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Earthen construction, an additional way to house the planet

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Building locally using earth could be one solution to the construction needs of the world's population. Raw earth is available in many places on the planet and answers the major contemporary ecological, cultural, social and economic issues. This "ready-to-build" material fosters local development by promoting local culture and know-how, while creating employment and wealth. It opens up an avenue that should be seriously reconsidered.

According to UN Habitat's estimations, three billion human beings will be poorly housed by 2050, in poor and rich countries alike (UN News Centre, 2005). In order to meet needs, 4,000 high-quality dwellings will need to "emerge from the ground" every hour over the next twenty-five years. Raw earth is a ready-to-build material; it is available in many places on the planet and offers one of the most viable alternatives for meeting this demand. In addition, given the importance of the construction sector in the entire economy, earth-based building must be considered as a major lever for local development, as it boosts employment and wealth creation without overconsuming energy (*Box 1*). There is consequently a pressing need for earth to have the share it deserves in the range of construction materials used by contemporary builders.

Environmental impact and economic weight: the building industry in figures
The building sector currently accounts for between 25 and 40% of energy consumed in the world, produces 30 to 40% of solid waste and is responsible for 30 to 40% of greenhouse gas emissions.
At the same time, it employs 111 million people worldwide (UN Department of Economic and Social Affairs, 2010), including 75% in developing countries and 90% in micro-enterprises.

Building with what is underfoot

The Great Wall of China is the greatest architectural work ever to be achieved. And yet, contrary to popular belief, it is not completely made of stone. Thousands of kilometers of the wall are made of earth. The rule that dictated the choice of materials is simple: to build using what was underfoot, stone on stone, earth on earth, and sometimes even sand on sand. This link between the geology and pedology1 of an area and its architecture is universal. Men and women use local materials to build their homes in all world regions. Today, it is estimated that over half of the world's population live in dwellings made of raw earth, on all the continents and in all climates (Anger et Fontaine, 2009). A hundred and thirty-five architectural monuments on the UNESCO World Heritage List, i.e. roughly 15%, are made of earth (Gandreau et Delboy, 2010) – *Figure 1*.

More than ever before, earthen construction offers real solutions for meeting energy and climate challenges. With all the advantages it offers, this architecture deserves to be once again recognized for the place it has in reality. Indeed, science has developed theoretical tools that are essential to gaining a better understanding of this material: by shedding new light on the know-how of traditional builders, the intimate knowledge of the most common substance now carries innovations for the future (Anger and Fontaine, 2009).

Earth is concrete clay

How is it possible to build with a material that would initially appear to be so fragile and sensitive to water? In order to understand how, its composition must be considered. Earth is a mixture of grains that have different names depending on their size: stones for the largest (between 20 and 2 cm), gravel (between 2 cm and 2 mm), sand (between 2 mm and 60 µm), silt (between 60 µm and 2 µm) and clay (below 2 µm). Stones, gravel, sand and silt, which make up the granular skeleton of earth, provide the material with structure. Clay, mixed with water, acts like glue. It is consequently the binder for earth, exactly like cement is the binder for concrete.

“Concrete” is, in reality, a generic term. It refers to a composite construction material made using aggregates agglomerated with a binder. Earth is consequently just one form of concrete among others, but it is natural and ready-to-use. The wide range of construction techniques for earth (rammed earth, clay mortar, cob, adobe…) is partly related to the great diversity of the material mix. Using these elements, a solid material is obtained that makes it possible to build edifices up to 30 meters high, such as in the City of Shibam2 in Yemen. When it is properly protected against rain and capillary ascent, there is no risk of chemical alteration to “earthen” material and it does not burn. It has an exceptional durability, as can be seen with the Great Wall of China and certain Egyptian, Chinese or Peruvian pyramids.

Practically no environmental impact

Housing is a major ecological, geostrategic and political issue. Buildings consume energy and emit CO2 at every stage of their construction, their use and, finally, their demolition. This begins with the production of construction materials: cement manufacturing alone causes 5% of global CO2 emissions. Then comes the transportation of materials and the construction in itself. Heating and air-conditioning needs account for the bulk of the energy bill. Finally, the demolition, storage and recycling phase for materials completes the cycle of a production industry that poses a problem due to the strong impact it has on the environment.

Earth is a natural resource that is often widely available. Practically all mineral earth containing clay can be used for construction (Guillaud and Houben, 2006). It only uses a very low amount of gray energy at every stage of its use.3 Earth can be used on the spot, requires no transport, no conversion or energy-guzzling firing. It is easy to maintain and repair. At the end of its life, the building is demolished and the earth can be reused or returned to the ground it came from. It is consequently recyclable and does not generate waste. It has practically no ecological footprint, which is an enormous advantage in the face of climate change and the need to reduce energy consumption. Earth can consequently provide a good substitute for cement concrete constructions in a number of cases, particularly for individual low-level dwellings.

When it is used, earth can help make substantial savings on heating in winter and on air-conditioning in summer thanks to its thermal regulation properties. Earthen walls regulate temperature differences between night and day, which helps maintain the temperature at a pleasant and constant level. This is due to thermal inertia, fostered by the high density of the earthen material. The thermal inertia of an earthen wall and that of a cement wall are similar, for equivalent densities.

In hot climates, earth naturally brings air-conditioning to homes. When the temperature rises, liquid water, condensed on the surface of the clay, evaporates. The wall consequently “perspires” in order to remain cool, in the same way that sweat evaporates to allow the human body to maintain its temperature constant.

In cold and temperate regions, earth stores and diffuses the heat transmitted by the sun's rays. The wall is optimal because it combines additional thermal properties: the insulation prevents the heat from escaping, the earth's inertia absorbs the temperature fluctuations.

Finally, clay, thanks to its absorption and evaporation capacity, regulates the humidity in the air, which helps keep the climate inside healthy: it absorbs the excess humidity and releases it when the air is drier. This natural hygrometric regulation does not exist with concrete or cement.

Give priority to the local approach, a vehicle for development

According to the Organisation for Economic Cooperation and Development (OECD), "the building sector has major impacts not only on economic and social life, but also on the natural and built environment" (OECD, 2003). A local approach makes it possible to give priority to short, low energy consuming industries, while exploiting know-how and the local labor force's capacity to learn the techniques.
The aim is consequently to take advantage of "constructive cultures" (knowledge and know-how) in order to factor in the local environment, the culture of inhabitants and their history. By relying on local potential and know-how, an experience, sometimes dating back a thousand years, can be exploited and have a fully-fledged place alongside industrial production.

The objective is to produce a "situated architecture", based on economic development and local culture, in opposition to a so-called modern conception of "international architecture" (Fathy, 1999). It is essential to give priority to local diversity over the increasingly imposed global solutions.
Local decision-makers and peoples increasingly expect architecture to emerge from the regions and cultures of inhabitants. The examples of Mayotte or El Salvador have now proved their relevance. They have led to the construction of several thousand housing units by small businesses or local jobbers (*Box 2*).

Mayotte: 500 businesses produce 20,000 housing units
In the 1980s, the French island of Mayotte (150,000 inhabitants) decided to make social housing production an engine of local development. Over 20,000 housing units have been produced, structuring the entire production industry (from the manufacturing of raw earth blocks stabilized with cement in small units, to the training of craftsmen and management within a cooperative framework), and allowing a fabric made up of over 500 small businesses to develop at the local level.

The building industry, when it is developed on the basis of a planned policy, easily fits in with attractive "turnkey" solutions. These solutions offer efficiency and meet specifications that set ambitious objectives in terms of quantity and time scales. Creating a scale effect attracts major industrial groups, whose processes and technologies can indeed offer efficient solutions in terms of production volumes. However, all too often they also bring architectural solutions that are not sufficiently adapted in terms of climate, social and cultural aspects.

These technology transfers are, indeed, dictated by major industrial groups' own logics and their international priorities. Their development strategies are based on their interests and do not depend on local interests, but on internal results. They can be factors of imbalance in countries where the economy is not based on a diversified corporate fabric.

The need to develop and the concern for effectiveness may prompt public authorities in emerging countries to call on imported solutions. Although this may prove to be necessary for major infrastructure, it ignores the fact that the building industry can also be structured at the level of the craft industry and create local production industries. Earth is available, often ready-to-use, and can be used without the need for complex and costly industrial processes. There is no need for energy-guzzling kilns, or extraction quarries requiring machines with a value that is completely disproportionate to the level of income of inhabitants.

This material often also uses know-how that is shared by all. It has numerous and diversified technical possibilities (solid walls, bricks, filling…), which correspond to know-how and organizational methods that are in line with the objectives of any development policy: to find the seed that will bear fruit for the economy, making the best possible use of local material and human resources.

Certain social organization systems make it possible to build durable and comfortable constructions at extremely low costs that can be up to 25% cheaper than conventional constructions.4 From rustic uses to more elaborate technical solutions, there is a potential for an entrepreneurial fabric, first and foremost made up of craftsmen, to develop.

The craft industry offers a great deal of flexibility in the choice of technical solutions and the distribution of investments. Moreover, it places the individual at the center of the economic system. It is time to fully exploit entrepreneurs' capacities to work for a development process, which is made even more sustainable by the fact that it is based locally and, therefore, on the local economy.

The choice of local materials, particularly earth, and production methods based on a local entrepreneurial network is not in contradiction with ambitious quantitative objectives. When the entire building industry is taken into account, it has a formidable effectiveness. The fragility caused by a too limited number of players, with a size that can sometimes be a handicap, is thus greatly reduced. The fact that this corporate fabric is locally-established and by nature flexible de facto makes it sustainable and ensures that it creates wealth.

Exploiting the complementarity of materials

In view of the housing challenge, which is notably related to exponential population growth, particularly in developing countries, earth is a material that cannot be ignored. Its cost and the way it can be adapted to economic and cultural developments make it a material that is complementary to heavier industrial solutions. The global housing problem will not by resolved by giving preference to one single material. Cement and earth are inextricably linked and are complementary to each other.

This virtuous circle may be slower to implement – this is its main handicap. However, it is less costly and offers infinitely more guarantees in terms of its capacity to be sustainably established in a region and to make the building sector a core engine of development.

This close link between an available material, a constructive culture and local know-how that can support a technical skill and, finally, the local wealth that can be created, make earth a coherent solution for local development. It offers a solid alternative to heavy industrial solutions. The over-systematic use of the latter makes us forget that technology is the sociology of the technique, i.e. the capacity to use local know-how and resources and turn them into production methods, and therefore to use the local economy. However, it is still important to recognize the complementarities and intelligence of mixed solutions that allow the greatest possible benefit to be gained from the intrinsic qualities of different types of material.

Footnotes

[1] Branch of applied geology that studies the chemical, physical and biological features of soil, its evolution and its distribution.

[2] The City of Shibam is listed as a World Heritage Site as mankind's most ancient skyscraper city (most of the buildings date back to the XVIth century): it was built entirely using bricks moulded in raw earth.

[3] Gray energy corresponds to the sum of all the energy required for production (extraction, transport and conversion of raw materials), manufacturing, implementation, use (including maintenance and repairs) and, finally, for recycling materials or products.

4 For example, in 2010, the post-flood reconstruction program in Bandiagara, Mali, financed by the Abbé Pierre Foundation and Misereor was implemented at a cost of EUR 40/m², whereas “classic” social housing programs cost over EUR 160/m².

References / **Anger, R., Fontaine, L., 2009.** Bâtir en terre, du grain de sable à l’architecture, éditions Belin, Paris // **Fathy, H., 1999**. Construire avec le peuple, éditions Actes Sud. // **Gandreau D., Delboy L., sous la direction de Joffroy T., CRAterre-ENSAG, 2010**. Patrimoine mondial, Inventaire et situation des biens construits en terre, UNESCO/CH/CPM, Paris // **Guillaud, H., Houben, H., CRAterre, 2006**. Traité de construction en terre, éditions Parenthèses, Marseille. // **OCDE, 2003**. Environmentally Sustainable Buildings: Challenges and Policies, OECD publications, Paris. // **UN Department of Economic and Social Affairs, Division for Sustainable Development, 2010**. Buildings and construction as tools for promoting more sustainable patterns of consumption and production, Sustainable Development, Innovation Briefs, Issue 9, March. // **UN News Centre, 2005**. World Habitat Day: By 2050, 3 billion human beings face the prospect of living in slums, press release, October 3.