EARTHEN ARCHITECTURE
Materials, techniques and knowledge at the service of new architectural applications

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ABSTRACT

The range of the technical, constructional and architectural possibilities of earth is very wide. The study of popular traditions and of traditional knowledge throughout the world has enabled some 18 different methods of utilization of the material to be identified, each in itself also capable of being used in a great variety of ways and forms. This wide constructional potential has enabled the building of modest shelters, of village houses, of urban blocks, of religious edifices as well as of palaces. This diversity of earthen architecture is not to deny that offered by the use of other traditional materials, with the exception that earth is probably one of the traditional materials which offers rarely equalled possibilities of use.

Recent technological developments and ongoing scientific research have result in modern production and construction techniques that are part of todays solutions to solve the world wide housing crisis.

1. A MAJOR BUILDING MATERIAL

The importance - both in quantity and quality - of unbaked earth constructions in the world is very little known. Thought to be antique and associated with the first ages of the civilizations of the Nile, the Tigris and the Euphrates, the Indus or the Huang He, unbaked earth is today no longer regarded as a major building material despite the fact that it continues to leave a undeniable and distinctive imprint on the architectural landscapes, both rural and urban, of very numerous countries. And yet it is a major building material, for unbaked earth remains to this day one of the main materials used by man to erect his home and city buildings. The passage of time has layered the sites of human occupation, which have constantly regenerated their daily built environment. It has not, however, effaced the permanence of the use of this material, excavated from the very soil, moulded by the hand of man or trampled by beasts of burden to create building materials the skilful use of which - resulting from a body of knowledge refined over the course of time - has enabled the construction of simple huts and modest homes, as well as farm buildings, grand houses, urban blocks and religious edifices, castles and palaces.

2. A CONTEMPORARY BUILDING MATERIAL

If the use of earth in countries known today as "advanced" regressed after the Second World War, that is to say barely fifty years ago, in so-called developing countries it has continued unabated. On the one hand, the industrialization of construction and the sweeping changes within industrialized societies rendered obsolete ancestral techniques based on the use of local skills and materials and on mutual help within a community; on the other hand, the dearth of processed materials, costly both in foreign currencies and in imported energy, the widening of the gaps in development and in the accumulation of debt contracted within the international monetary system, the survival of the life-styles of local societies accustomed always to coming together for mutual help for survival, dictated the continuing use of locally available solutions, materials and knowledge. In these countries with no industrialized means, in a wide range of latitudes throughout the world, earth remains the main - if not the essential - building material. Does this then make it a poor material using outmoded techniques, unsuitable for promoting a legitimate and necessary access to development? Far from it, for these

materials and techniques are for the most part very well used and can ensure true architectural quality, allowing communities to continue to create their private or public living environments and to integrate their built structures into a coherent network of self-generated development which makes the most of the resources available, human and material. Moreover, developments in scientific and architectural research on earth as a building material and on building techniques over the last decades, the investment of construction industrialists and companies, today have combined to make a wide range of perfectly mastered production procedures and technical solutions available and are offering great flexibility in meeting the wide range of possible applications.

3. A CLEAR MARK ON THE WORLD ARCHITECTURAL LANDSCAPE

Thanks to the most recent world surveys, although these of course remain partial, we have a quantitative picture of earth structures which embrace some 30% of world population housing. In developing countries alone, 50% of the rural population and 20% of the urban population are concerned. These figures, which emerge from the combined data of statistical surveys in various areas and from bibliographic information, are without doubt underestimates of the true position. 60% of housing in Peru is in moulded bricks or rammed earth. 38% of housing in Kigali, the capital of Rwanda, is in earth. More than 70% of the housing stock of India is in moulded earth bricks or in successive layers of earth. In France, there are rural dwellings in unbaked earth, with, in the Dauphiné region, some villages having up to 90% of their buildings in "pisé" earth rammed.

From the very humblest shelters in concessions to the multi-form granaries of Africa, from the palaces of the Hausa emirs of Nigeria to the ksours and kasbahs of Morocco, from the mosques of Mali to the tightly-packed neighbourhoods of Ispahan and Iran, from the fortified dwellings of the Najran area of Saudi Arabia to the ten-storey or more earth blocks of Shibâm, in the valley of the Hadramaut in Yemen, from the moulded brick farms of Aquitaine to the baroque and neo-classical castles of the Saône valley, from the pueblos of the New Mexico Indians to the houses in concentric rings of the Hakkas of the province of Fujian, in China, the whole world bears the indelible stamp of earthen architecture, vestiges of past history and a living framework for history in the making.

4. ONE OF THE POSSIBLE AND REALISTIC SOLUTIONS FOR THE FUTURE

Confronted by the "energy crisis" of the 70's, oil-dependent industrialized countries were forced to call radically into question tried and tested technical solutions which now proved too "energy-greedy". The building sector was not spared and the search was on for solutions allowing energy savings both at source (production and application of materials) and further down (maintenance) the production chain. Research on biomass and solar energy ran in parallel with experiments to update traditional materials and to attempt to rationalize the production process. Earth became once more a material of primary interest and government institutions (notably in France) supported a considerable amount of research and experimentation both in the area of application to industrialized countries and in that of developing countries in the context of bilateral or multilateral cooperation. Today, the threat hanging over the ecological balance of polluted, degraded, or plundered natural areas highlights interest in materials and techniques which are inherently environmentally friendly. The increasing involvement of people in the control and management of the production of their living environment which results from a new awareness of the options available, qualitative research and increased leisure time, is associated with the use of simple, economical techniques, easy to use, and allowing a great measure of partial or complete self-help building. Viewed from this perspective, earth as a building material has definite advantages and plays an important role.

In developing countries, burdened by debt and confronted by an urgent need to build on a scale unprecedented in history, imported materials, techniques and energy are for the most part inaccessible to most and contribute to promoting "bad development". Building with earth emerges as one of the efficient short-term means of production of housing or public facilities (schools for example) which are both economical and offer high quality (being culturally and climatically suitable). Decision-makers in these countries are well aware of this and mobilize "up-stream" feasibility studies for their

"education programmes" or their popular housing programmes for example, and research on resources and local knowledge, on labour-intensive techniques generating employment and enabling the population to gradually become "monetarised". The days of costly experimentation, often with no further outcome, are now over. A new confidence in the resources available is encouraged; completed examples are being multiplied and the men who realize them are being trained. At the same time, accessibility studies show that the populations concerned have in the main no choice but to employ local materials, most often earth. Some measure of the scale of the dramatic issue facing generations of decision-makers and builders meeting these needs can be appreciated. The use of earth and other locally available materials is unavoidable, and should indeed be encouraged by them.

5. ENVIRONMENTAL ADVANTAGES

It seems particularly important to enumerate the many advantages of building in unbaked earth from the point of view of the environment. This issue is increasingly a central one and forms part of the contemporary problems facing society which will play a greater part in political, economic, social and cultural strategies linked to the planning and improvement of the quality of life. Here we refer to the concept of the environment in the widest sense of the word, ecological, economic, technical, health-wise and psychological, cultural and human.

5.1. From the point of view of the ecological environment

In terms of pollution and degradation, unbaked earth can offer a totally positive picture:

- It does not contribute to the deforestation which follows for example the use of organic resources for firing baked earth materials.

- It does not consume any non-renewable energy (oil, gas, etc.) at source for the processing and production of materials or further down the production line for their application as does the production of cements, lime and other conventional binding materials and steel.

- By exploiting strata on construction sites, it allows a considerable saving in energy for the transportation of materials.

- It does not contribute to a degradation of the landscape as does the extraction of minerals and ores which hollows out hillsides and open cast sites. A great deal of the earth excavated in the course of large public facilities works (notably roads and motorways) can be recycled and used in building (allowing very easy decentralized distribution).

- It does not contribute to the diminishing of resources of aggregates such as gravel and sand, excavated either from quarries or from water courses, in insular sites or lagoons, putting into peril the ecological balance of these natural environments.

- It uses very little water, essential for the life of the people.

- It produces no industrial or chemical waste and moreover has the additional advantage of being almost entirely recyclable.

5.2. From the point of view of the economic environment

- It is often comparable in cost with, or indeed more economical than, competing technologies and requires no major financial mobilization for its generally light production infrastructure.

- It guarantees rapid amortisement thresholds for bankable investments thanks to its low infrastructure requirements for usable production.

- It makes a contribution to the stimulation of local flexibility of adaptation to decentralized situations.

- Throughout the production process, it creates employment and monetary added-value which can be injected into other sectors of the economy, particularly in the development phase of societies.

- By allowing savings in energy and in foreign currencies, it contributes at the macro and micro economic level of the building sector, to a considerable reduction in developing countries' debt and to the balance of payments.

5.3. From the point of view of the technical environment

- It has thermophysical and hydric properties which contribute to the regulation of thermal comfort and the exploitation of the mechanisms of the bioclimatic functioning of shelter: good conductivity, energy retention capacity and thermal differential (effusivity and diffusivity), delayed temperature differences etc.

- It requires most often only simple production and application tools (moulds, presses, light shuttering, normal masonry tools, etc.) accessible to a wide population of masons and self-help builders.

5.4. From the point of view of health and the psychological environment

- Not only non-polluting in its use, it also guarantees the absence of harmful effects in the context of daily life such as the absence of gaseous emissions or other toxic chemical components, radioactive emission etc.

- It contributes to psychological well-being by the architectural exploitation of its inherent characteristics; these include the surface texture, colour, form and luminosity of the material. It thus makes an active contribution to the beauty of the living environment.

5.5. From the point of view of the cultural and human environment

- It follows on in the heritage of the traditional architecture of numerous countries using local materials and thus plays a part in the respect for, as well as the survival and updating of, cultural, architectural and urban environments.

- It allows local populations to take charge locally themselves of the production of their built environment and thus contributes to the expression of the democratic rights of all to control their living environment.

6. THE FUTURE OF EARTH ON THE MOVE

It is undoubtedly in the "Great Book of History" that possible solutions are being researched for a future in which building with earth, amongst a wide range of local techniques, will play a new technological, social, cultural, ecological, economic and political role of paramount importance.

7. THE VARIOUS METHODS OF UTILIZATION

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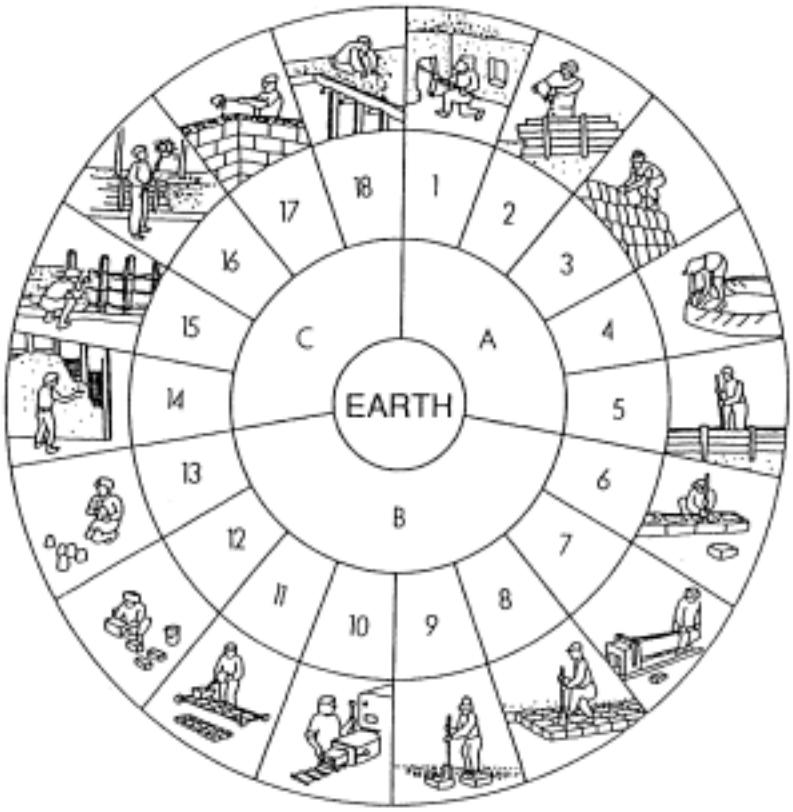
7.1. Six principal techniques

Together the methods of utilization of earth referred to before have given rise to numerous applications using a wide variety of production and construction techniques. Certain of these techniques are still used traditionally in many countries of the world, others have been abandoned, and still others have only recently been the subject of developmental experimentation. It will be noted that there exists a register of principal techniques, mainly associated with processes using moulds, shuttering and direct shaping. The most widely used of these techniques are known under the names of "adobe", "rammed earth", "straw clay", "wattle and daub", "cob" and "compressed blocks".

7.2. Three major techniques

Within these six principally used techniques, three remain very traditional, i.e. wattle and daub, straw clay, and cob, whilst the three others have recently been the subject of a spectacular evolution linked to the modernization of production machinery and methods of application; these are adobe, rammed earth and compressed earth blocks.



A : The use of unbaked earth in monolithic load-bearing form	B : The use of unbaked earth in the form of load-bearing masonry	C : The use of unbaked earth in conjunction with a load-bearing structure
1 : Dug out	6 : Tamped blocks	14 : Wattle and daub
2 : Poured earth	7 : Compressed blocks	15 : Cob on posts
3 : Cob	8 : Cut blocks	16 : Straw clay
4 : Direct shaping	9 : Sod	17 : Fill-in
5 : Rammed earth (pisé)	10 : Extruded earth	18 : Earth sheltered space
	11 : Machine-moulded adobe	
	12 : Hand-moulded adobe	
	13 : Hand-shaped adobe	