. high and then subtracting a 4 in. overlap each time a form is placed over a previously built ring the total height of the wall when finished is approx. 8ft. In each of these three rings there are three layers of two strands each of barbed wire thus tying, horizontally, the whole building together.

ROOF

As the final ring is tamped reinforcing bars are set a foot down with one end sticking out at the top. The purpose of this is that the rebars hold the wood tie beam securely to the rammed earth wall. These rebars should not only hold the tie beam down but also should be spaced so that they coincide with the wood trusses or rafters thus tying those securely down also.

The center in Las Matas was built to have shed roofs because

we knew it is the easiest type of roof to build. Though all the buildings there are built and look good, we decided that the roofs in Loma de Cabrera should be gable roofs, because it was difficult for us to get beams the size and length we needed to cover the large spaces we had. In a gable roof one can use trusses that employ smaller sizes of wood and also easier to obtain. In a shed roof one wall has to be higher than the other, and in our case, because of the required slope of the roof, that wall was over 10 feet high, too high and therefore too unstable. In Loma de Cabrera we are using a gable roof with a ridge beam supported at certain intervals by double trusses; then down the ridge beam we have rafters tying into the wood tie beam atop the earth wall. We designed this system specifically to save wood.

The roof itself is made of sisal-cement sheets that we construct on site. The principal is very similar to the sheet of asbestos-cement but in our case the fiber is sisal, a readily available raw material in the Dom. Rep. The development of this roof is probably one of the greatest triumphs of our construction program because it can be made on site by the workers, is inexpensive, uses local materials, and is sufficiently strong to withstand the weight of any normal man.

WEATHERPROOFING — FINISH

There are several considerations to take into account with regard to the finish and weatherproofing of the buildings. One is that we knew that we could not leave the wall its natural color because it would be rejected by the people, and we also knew that if we applied any sort of weather proofing it would have to have an appealing finish and color to it. At first we tried treating the raw earth wall with liquid asphalt diluted with kerosene, but the result was not pleasing to the eye because the texture was rough and the color was black. There were other possibilities also such as using the sap from the plantain and other plants but these were not in sufficient quantity to warrant our recommendation for widespread use.

At one time we even liquid asphalt into the earth that we then rammed but for economy sake we rejected that method in favor of a surface weatherproofing that also served as a finish for the structure.

What we came up with something similar to that which the Spanish did to the colonial buildings that still stand today. They finished their structures with a combination of clay, sand and lime and considering everything it has weathered well. In our case, however, we used a mix of 6 parts sand, 3 parts lime and 1 part cement.

This finish is applied in the same fashion as any other finish using a float. Originally we tried to use a mix that did not have any cement in it, but we found that it did not adhere to the wall to our satisfaction. The final color and texture of the wall was pleasing. The resulting color was a light gray which we them either white washed with lime or painted with a water base paint. With a final coat of lime the buildings sparkled with a brilliant white.

We did several water tests to the finish and found that the mix that best resisted the force of a hose was that one that included at least one part in ten of cement.

DESIGN OF BUILDINGS

The design of the buildings was such that they not only adhered to the activities they were to enclose but also to a series of recommendations that would make them earthquake proof. Neither of these centers is in a hurricane prone zone so we only concentrated on making the buildings earthquake proof. We respected such criteria as making the basic shapes rectangular or square, locating windows on opposite walls just as doors were located on opposite walls, making the roof a complete integral structure not likely the break into pieces and collapse, locating columns along the walls at certain intervals, using barded wire. . . keeping the windows and doors small and at a certain distance from the corner, tamping whole wall sections at a time, building interior walls that help brace the outer load bearing walls, etc. These caracteristics that we have observed give us enough confidence to be able to replicate this system in any extension project of the centers.

WORKING DRAWINGS

An easily understandable tecnique of working drawings developed out of the use of modular formwork. By drawing the wall showing the number and size of the forms the wall will take, the worker need only count them, lay his forms out accordingly, make sure they are plumb and start the ramming process. An attached drawing will better describe this. Here again we were trying to simplify all aspects of the total construction process so that any outsider, educated or not, could understand and follow it.

INTEGRAL COMMUNITY OF LA CIENAGA

On May 4 of this year the Foundation began the initial stages of the construction of a community in La Cienaga located on the south west coast of the Dom. Rep. This project was designed by the National Housing Institute (Instituto Nacional de la Vivienda-INVI) a goverment institution but will be implemented by the Foundation which is a private entity. This project is to be a model in two ways. First, it represents the first time that the National Housing Institute has provided the design of a project and then signed an agreement with the private sector for its implementation . This agreement is a model for future projects between the public and private sector. This project is the first in a series, and already the location of a second one has been selected, both of them representing two very different set of conditions that exist in this country. La Cienaga is a coasted project, very vulnerable to hurricanes, with its particular economy, terrain, vegetation, culture, etc. The other site is Villa Vasquez, in the north, located in an arid region. This project is to respond to all the particular conditions of that region, such as its water problem, wood problem, food problem, etc. Each of these projects can be replicated, with some variations in the design, in the other areas of similar conditions. The community in La Cienaga is to be almost completely self-sufficient in food, health, energy, recreation, housing

education, and in sources of work. It will contain an area for the tree lucaena which will produce biomass, a communal organic farm, a market, a park, a school, a clinic, a communal lectrine, an open space for sports and recreation, a communal center, 70 earthquake and hurricane resistant houses, and three small income generating businesses. All the structures will be made of pressed earth blocks using a machine we developed ourselves.

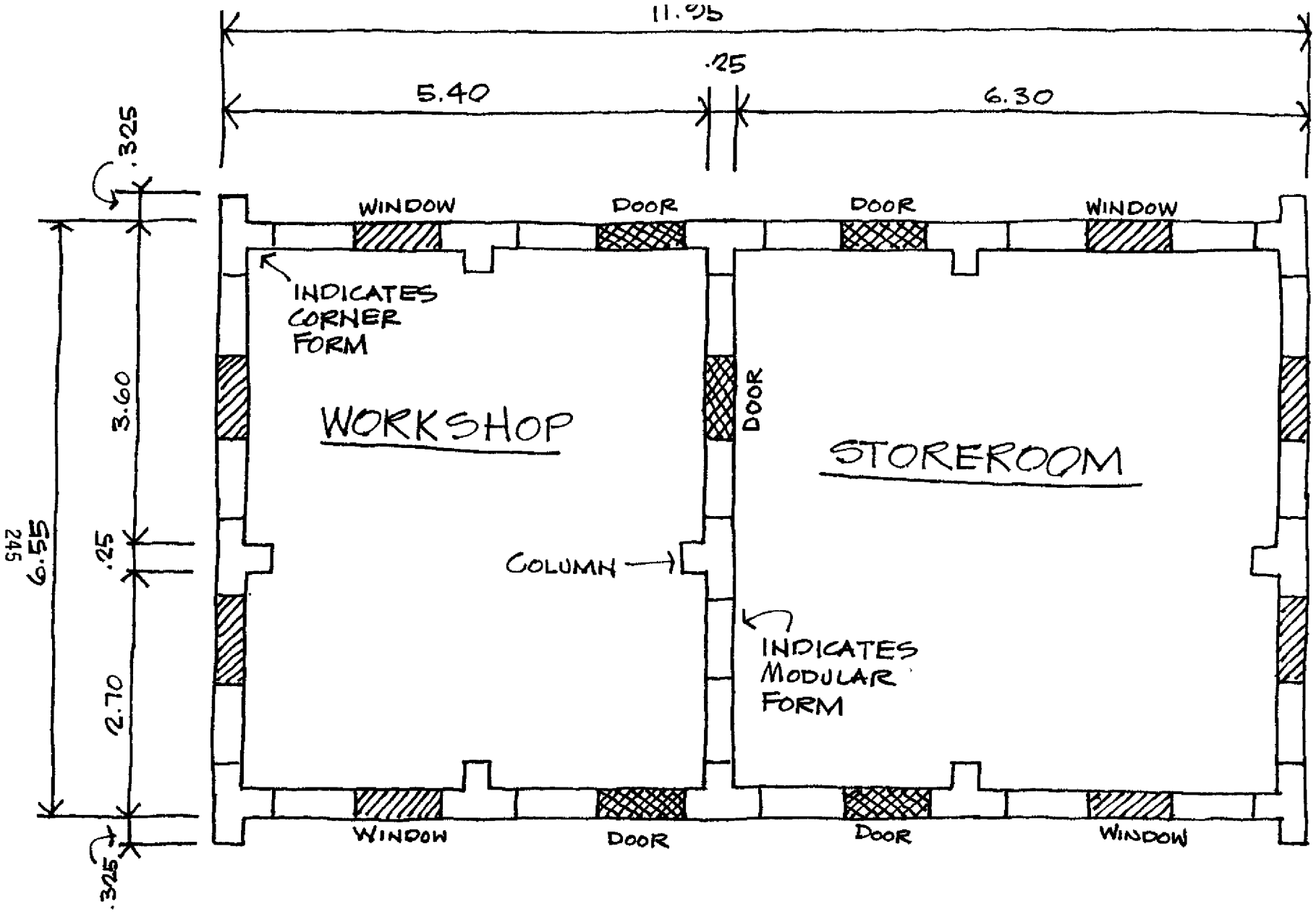
This project is a major landmark in the rural development of the Dom. Rep. and should set the standard for future projects, both of the public and private sector.

CONCLUSION

The Dom. Rep. has not been spared of the economic and energy crisis that is affecting the world. Change will inevitably come and we are fortunate to be in a position to help guide it where it should go.

Such traditional construction techniques using concrete block and wood are becoming the exclusive property of only the rich. Even the unfamiliarity with earth construction will not be a barrier to its eventual use since economic factors and the ready availability of earth as a building material as compared to the slowly incrementing scarcity of cement and wood have become a powerful argument.

Though the Dom. Rep. has been relatively isolated to the flow of new ideas perhaps this very isolation will permit it to create solutions all its own.



PLAN OF WORKSHOP - STOREROOM