CRATerre

The International Centre for the Research and the Application of Earth Construction (Grenoble, France)

This paper was prepared by three members of the CRATerre team at the School of Architecture of Grenoble· Patrice Doat, architect and professor, Hubert Guillaud, architect and researcher, and Hugo Houben, engineer, teacher and researcher and delegated to represent the team at the seminar.

Background and Aims

The beginnings of CRATerre can be traced back to 1973 It was a period marked by the energy crisis prompting a group of students from the School of Architecture of Grenoble to start experimenting with simple, cheap building materials and energy-efficient techniques which would be suitable for producing low-cost housing. Their research led them to the age-old tradition of building with earth. The Dauphiné region itself, moreover, was noted for its long tradition of loam-earth construction, a real living laboratory encouraging still more thorough research. By 1976 a course on earth construction was being offered at the School of Architecture and a year later an "Earth Laboratory" was set up for the purpose of providing specialised training.

With the establishment of CRATerre in 1979, the team was able to accomplish the following:

1) Broaden the scope of its activities with the arrival of researchers working in various sectors of low-cost housing.

2) Develop a programme of scientific and technical research on earth construction.

3) Ensure the gradual development of specialised training programmes.

4) Assist operations by providing technical and architectural know-how for projects being carried out in the field in industrialised as well as developing countries.

5) Develop an international network for the dissemination of information and know-how for a large audience of decision-makers, technicians and consumers through publications, seminars and technical assistance.

Meanwhile, the ties between CRATerre and the School of Architecture were gradually strengthened, especially through the introduction, in 1984, of a post-graduate degree in Earth Architecture which is a two-year programme of advanced training in theory and practice and awarded upon completion of a paper. This type of specialised training is the only one of its kind in the world and is made possible through close collaboration with the University of Science, Technology and Medicine of Grenoble and the active participation of numerous international experts and organisations.

To date, the team has assisted with projects in more than 30 countries in Africa, Latin America and Europe at the request of government agencies, institutions and international organisations such as the World Bank, I L O., UNESCO, U.N C H S -Habitat and private individuals. It maintains close relationships with professionals from many disciplines, including architecture, engineering, history, ethnology, archaeology and economics and collaborates with over 200 other associates the world over who are directly involved with earth construction and architecture (universities, vocational schools, research centres and experts).

Earth construction is both an art and a science. There are rules to be mastered, as well as knowledge to be acquired of when and how to apply the rules in individual cases. As a centre of research and application, CRATerre approaches the study of earth construction on both of these levels, the theoretical and the functional. It aims, in conjunction with the Earth Architecture Department of the School of Architecture of Grenoble, to define and produce, collect and disseminate the scientific and technical know-how needed for producing a new earth architecture of superior quality.

Research

Basic research on earth construction is carried out at the School of Architecture of Grenoble working in close collaboration with the four institutes concerned with earth construction at the University of Science, Technology and Medicine of Grenoble (U S T M.G) The research conducted is based strictly on scientific principles and methods. Earth, as the primary substance or matter of earth constructs, is studied first in its elemental form. It is then examined for the specific properties which allow it to be used as a building material. The rules of construction and building are then applied with regard to the structure, the form and the architecture of earth constructs. This step-by-step approach lays the groundwork necessary for producing an earth architecture of quality.

1) *Earth as prime substance* or matter is studied in its elemental form at the laboratories of the Dolomieu Institute of Geology and Mineralogy which are equipped for carrying out mineralogical and chemical analyses. Besides mastering the rules of construction and the art of building, the quality of earth architecture depends much on the choice of a good building earth whose mineralogical and chemical strength must first be determined The presence of unstable clays and sulphates, for instance, has shown in many recent earth constructs that neglecting the mineralogical and chemical composition of an earth reduces considerably the resistance and durability of earth construction materials.

In some African traditions the durability of earth constructs such as the *obus* (ground mortar huts of the Mousgum tribe of North Cameroon), for example, is ensured by improving the quality of earths either by mixing them or by adding natural products of vegetable or animal origin. This contributes to stabilising the mineralogical and chemical structure of the earths, as well as improving their resistance against any erosion caused by running water. These traditional practices can now be explained and reproduced by means of modern scientific methods. This kind of scientific knowledge is indispensable for knowing how to select the best and most suitable earths and the optimal conditions needed for utilising them as compounds and building materials.

2) *Earth as building material* Research on earth building material and ways of producing it is conducted at the Scientific and Technical Institute of Grenoble (I S.T.G.) and the Institute of Interdisciplinary Research on Geology and Mechanics (I R I G M) The scientific process adopted aims at studying the material not only as an isolated laboratory sample, but in its specific function as a building material destined for a particular

UNESCO seminar at CRATerre.

Photo: CRATerre.

purpose, such as a wall, for example. In addition, standards and rules are drawn up for the production and quality control of earth construction materials.

3) *Earth structures* built either reduced in scale or according to actual size are tested for durability at the facilities of the University Institute of Technology (I U.T.). By testing the crush-resistance of walls and arches, vaulted and domed earth roofings, the structure's organic relationship with the substance and the materials can be determined. At this point in the research process there is also the question of the mass effect of the materials which can contribute to the stability of a structure as well as provide thermal and acoustic insulation. The purpose for all this testing is to determine the rules governing the dimensions of earth structures in view of actual architectonic projets.

4) *Form and architecture* are studied in conjunction with the earth construction training programme at the School of Architecture as well as within the framework of research being carried out in the Department of Earth Architecture. The training programme consists of coursework in both theory and practice. Lectures and workshops are closely interconnected, allowing the student to apply his theoretical knowledge by testing out his designs with real earth materials. Projects are first conceived on paper and then constructed as mock-up models either reduced in scale or in actual dimensions. These workshops permit the student not only to develop a sensitivity for tangible form but also to learn some indispensable techniques for constructing with earth such as walls, openings and roofings. The research programme at the Department of Earth Architecture consists of extensive research studies on earth construction materials, the modes of production, construction techniques and their application as well as the traditional and modern practices of the art of earth construction.

An important distinction to be borne in mind with regard to the type of research that is being carried out is that it is not purely technical and abstract, but is approached in a contextual framework which takes into

account the manifold constraints governing architectural production. Specifically, these are the constraints imposed by historical developments, physical environment, social structures, cultural attitudes and customs, technology and the state of the economy. Consequently, this approach has led to the development of interdisciplinary research combining the technical sciences (architecture and construction, engineering, geotechnology and geology) with the social sciences (history, ethnology, sociology and economics), thus permitting a wider range of operable methods, resources and expertise for carrying out actual projects.

The methodology for this research developed as a result of working on actual earth construction projects such as the one that was undertaken on Mayotte Island (Comoro Islands), for example, which entailed a complete programme of earth constructed low-cost housing. The CRATerre team in collaboration with the University and School of Architecture of Grenoble and several local partners (Mayotte Real Estate Company, Department of Infrastructure, Musada Co-operative) worked together on the plan and construction of earth-built low-cost housing units. Also engaged were local architects, contractors and craftsmen who benefitted from on-site training.

The success of the project was due to the long programme of research and analyses of the historical, ethnological socio-cultural development of Mayotte Island. Only a holistic approach of this type could ensure the integrity as well as the total integration of earth-constructed housing units into the long-term programme of the socio-economic, technological and cultural development of the island, providing thousands of new housing units and employment opportunities.

In summary, the research programme co-ordinated by the CRATerre team within the framework of the Department of Earth Architecture is wide-ranging, scientifically grounded, holistic in its approach and constantly reviewed and up-dated in order to keep up with the latest developments in those aspects of human activity which could have direct bearing on earth construction. Close relations are maintained with collaborators and partners from all over the world for keeping abreast with new ideas and techniques, for advice and consultations, as well as for collaborating on many different projects. Priorities are always being set up for the type of research that is most in demand. To date, earth roofings, surface protection of walls, standards for quality control of materials, pathologies of earth architecture, training and the development of an information network have been the top priorities.

This is a vast programme of research aiming to establish a corpus of information covering all aspects of earth construction, including a review of earth architecture types as used in traditional and modern cultures, in rural and urban communities. Documented case studies have already been carried out in the United States, Mexico, Europe and the Middle East.

An integral part of the research programme has to do with feasibility studies. No project is proposed or undertaken without first investigating the situation in its entirety; that is, from the technical, economical and socio-cultural frames of reference. These studies have proven to be an invaluable source of information and have already been successfully applied in many important projects in France and Africa.

All this research is not, however, for the sole purpose of making analyses and data collecting, but is intended to assist in the training of experts by making available to them the acquired knowledge and technical know-how. In view of this, a technical dictionary now in preparation is soon to be published (for which several reference papers have already been published), and specialised courses of training are being offered on a regular basis, including seminars and post-graduate studies for those seeking proficiency in the field.

Application

The need for cheap housing in developing countries is enormous. Supposing that, at best, half of the already existing housing (mostly emergency-type dwellings) could be restored, no less than 400 million new housing units will still have to be built for the world's needy people before the year 2000. This mind-boggling forecast has been confirmed by the United Nations as well as the International Union of Architects.

For Africa alone, it is estimated that over the next fifteen years 13.5 million new units will be needed for countries in twenty-three of which (representing 37 per cent of Africa's population) the GNP per capita was less than 1,500 FF in 1979, and in sixteen of which (representing 27 per cent of Africa's population) the annual GNP per capita ranged between 1,500 FF and 3,000 FF.

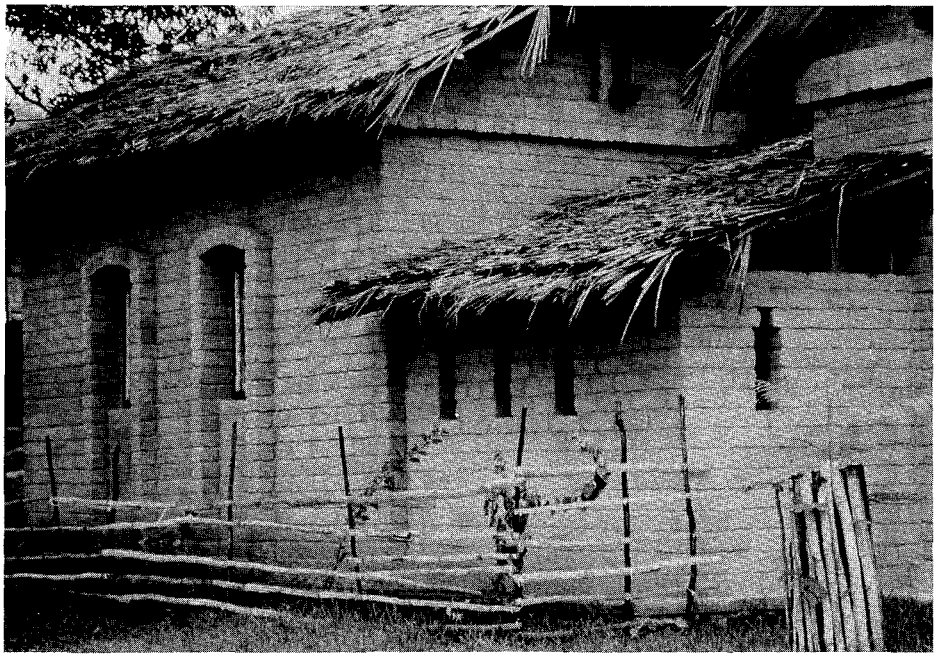
The magnitude of the problem, however, is much the same in other underdeveloped countries of Latin America, India, China and elsewhere.

This tremendous need has been caused by many diverse factors among which are:

- an unprecedented population explosion,
- rapid urban growth,
- an unequal distribution of resources,
- a shortage of cheap, modern building materials and compounds, and
- the misuse of an imported and too sophisticated technology which is neither economical nor energy-efficient and that does not necessarily solve the needs of individual communities.

The situation is further aggravated by an apparent lack of competency on the levels of management, decision-making and production.

The fact that the needed financial resources in underdeveloped countries are extremely limited, if not totally non-existent, makes the situation even more problematic and challenging for those of us who are concerned. In fact, members of the poorest urban population of Africa (15 per cent) cannot be expected to pay more than an average price of 88 FF or US$10 per square



House, Mayotte, designed and built by Ecole d'Architecture de Grenoble

Photo CRATerre

metre of livable space for any type of long-term housing. Therefore, the average asking price of US$100 set by certain international organisations is to be considered much too high, ten times too high for poor countries. It is meant more for the middle classes or even the higher echelons of certain societies, but in no case for those which are the least solvent.

Major international organisations have conducted studies which show that in those countries where the people can only afford very cheap housing they have no other choice but to build with the materials locally available using traditional building techniques. In many of these countries earth building materials and earth construction techniques are the only possible resource and solution.

John Turner has said, "A material is not interesting in itself, but rather for what it can do for society." Because of the easy accessibility of earth and the simplicity of techniques for employing it, we believe that earth construction can be a valid solution for solving the critical housing shortage for the world's needy people. However, we are also very much aware of the fact that the quality and feasibility of earth constructed dwellings are largely dependent on the expertise, both professional and technical, of those who produce them. We are therefore deeply committed to making available the results of our research and work to those involved with earth constructed housing for the needy in informal rural communities, by encouraging self-help in the production of earth building materials as well as the construction of earth dwellings and, in the more formal urban communities, by encouraging the development and production of earth-constructed units within the means available and according to the specific needs of the community

Our efforts aim at launching the production of housing by exploiting as much as possible the human and natural resources that are available locally with the purpose of consolidating conditions favourably for socio-economic, cultural, technological and political independence. In that sense, the development of local subsidiaries is meant to contribute in the promotion of jobs and specialised skills at the decision-making level as well as the professional/technical level.

In order to ensure the dynamics for promoting this type of self-centred local development, we are concentrating our efforts on training programmes (academic and professional) and the dissemination of information and technical know-how to the greatest number of decision-makers, technicians and consumers. Doubtless, at the core of any training programme is the need to prepare professionals to assume top-level and middle management positions which hold the key for the development of earth constructed housing. It is well known that in this sector very little has been done in the world, especially since there is a tremendous lack of qualified educators and an awesome void of specialised, fully integrated training programmes (in universities, schools of engineering and architecture and vocational training centres).

Dissemination of Knowledge

Being concerned with the communication and dissemination of basic knowledge and information for training and decision-making, for the planning and carrying out of earth-construction projects, the CRATerre team promotes an important programme of training and instructive research. Motivated by a desire to instruct and communicate, the team seeks to establish a world-wide "earth network" for the purpose of sharing experiences and co-ordinating research, training and application.

One important training activity is in the form of seminars and information meetings which are organised at the request of international and national organisations involved with low-cost housing. This type of activity

was carried out specifically for the CONESCAL and UNESCO seminars.

1) *CONESCAL* The Regional Centre for School Building in Latin America ("Centro Regional de Construcciones Escolares para America Latina") organised in 1982 a two-week seminar in Mexico within the framework of a school building programme in which the application of earth construction was being envisaged. Two on-site preparation missions preceded the seminar which was intended for promoting a greater awareness and appreciation of the potentialities of earth as building material. The first week was devoted to theory and was followed by a week of practice with the building of a mock-up model constructed with adobe bricks. Thirty-four Mexican engineers and architects attended the seminar. The proceedings of the seminar, "Technology of Unbaked Earth Construction" ("Tecnologia de construccion en tierra sin cocer") were published in collaboration with CONESCAL.

2) *UNESCO.* Another seminar within the framework of school building programmes for six Islamic countries (South Yemen, North Yemen, Somalia, Sudan, Mauritania and Djibouti) was held for one week at the School of Architecture of Grenoble in November 1984. It was preceded by a mission to aid in the planning of construction systems for projects to be carried out by the UNESCO team of architects. The seminar, which was attended by twelve architects and engineers representing the six countries participating, consisted of consciousness-raising sessions, the construction of a mock-up model, a visit to the scientific and technical laboratories of the University of Grenoble and visits to the Earth Village ("Village-Terre") on l'Isle d'Abeau and to the local producers of earth materials.

Training

C E.A.A Terre. A certificate of specialisation in earth construction ("Certificat d'études approfondies en architecture de terre") created in 1984 considerably strengthened the ties and expanded the collaboration begun many years ago between the CRATerre team and the School of Architecture of Grenoble. Other university institutes are also collaborating in the training programme by conducting supervised workshops in their laboratories.

The programme of specialised training leading to the C E A A. Terre is intended for developing
- a process of scientific research on earth building materials and earth construction,
- research on the production of cheap housing in developing countries, and
- experts specialising in earth building materials and their architectonic possibilities.

Curriculum. The coursework consists of two consecutive years of 400 hours each. Lectures, workshops and advanced training constitute the work for the first year; whereas the second year is devoted to research and the writing of a post-graduate paper.

The C E A A Terre under the responsibility of CRATerre is the only training available in earth construction anywhere in the world. It is open to all architects, French and foreign, holding a degree in architecture or a diploma permitting them to begin the third university level (troisième cycle) and aims at establishing the candidate's competency on four levels:

1) decision-making
- to identify and define local needs,
- to ensure the technical and economic feasibility of using earth as building material,
- to conceive and apply appropriate solutions for local conditions by exploiting the potentialities of earth for construction;

2) implementation
- to set up local units for the production of earth building materials,
- to train local personnel in the necessary technical skills;

3) planning
- to establish programmes for earth constructed housing which would lead to architectural projects,
- to ensure the necessary technical and architectural framework for conceiving projects appropriate to local needs, demands and means;

4) production
- to organise and train building technicians,
- to ensure the smooth running of technical operations,
- to define the type of structures that are suitable for the operational development of projects, co-operatives and similar institutions,
- to co-ordinate building sites and train for competency in this domain.

Manual. An instruction manual, *Earth Construction Primer,* published in 1984 under the auspices of U.N C.H S -Habitat is used as textbook and contains all the essential theory of basic scientific principles, as well as giving practical information covering all stages of earth construction, from conception and planning to production and completion. It is published in English, but will soon appear in French, Spanish and Arabic. In addition, supplementary didactic materials and documentation are also made available to the teaching team and includes illustrations, slides and exercises for practical training.

The programme of training and research for the C E A A Terre is organised and co-ordinated by the CRATerre team; however, it draws heavily on the expertise of professional national and international organisations, research centres, universities and individual specialists from around the world. They are invited regularly to CRATerre for lectures in conjunction with the first year's course and cover various fields of research informing of the latest developments, experiments and projects.