RESEARCH AND PROMOTIONAL REQUIREMENTS FOR EARTH BUILDINGS IN DEVELOPING COUNTRIES

BY ERIC CARLSON
Deputy Director, Appraisal
UN Centre for Human Settlements
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ABSTRACT

Review of world shelter requirements. Efforts to develop improved adobe blocks through invention and utilization of CINVA-RAM soil cement portable blockmaker by different agencies in many countries over past 25 years. Properly stabilized soil blocks seen as one answer to avoiding many construction defects in adobe houses in earthquake areas, though other design and construction aspects also most important. Review of recent international experience with development and promotion of asfadobe technology in Peru, Sudan, etc. Positions of international agencies, UNEP-UNHHSF-UNCHS, and forthcoming international events focussing on human settlements technology. Importance of institutionalizing and supporting network of environment building centres. Possible model is Consultative Group on International Agricultural Research. Standing International Advisory Committee on Built Environment is needed.

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Improved methods for using earth as a basic building material for shelter and other structures are finally receiving increasing acceptance in many developing countries, and we can expect accelerated production of earthen buildings in the years ahead both for formal and non-formal (squatter) construction. That makes the subject of this workshop especially timely, as there are no inherent reasons why "earthen buildings" should be less safe than other forms of construction in seismic areas, provided that their characteristics are understood and simple design principles are incorporated to improve their structural integrity during earthquake movements.

Probably the majority of buildings in the world today are built with mud and earth as their major components. This situation is not likely to change for some time considering the dynamics of population growth and its effect on human settlements. The world population reached 4400 million in 1980, an increase of about 20% over the 1970 figure. About 75% lived in less developed regions with 30% in urban areas. The urbanization phenomenon is such that while in 1950 the proportion of world population living in towns and cities was 29% by the year 2000 it will be over 50%. This transformation involves enormous numbers of people: between 1970 and 1980 the urban areas of less developed regions absorbed about 320 million; between 1980 and 2000 the increase will be more than 1000 million. In 1950 there was only one developing country city (Greater Buenos Aires) with a population of over four million, by 1980 there were 23 such cities compared to only 15 in the more developed regions and by the year 2000 there will be about 60 compared to 20, with 18 of them expected to have more than 10 million inhabitants. At the same time, in connection with raising levels of health and productivity,there will be new emphasis on upgrading the quality of rural housing and settlements upon which so much of the world's food and resource expansion depends, with 50% of the total world's population still expected to be rural in character by the year 2000.

So the problems of providing shelter, buildings, infrastructure and services are immense. Moreover, the financial and energy constraints appear overwhelming especially for the many developing countries with per capita incomes of less than US$ 300 per year whose growth prospects look gloomy. In these circumstances, more and more governments will have to adopt new housing policies, modify their building codes and regulations, reduce their imports of building materials, establish more appropriate financial and credit institutions, allocate land with services to their low income populations and give them "freedom to build" in progressive improvement modes, a far cry from typical contractor-type construction. These efforts will involve fundamental professional reorientation linked with new national and international training, technical assistance, information, demonstration and development efforts for up-grading of the self-help and cooperative construction that many families will be engaged in. The most common "building block" is likely to be mud and earth.

Fortunately, this whole area may offer some unique opportunities for promoting closer linkages between developed and developing countries. Who can forget the stimulating efforts of those depression era publications of the US Department of Agriculture and others on earthen buildings with adobe, rammed earth and other technologies. The traditional adobe construction of the West has been greatly enhanced by the commercialized production of stabilized blocks, asfadobe and others for a period of almost 50 years, if we take as an example the Hans Sumpf operation in Fresno. These products are used in the finest residences and even commercial structures, giving high respectability to earthen buildings. The new vogue of adobe construction has now spread widely for home building in a number of states, aided and abetted by such unique, innovative and practical publications as the Adobe News and training and demonstration efforts accompanied by growing acceptance in building codes. Even the Architectural Record, a McGraw-Hill New York publication, gave considerable space to the remarkable demonstration by 81 year old Hassan Fathy from Egypt of building a mosque right here in New Mexico using traditional mud architectural technology. I might add that the US Housing and Home Finance Agency had issued in 1957 a publication on "Mud Brick Roofs" featuring Hassan Fathy's work, so we cannot say that the government has not been aware and supportive of some of these developments, particularly for use in developing countries.

My own continuing promotional commitment and involvement with earthen buildings began in 1956 through my role then as Director of CINVA, the Inter-American Housing Centre in Bogotá, Colombia, a project of the Pan American Union. There a development team was concerned with improving the use of earth as a building material for the poor. This resulted in the invention of the CINVA-RAM machine, a hand-operated stabilized earth block maker which was originally designed to fit within the criteria of a $50 cost limitation and easy portability on muleback or other transport through roadless territory. The machine, whose direct development cost and prototype manufacture was less than $8,000, has now built hundreds of thousands of low-cost dwellings and schools around the world, and is manufactured locally in many countries, from Ghana to Indonesia. I brought the first one myself to Washington in early 1957, where we demonstrated it in the gardens of the Pan American Union, and received subsequent world-wide publicity in Time magazine and elsewhere. Though it is by no means a universal answer to production of shelter, the CINVA-RAM has served as symbol for self-help and mutual construction and community organization efforts in many places.

The distinguished Chilean engineer who devoted himself to designing the machine, Raul Ramirez, was himself a high technology expert on anti-seismic design of tall buildings in Santiago. At CINVA, we were soon to contract out with the University of Chile for a major report on Earthquake Proof Design of Low-Cost Dwellings, published in 1959. This work was further elaborated upon in two UN publications, one issued in 1975, on Low-Cost Construction Resistant to Earthquakes and Hurricanes, and another in 1977, on Repair of Buildings Damaged by Earthquakes.

The pace-setting work carried out by CINVA, the first regional housing centre, from 1951 to 1977, when it was discontinued by the

Organization of American States, had considerable influence throughout Latin America through its extension services, demonstration activities, publications, and produced a body of professionals and technicians many of whom continue today in the housing institutions of their respective countries. The first structures built in 1957 with the CINVA-RAM stabilized soil blocks still stand - a 50 square meter tile roofed "Casa Campesina" costing $300 on the grounds of the National University; a large parabolic single brick width arch, the primary schools at Tabio and Saucio, and others. So I have personal knowledge and evidence that the material is durable.

CARE was one of the first international organizations to use the CINVA-RAM Portable Building Block Press and placed an experimental order in early 1958. In the same year, the machines were first put to work in a building improvement project throughout rural villages in Mexico. CARE's next project using Cinva-Rams was to build 64 houses for North Korean refugees settled in an "assimilation" village on the Han River, north of Seoul in South Korea.

After that year, CARE began utilizing Cinva Rams in many of its community development projects to build homes, schools, clinics, school kitchens, community and health centers, latrines, rehabilitation centers, shelters for animals, warehouses, students' dormitories, teachers' quarters, post offices, churches and other public buildings. For example, in 1967 in Sri Lanka, CARE cooperated with the government, various community organizations and an American Catholic priest in a community development program to build low-cost housing for low-income farm families. With land donated by the government, labour supplied by the villagers and the use of the CARE-provided Cinva-Rams, CARE was able to construct 200 housing units to benefit approximately 1,050 people. In addition, a "bank" of Cinva-Rams was established in the village for use - on a loan basis - in other development projects. As another example, CARE's provision of Cinva Rams to the Vietnamese Government's Department of Land Development assisted in providing resettlement homes for thousands of displaced families and also encouraged them to additionally construct temples, public markets, meeting halls and schools.

CARE has also provided Cinva-Rams to use in large-scale construction projects such as the SCIDE (Servicio Cooperative Interamericano de Educacion) Project in Honduras. This organization, part of the Alliance for Progress, undertook to construct schools in 77 villages throughout the country. At the same time, teacher-training facilities were being improved so that it would be possible to staff the new schools with qualified teachers. CARE's provision of the Cinva-Rams made it possible to complete the project through the use of thinner, lighter and less-expensive materials and provided educational opportunities for thousands of rural Honduran children.

Perhaps one of the largest CARE programs in which Cinva-Rams were utilized was in Bangladesh (formerly East Pakistan) and began 1968. CARE initiated a housing program to assist victims of a tornado when the program developed into a long-range housing rehabilitation project under a partnership agreement with the government with partial support from USAID. A total of 3,500 homes were constructed in the Chittagong District under this program and a second agreement was signed for expansion of the housing construction. CARE had constructed 800 houses when the program was interrupted by the 1971 Civil War. Impressed by the success of the first two CARE projects and convinced of the need for introducing low-cost permanent housing to the nation as a whole, the new Government of Bangladesh requested CARE to build houses throughout the country on the sites of villages destroyed during the independence struggle. In 1972, under a tripartite agreement between the government, CARE and USAID, CARE undertook the extensive 62-Village Housing Reconstruction Program in each of the 62 sub-divisions of Bangladesh. Although this project was carried out under extremely difficult conditions prevailing in post-war Bangladesh, CARE constructed a total of 8,600 houses in a period of about one year. This was the largest project of its type ever undertaken by CARE. In addition, CARE entered into another agreement to construct houses in Bangladesh; this time involving a proposed 15,000 houses in the Delta Coast region - one of the hardest hit during the 1970 Bangladesh cyclone catastrophe. The program was intended to be an expansion of the original housing program with the former government but due to change in priorities from rehabilitation to development, targets for this project were re-defined. By the program's completion in November 1974, CARE had constructed a total of 7,500 houses in the Delta area and had entered into an amended agreement for construction of godowns (storage facilities) and schools.

As in all such CARE projects, construction is done on a self-help basis, mainly by the people themselves, in cooperation with the local governments. Since the machine is designed for do-it-yourself construction, usually the only cost is the cement. The main ingredient, earth, is plentiful in even the poorest countries. The process is further simplified for unskilled peasants because no power source is needed. All it takes is a willingness to dig and sift the soil, mix it, hand-operate the machine, stack the blocks and then join them with a mortar of similar mix. Though sandy soil is best, almost any dirt free of vegetable matter will serve. Other stabilizers, such as lime which may be more available in some areas, can be used. Since the blocks are larger than conventional bricks (4" x 6" x 12"), this means more rapid construction since fewer blocks must be produced for each structure. Two men working together - one to operate the machine and the other to feed the mixture into the mold and remove the pressed block - can produce up to 600 blocks a day, depending upon their experience. With more workers, production is increased. In the town of Fuquene, Columbia, for example, workers produced 130 blocks per hour per machine on two Cinva-Rams provided by CARE. To construct a health center, they made 8,000 blocks and a typical two-room rural house required 2,500 blocks. In addition, the machine - which is made of steel - weighs only 128 lbs. packed. This makes it light enough to be transported easily.

The most recent large scale low cost housing program using the Cinva-Ram was in Pakistan where in the latter part of 1970's over 4500 houses have been built in three different projects. These houses are both rural and urban and the projects provided for training in rammed earth block-making techniques and low cost housing methods. Block-making teams were trained which in turn worked with and trained the villagers.

According to tests by laboratories in various countries including the U.S. Bureau of Standards the blocks are comparable to, or even better than conventional cement or cinder blocks in strength and endurance under various climatic conditions. Under the machine's design, the pull-down lever moves a piston that produces a compression force of 40,000 pounds. The machine turns out either solid blocks or blocks with a rectangular indention, which are made by using a wooden form which can be placed inside the metal mold box. The indentation helps save on materials.

As of 1978, CARE had put some 3250 Cinva-Rams into service in thirty countries throughout Latin America, Africa, Asia and the Middle East. One reason for not arriving at a total is that many of the machines were left on loan with responsible local groups for independent projects after original CARE programs were completed. In Nigeria, for example, CARE launched an extensive reconstruction program after the Nigerian Civil War to include the repair of an undetermined number of public buildings such as health centers and schools. The Cinva-Rams were used to rebuild the walls of the structures and then many were left on loan for further rehabilitative and development projects since that time.

UNICEF, VITA, and the Peace Corps are among the other organizations which have made extensive use of the machine. Countries which have received CARE Cinva-Ram machines for development projects include, Afghanistan, Bangladesh, Belize (British Honduras), Chile, Columbia, Costa Rica, Ecuador, Gabon, Greece, Guatemala, Haiti, Honduras, India, Indonesia, Kenya, Korea, Liberia, Malaysia, Mexico, Nicaragua, Nigeria, Pakistan, Panama, the Philippines, Poland, Sierra Leone, Sri Lanka (Ceylon), Turkey, Uganda and Vietnam.

In some of these countries, and others, such as Tanzania, and Ghana, production of the machine has been undertaken either by public or private sector interests, and sometimes the machines have been modified. In view of the heavy pressures generated, it is vitally important that full quality control be maintained, together with maintenance and the availability of key replacement parts. In Kenya, for example, a somewhat heavier CINVA-RAM is currently being produced and sold at a cost of US$200.

Although it is now 25 years since the Cinva-Ram was invented, it is evident that there is still a large need and demand for a machine of this type, which ideally should be accompanied by more regularized technical assistance and training. Also the Cinva-Ram should ideally be part of a building system which could involve a Mobile Field Manufacturing Centre and Kits of Parts for whole single small shelter modules suitable for cooperative cluster construction. An example of an early demonstration of such an on-the-ground system was built for the World Housing and Planning Congress of 1960, held at San Juan, Puerto Rico. Three dwelling units were erected from Cinva-Ram blocks manufactured on site by unskilled labour. Two were of expandable design but varied in the use of roof span materials. The third unit was built from a kit of parts, including a unique butterfly corrugated aluminum roof which caught the almost daily rainfall and drained it into two steel tanks built into the maximum utilization. Screen fillers of split bamboo were applied to moving part. Basic minimum surface wired lighting, hung fold-down table and shelves formed the remainder of the kit, along with framing clips, reinforcing rod, cement for the blocks and a Cinva-Ram machine.

Main Construction Defects in Adobe Houses

Considerable attention has been given to the shortcomings of typical adobe structures during earthquakes. The United Nations publication, Repair of Buildings Damaged by Earthquakes, 1/ has the following to say on the matter:

When adobe structures are inspected after an earthquake, failures are very often found which are due to a total lack of verification in the process of design, construction and utilization of this material, magnifying the errors due to ignorance that are typical of the system of unguided construction usually encountered.

The most common defects are the following:

(1) there is no foundation, or it is not deep enough, or it is very poorly made;

(2) no consideration has been given to the important function of a foundation as protection of the wall against ground moisture (capillarity);

(3) poor overlapping of the adobe bricks;

(4) there is nothing to anchor the structure (tie-beam of adobe clay at least);

(5) the distance between columns, wall intersections or other load-bearing members is too great;

(6) the area of the openings in the walls (doors and windows) is excessive;

(7) the openings are too far away from wall intersections or junctions;

(8) there are not enough cross-walls to resist the horizontal forces of earthquakes;

(9) the roof is too heavy;

(10) the roof supports are inadequate;

(11) the eaves are not large enough to protect the walls from rain;

(12) elements of the pediment or gable are poorly joined to the rest of the structure;

(13) the height from floor to ceiling is too great or the structure is more than one storey high;

(14) the lintels are insufficiently embedded in the walls.

1/ United Nations, Repair of Buildings Damanaged by Earthquakes. New York, 1977. ST/ESA/60. Sales No. E.77.IV.8

The following may be said with regard to adobe bricks as material:

(1) use of inappropriate soil, poor proportions of stabilizing material and/or excessive water in fabrication;

(2) improper dimensioning, especially adobe bricks of excessive thickness.

The following are the main construction faults:

(1) use of very fresh adobe bricks;

(2) absence of filling in the vertical joints;

(3) poor workmanship in laying the bricks, which is reflected in the poor geometrical quality of the walls (bricks out of line or out of plumb);

(4) building during the rainy season without adequate protection;

(5) very rapid elevation of the wall causing settling in the lower courses.

Lastly, there is widespread over-burdening of adobe structures by occupants (materials leaned against the walls), lack of maintenance of the necessary outside protective elements, subsequent changes in the structure, and addition of new construction with greater rigidity than the original building.

The initial inspection of adobe structures must bear in mind all the above-listed aspects.

The above findings are corroborated by the United Nations publication, Low-Cost Construction Resistant to Earthquakes and Hurricanes 1/ which contains the following listing of main construction faults affecting the stability of adobe houses:

(1) poor adobe-making techniques;

(2) use of insufficiently dried adobe;

(3) incomplete covering in the horizontal layer between adobe blocks;

(4) incomplete fill of the vertical joints between adobe blocks;

(5) poor geometrical quality of the walls (undulations and sagging);

(6) poor interlocking at the wall intersections;

1/ United Nations, Low-Cost Construction Resistant to Earthquakes and Hurricanes. New York, 1975. ST/ESA/23. Sales No. E.75.IV.7

(7) lack of adjustment in the wall arrangement and introduction of adobe pieces to correct the arrangement;

(8) walls built too rapidly (the maximum vertical rate should be 1 metre per day);

(9) plastering without taking the necessary precautions to ensure adhension of the coating to the wall;

(10) failure during construction of the wall to insert the wooden plugs for fastening frames, partitions and ornaments;

(11) the courses must be laid along the whole contour of the walls, avoiding construction by complete or isolated panels, in order to prevent possible differential settlement cause by the loads or by different degrees of dryness;

(12) lack of continuity in the timber tie-beams because of careless execution of the joints at the corners and intersections (splicing, use of double-headed nails) and/or the splicing of the longitudinal parts;

(13) poor execution of the wall coverings designed to protect the adobe blocks.

In the Department of Commerce Publication, Design, Siting and Construction of Low-Cost Housing and Community Buildings to Better Withstand Earthquakes and Windstorms, 1/ a number of recommendations are given regarding structural configurations that result in improved behaviour under seismic loads. These are as follows:

(1) Low-cost housing construction should be limited to one - or at most two-story units. This practice permits maximum exploitation of locally available construction materials and increases the feasibility of producing better seismic-resistant structures.

(2) The weight of roofs and floors should be kept to a minimum.

(3) The shape of the building, the arrangement of walls, partitions and openings should be made in a balanced matter to obtain as uniform a stress distribution in the building as possible.

(4) Heavy elements should not be attached to non-structural walls.

(5) The size and spacing of openings should be governed by requirements of minimum width of piers flanking adjacent openings, maximum permissible length of lintels spanning across the top of openings, and uniformity of overall layout.

1/ US Department of Commerce, Building Science Series 48, Design, Siting and Construction of Low-Cost Housing and Community Buildings to Better Withstand Earthquakes and Windstorms. Washington, D.C. Jan. 1974.

(6) Exterior walls forming a rectangular enclosure may be prevented from separating at the top corners by providing a continuous collar or ring beam having sufficient tensile strength to resist forces acting on the upper peripheral junctions of the walls.

(7) Structural damage resulting from hammering of unattached adjacent walls may be avoided by providing connections between these walls for integral action against earthquakes, or by providing sufficient space between adjacent buildings to avoid impact.

As for Foundations, it is recognized that low-cost single story housing will have only superficial foundations, but the following requirements should be met to achieve more earthquake resistant construction:

(1) The base of the foundation should be below superficial or "top soil" level, and below the major vegetal root level. In locations subject to freezing, as in Turkey and Iran, the bottom of the foundation should be below the freezing level of the groung.

(2) Continuous wall footing should extend under the entire length of the wall and sufficient vertical dowel reinforcement should be provided between wall and footing to develop continuity and capacity for intergral action. This practice should minimize differential settlements and local damage to the walls and should permit a more uniform distribution of bearing pressures in the soil.

(3) For single story construction the width of the continuous footing should preferably be more than one and one-half times the thickness of the wall or 35 cm., whichever is larger. Depth should not be less than 45 cm.

(4) Foundation materials of gravel mixed with soil stabilized with asphalt or road oil may be used unless better materials are available at comparable cost. Stabilization of the foundation material provides protection against moisture and other deteriorating agents.

(5) Split cane, bamboo or wire mesh may be used for vertical reinforcement to provide continuity between walls and footings.

As for Walls, Frames and Shells, the report gives considerable attention to improving the seismic resistance of walls constructed out of stabilized adobe block by using locally available reinforcing materials, for example, using split cane for reinforcement with oil stabilized block may provide an increase of over 100% in resistance to static lateral force. Adobe walls may be further strengthened by the use of cane or wire-mesh reinforcement to inhibit brittle shattering and rupture of walls and to control cracking. An effective method of improving the strength of walls is to provide a ring beam at their top, to tie the top of the walls together and to prevent tensile cracking from developing at the upper corners. A ring beam should be reinforced with materials of high tensile strength such as bamboo, wire or steel rods. Openings require special attention - especially their location and size and the need for effective reinforcement around them.

As for roofs, it is evident that the seismic performance of buildings will be improved if their weight is reduced. This can be achieved without loss of strength by substituting lighter-weight materials for roof covering in liue of heavy traditional materials such as mud or tile. Reduction of weight can also be achieved by using shorter spans which require the use of load-bearing interior partitions. This will also increase the lateral resistance of the system. The reduction of weight is greater than the reduction of the span, often by significant amounts.

It is clear that the improvement of the structural performance of earthen buildings during earthquakes depends on several key factors. But undeniably most important is the quality of the adobe block itself, and here every effort should be made to improve it. I have described the CINVA-RAM as one example of a low-cost machine for producing high quality soil-cement or lime stabilized blocks under compression. The basic techniques are not far different from traditional adobe block making and adequate experience is available after 25 years of the use of this technology in many countries. Its use should continue to be encouraged and promoted through much more widespread and consistent technical assistance, training and demonstration projects.

Another basic method is the production of adobe materials by the addition of asphalt emulsion, bunker oil or other petroleum derivatives. This produces asphalt-stabilized adobe brick of high durability and water repellent qualities. With good workmanship stabilized adobe bricks with high compressive strengths can be obtained. Mortars used with adobe units are mixtures of soil and cement, with asphalt added to give it the desired stability.

In my view, the production of this type of asfadobe brick has major potential, especially in the developing countries, and should help considerably in improving the structural quality of buildings in earthquake zones. With the present "oilglut" in the world today, conditions of supply and pricing of the additives required are likely to remain competitive in the years ahead compared to other materials. Getting far greater general acceptance and utilization of the relatively simple asfadobe technology will, however, require new and continuing efforts at both national and international levels. Let me briefly review a few of the efforts to date in this direction.

First, we can say that several factors have been responsible for reviving asfadobe technology. It is a technique of earth stabilization by processing with asphalt additives, its use historically recorded in the time of Assyria and Chaldea. It gives the soil greater durability without the need for firing it, greater stress-and-pressure-resistance whilst reducing the need for maintenance, rendering it insect-proof and waterproof.

One of the most unique and important properties of asfadobe is that due in part to its internal dryness, it is not generally an acceptable host for most biological pests (including rats), many bacteria and insects. It is therefore an extremely sanitary building material for both, domestic construction and storage for agricultural and other produce. Again, because of its internal dryness, it has excellent thermal qualities, its heat conductivity being less than that of poured concrete, concrete blocks or fired brick. With proper consideration of roofs, floors, doors, windows, and other sources of heat loss or gain, asfadobe homes have very desirable heat transfer characteristics. Generally, asfadobe walls maintain heat equilibrium by functioning as heat storage and heat dissipation units and make an excellent medium for the design of "solar" houses. An acceptable mortar using asfadobe can also be used for dwelling construction.

Asfadobe meets the following criteria to be used in promotion and implementation of a low cost self-help housing programme:

(1) the basic material, the component soil, is familiar and economically accessible to the inhabitants since it is found in their region;

(2) it is also acceptable and usable as a modern building material, particularly in light of current ecological concerns and the economic re-assessment brought about by the energy crisis; it requires only sun for curing, a minimal amount of structural elements, if any and may also be used for foundations, floors, walls and roofs;

(3) the material is labour-intensive and can provide employment for unskilled people; the process of manufacture is simple, cost-efficient, requires minimal amount of equipment readily learned, therefore trained manpower could teach it to other unskilled workers in proposed areas of application;

(4) it provides adequate structural strength and conditions for comfort, health and sanitation;

(5) with the revival of traditional technologies of building in improved earth there is no disadvantageous "transfer of technology" in the use of this building material; the stabilizers required are readily available in many countries. Emulsions to suit individual soils, can usually be processed and produced at reasonable cost and adequate quantities can be made available for shipment in container or bulk form. The fact that many countries will be carrying on road building programs using asfalt and earth stabilizers is another factor adding to the rationality of application to building construction

In 1965, while serving as chief of housing at the United Nations headquarters in New York, I was approached by Mr. Yonan Malek, a retired inventor of Irarian extraction, who had become convinced that building with asphalt stabilized earth represented the wave of the future for housing and shelter needs in developing countries. Mr. Malek recalled his youth in a mud built house in Iran, spoke of the centuries old structures built with asphalted earth, and was thoroughly familiar with the asfadobe commercial brick production in Fresno. Following our conversation, Mr. Malek's promotional zeal led him to interest Fresno State College, now the California State University, Fresno, to establish in 1966 an International Institute of Housing Technology one of whose prime purposes is to conduct research and development on soil stabilization for construction purposes, particularly to increase the resistant qualities of bricks made from soil without greatly increasing their materials cost. The Institute drew upon the collaboration of the Hans Sumpf Company, and organizations such as the Chevron Asphalt Company.

Though its funding and staff have remained modest and minimal, the Institute has made some notable contributions to developments in the field, such as its well-illustrated publication on The Manufacture of Asphalt Emulsion Stabilized Soil Bricks. The Institute has also conducted a number of training courses for developing country participants, and engaged in several pilot and demonstration projects on behalf of international organizations.

One such project was carried out in Peru, following the disastrous quake of May 1970 which destroyed or severely damaged most of the adobe buildings of a large section of the country, with a considerable loss of human life and material resources. A project for the establishment of a special Adobe Improvement Program was financed by the US AID. It included the development of two pilot housing projects, following testing and research activities, in the coastal region and the highlands of the earthquake zone. Thirty-one houses of asfadobe brick were built in Nepena, Peru. These projects included the production of stabilized adobe bricks, the construction of prototype dwelling units and the training of families in the new construction techniques. The report on the project indicated that block stabilization with rapid curing road oil had produced highly satisfactory results with the proportion of asphalt used varying between one and two percent. In order to improve the building structures, various building techniques and designs were also tested. New blocks were square instead of rectangular and the walls were reinforced with cane rods fitted vertically into holes in the blocks in much the same way as steel bars are used in conventional construction and with much the same effect. A two-room expandible experimental house built at the University had a sloping cane roof covered with stabilized soil, which offered a high degree of thermic insulation. Perhaps the most important feature of the model house was its capacity to reasonably withstand the action of earthquake forces, through a careful process of structural design and the use of improved construction techniques.

The IIHT has been involved in other training and demonstration projects in other countries of Latin America, including Guatemala, Honduras, Costa Rica and El Salvador. The Sudan, however, proved to be a breakthrough point for asfadobe production demonstration. The Sudanese Ministry of Construction and Public Works had become interested in the introduction of asfadobe technology in December 1975, and built an experimental asfadobe house. As the result of a government request to it, the United Nations Habitat and Human Settlements Foundation, with which I was then associated as Acting Director of Financial and Technical Services, approved in June 1977, a contract with Soil Technology International of Fresno, California, to provide technical assistance to transfer the asfadobe technology for large-scale production from Fresno to Sudan. The UNHHSF assistance in total amounted to $300,000 for the Sudan project. A four man team of selected Sudanese personnel completed a training course in Fresno specifically for this purpose. A complete operational equipment system with the capability of producing 22 million bricks in one year was designed, fabricated, tested and shipped to the Sudan. Initial production was destined for a 200 house demonstration project. An evaluation mission undertaken in January 1980 reported that, although there had been certain delays and difficulties the Khartoum asfadobe plant was fully operational producing a good quality of brick from soil stabilized by bunker oil. Construction was underway on the first sixteen houses of the 200 house pilot project. It was clear also that asfadobe bricks and mortar as such were producing a high quality product at 30% lower cost than other available building materials. The United Nations Development Programme has also supported an asfadobe research and development project in the Sudanese city of Juba, in association with the University there.

Currently, the UN Centre for Human Settlements is considering the use of asfadobe construction as one element in a 26 house demonstration project being undertaken in the large World Bank financed Dandora project.

So, these are indications of growing international interest in earthbuilding technologies, which, as stated earlier, can have major importance in improving the performance characteristics of adobe buildings in earthquake areas. There is a large role for the private sector to play in the future to accelerate utilization of stabilized earth blocks. At least three private organizations have been established to date for work in this field: Asfadobe Technology International (ATI) of Fresno, California; Asfadobe and Terra Systems Ltd., Nairobi, Kenya and Asphajor Corp., Tehran, Iran. The latter was established specifically for large-scale production of asphalt stabilized bricks and had been stimulated in part by Mr. Yonan Malek's demonstrations and construction of a model house in 1975.

The International Institute of Environment and Development of London has recently prepared a publication for wide circulation on Building with Mud, which reviews both national and international experience in this field. This is likely to stimulate further requests from both public and private sector interests for technical assistance, guidance and training.

Both the UN Conference on the Human Environment held in Stockholm in 1972 and the UN Conference on Human Settlements held in Vancouver in 1976 gave considerable attention to the development of building materials that are readily available locally. The UN Environment Programme (UNEP) in 1975 held an Advisory Group Meeting which drafted general guidelines for human settlements technology. This was followed up in February 1976 by an Expert Group Meeting on Human Settlements Technology for the regions of Africa and West Asia. For immediate action it was recommended that:

UNEP should sponsor a major effort to extend the application and improve the performance and acceptability of common mud as a building material. This effort will consist of two main sections:

(a) The evolution of a rationalized and simplified vault and dome technology, to be carried out by a development team in three stages:

  (i) Assessment of existing materials, and review of local workshops and craftsmen;

  (ii) In the light of resources found to be available, design a modified dome or vault constructing technology;

  (iii) Transfer the technology to a selected country on a pilot scale. At least 10 structures should be built in different locations.

(b) Improving the performance of mud-based building technologies, also to be carried out in three stages:

  (i) Compilation and assessment of information on requirements and resources:

(ii) Experimentation to improve existing technologies and, in some instances, evolution of entirely new methods to improve performance;

(iii) Dissemination of the successful results by means of pilot demonstration projects.

The five principal existing techniques for improving the durability, appearance, load-bearing capability and cleanliness of mud are:

Burnt brickmaking;

Coating with cement composites;

Soil cement;

Asfadobe;

Protective detailing.

In the course of the study other methods may also come to the fore.

UNEP should also sponsor a pilot demonstration project to establish the potential of asphalt adobe brick-making in several African countries. The programme would involve an initial feasibility study to determine the availability of suitable materials, followed by a second stage in which bricks will be produced on a pilot scale and houses constructed with the bricks. The project should be large enough to make a significant impression and promote widespread adaptation or imitation.

Unfortunately, relatively little has been accomplished to date to carry out the above recommendations. The UN Centre for Human Settlements (Habitat) was established in Nairobi in 1978, but to date has not done much in the way of research and development activities, though it does maintain an active technical cooperation programme for work in developing countries. The UN Environment Programme, based in Nairobi since 1973, has reduced substantially its support for human settlements projects. The UN Habitat and Human Settlements Foundation no longer exists as an independent agency, having been absorbed by the Centre for Human Settlements.

In one country after another, however, we do see evidence of considerable attention to both research and demonstration for the application of appropriate technology to the shelter-building process, with considerable emphasis on earth construction. The two countries which have established Ministries of Human Settlements, Mexico and the Philippines, have leadership roles in this field. A particularly good example is the publication, Indigenous Materials for Low-Cost Housing, published by the National Science Development Board of the Philippines in 1980 1/. This provides clear how-to-do-it text and illustrations and further reference sources.

As mentioned earlier, the work carried out in Peru in cooperation between the Ministry of Housing and Construction, the Housing Institute (INIAVI) and the College of Engineers, has been notable. The Central

1/ National Science Development Board, Indigenous Materials for Low-Cost Housing. P O Box 3596, Manila. May 1980.

Building Research Institute (CBRI) in Roorkee, India, has carried out much practical research and work on the use of stabilized soil and mud for many aspects of the building process, as has the UN Regional Housing Centre in Bandung, Indonesia and the Building Research Unit in Tanzania, and the Housing Development and Research Unit in Kenya. In fact, there are literally dozens of institutions that have been doing good work in this field, though coordinated approaches and substantial financial support have usually been lacking.

While I served for only a brief period as head of human settlements for UNEP, we did make an effort to establish a networking concept which would promote increased interchange and concentrated building research between building centres and institutes within each region. This was to include such general areas for action as Ecodesign; Infrastructure; Services; Building and Energy. It was also to give special attention to ecologically-oriented principles such as: Maximum use of renewable resources; Utilization of industrial, agricultural and household waste material in construction; use of non-contaminating energy from wind and sun for lighting, cooking and heating purposes; recycling and minimum use of fresh water for household purposes; and waste reduction through modular design, rationalization and standardization of building materials and components.

The general objectives were:

(1) To develop interdisciplinary research capacity leading to a better use of human and material resources and establish permanent functional relations between research and other organizations in charge of implementing human settlement projects in every country.

(2) To arrive at ecologically sound solutions to human settlement problems with emphasis on the lowest income groups of the population through community participation, labour intensive methods, generation of small scale industries and development of improved technologies based on locally available resources.

(3) To train and retrain personnel to adequately staff human settlement programmes.

(4) To open regional and interregional channels of communication exchange, adaptation and generation of new information and cooperation among all countries.

(5) To provide a forum for global discussion of problems related to human settlements technology.

Only in Latin America, in Mexico, under the auspices of UNEP, the Regional Economic Commission and the Government, was a special regional office established to deal with objectives of the above type, and it is good to report that considerable progress has been made with the networking concept among concerned institutions in that region.

Several forthcoming events may provide opportunities for further promotion, demonstration, information exchange and discussion regarding earthbuilding techniques. These are the UN Conference on New and Renewable Sources of Energy, to be held in Nairobi from 10 to 21 August this year.

The non-governmental Environment Liaison Centre is organizing a series of meetings and exhibits in connection with this Conference, which will include techniques for earth construction. Another NGO, Technology for the People, based in Geneva, is currently organizing a Second Annual International Trade Fair, to be held in Mexico City, from 6 to 13 November 1981. The UN Centre for Human Settlements has proposed a Global Conference on Human Settlements Technology to be held in 1982 or 1983. The UN General Assembly this year will also consider a proposition to designate 1983 or 1984 as the Year of the Homeless, which would focus on the massive refugee and resettlement problems the world faces, including squatters and the housing and shelter needs of the low-income populations.

So, the agenda for the future in this field is full and still growing, but the need for more concentrated support for institution building and development is clear. We must look at achievements in other sectors, and here one of the most successful models may be the Consultative Group on International Agricultural Research (CGIAR) organized in 1971 jointly by the World Bank, the UN Development Programme and the Food and Agricultural Organization. The Group is an informal association whose members are countries, public and private foundations, and international and regional development institutions. In Calendar 1980, the donor members made grants amounting to about $120 million to support a network of 13 specialized international research institutions whose work is concentrated on those food crops and livestock most important in the diets of people living in developing countries. Similar concentration on building research, including earthquake resistant construction, will undoubtedly also produce very major results and high cost benefit ratios.

Many international financial institutions such as the World Bank and Regional Banks, the European Development Fund, the International Fund for Agricultural Development, etc., recently have been devoting more of their resources for lending in rural areas, particularly for integrated rural development projects and programmes, and increasingly some funding is available for related shelter requirements, especially if so directly linked to production. Just as there has been a vogue for provision of "sites and services" for the poor in urban areas, often sparked by international lending, similar compelling reasons may well prevail for the extension of credit to enable substantial improvement of rural habitat and settlements, perhaps also with a "sites and services" approach.

This will offer new opportunity for upgrading the traditional type of construction with adobe and heavy tile or mud roofs which are so disaster-prone. But without a more adequate institutional structure at international, regional and local levels, the basic concerns will remain of how to get the information about the improved construction technologies into the hands of the users, the people themselves. This will require well-organized training and demonstration efforts, new development-oriented curricula in the universities and in the architectural and engineering schools, and the production of "barefoot" builders, teachers, and settlement managers on a large scale. Certainly to achieve these objectives and others, at least 12 to 15 international-regional interconnected environment building centres should be established or designated and supported by a combination of international, public and private sector funding.

This sort of development will undoubtedly require the establishment of a Standing International Advisory Committee on the Built Environment, under appropriate auspices, perhaps under similar concepts as have guided the Consultative Group on International Agricultural Research. This would, at last, represent a solid and continuing commitment for the cause of improved habitat and human settlements for the peoples of the world, and the phrase "Building for Peace" will take on new meaning.

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