Paper No: 731 Sustainable Ecological Habitat: Towards Zero Energy Building

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Abstract

A suitable design and building of a sustainable habitat is an essential condition for people's living worldwide and a fundamental factor to reduce the severe environmental impact provoked in many areas of our planet. This project deals with a domestic habitat located and built in a typical rural community in a prevailing temperate region of Mexico, and focuses on the application of bioclimatic design integrated with sustainable technologies, based on the use of renewable energies, using local low energy intensity earth building materials and appropriate construction systems. The objectives of this project are aimed at reducing construction costs whilst providing indoor thermal comfort for the occupants and high levels of self-sufficiency in energy and water, as well as integrating a sustainable sewage system, a waste treatment and food production systems. This approach is also aimed at improving the inhabitant's economy and quality of living as well as the environment. This project has been developed to serve as a demonstrative example to become a representative habitat in a low energy community with sustainable regional design, based on the application of building and community integrated appropriate renewable energy technologies, meant to provide a suitable alternative for those communities whose people live under the line of extreme poverty conditions so that building houses applying this approach can be more affordable. Results and experiences from this work have shown that this project can be applied for promoting a multiple effect with global benefits, aimed at reducing the severe environmental damage, whilst providing the basis for a favourable social equity and a better understanding of the responsibility of preserving our planet and its valuable resources and ecosystems, and that the lessons can be eventually learnt and applied in communities for the benefit of the existing and new generations.

Keywords: Sustainable Habitat, Zero Energy Building, Renewable Energies.

1. Introduction. Provision of a Habitat

The provision of a suitable habitat is an essential component for people's living worldwide. However, there is a large house deficit in many regions of the planet. Other situation relative to housing provision deals with the increasing percentage of people moving from rural to urban areas. According to the United Nations Human Settlements Programme [UN-Habitat, 2007], the world is at the dawn of a new urban era. Half of the Humanity lives now in towns and cities. (The world population is estimated in 6, 720 million by end of 2008). It is estimated that by 2030, two-thirds of the world's people will be urban dwellers. Apart from the housing deficit and the rapid urban growing in many cities of the world, the lack of basic services for housing is provoking unhealthy conditions in various regions of the planet. At the beginning of the third millennium 1.2 billion people of the world survive in housing conditions that are unhealthy and precarious, including 100 million who are homeless in urban areas alone. If rural areas are included, the number of people living in housing under extreme poverty conditions can well be twice as much. At least 600 million urban residents in developing countries, with these numbers swelling everyday, already live in housing of such poor quality and with such inadequate provision of water, sanitation and drainage that their lives and health are under continuous threat [UN-Habitat, 2007).

This housing poverty condition is best exemplified by the sprawling slums and informal settlements in the cities and towns of developing countries around the world. UN-HABITAT has estimated that the annual need for housing in urban areas of developing countries alone will be around 35 million units from now until 2010. The bulk of these, some 21 million units, are required to satisfy the needs of the increasing number of

households in the planet for the next 20 years. The rest is needed to meet the requirements of people who are homeless or living in inadequate housing. This implies that, some 95,000 new urban housing units have to be constructed each day in developing countries to improve housing conditions to suitable levels. However, under the present circumstances and taking into account the housing rate in these countries, it is very unlikely that this demand can be fulfilled. Some factors that prevent people to have access to an appropriate house worldwide are mainly due to the high cost of construction, including land cost, and to the lack of knowledge and information available for appropriate construction methods.

2. Factors Affecting Housing Availability in Mexico

Mexico is a country of 106 million inhabitants and the housing deficit is over 12 million houses, being more evident in areas where people live under the line of extreme poverty conditions, which represents more than 50 percent of the total population. More than 200, 000 communities located in rural, disperse and remote areas, are representative of this situation, mainly found in the southern and low central parts of the country.

The lack of housing in Mexico is a severe problem, and to meet the demand, the annual dwelling construction rate needs to be of about 600,000 houses from now until the year 2025. This deficit of houses in Mexico is mainly due to the following factors:

- Demographic growth
- Uneven geographical population distribution
- Lack of land planning
- Land use speculation
- Loss of self-construction capabilities
- High cost of conventional building materials

Certainly, the provision of a house is a basic need which has a significant social and economic value for the occupants. The lack of housing in the majority of urban and rural areas of Mexico and its relative high cost provokes social conflicts, affecting people's health and preventing the family to have a suitable integration. This situation is aggravated for the migration of people, mainly to the US, in search for better job opportunities for their families. Inadequate housing offer, at affordable prices in urban areas is the main factor that causes an irregular land occupation, as well as frequent moving of people from out-of control urban locations to high risk zones or environmental protected natural areas, and this in turn results in paying very high costs for urbanization and provision of basic services, and very often, irreversible ecological damage which in some cases has irreversible conditions in the country.

3. Alternatives to Lack of Housing and a Suitable Design Approach

In order to provide alternative solutions for the provision of suitable housing and to reduce the current deficit n Mexico, some alternatives have been proposed and applied in previous works [García Chávez, 2002, 2004, 2006]. These alternatives can be summarized as follows:

- Use of innovative low cost building materials
- Self-training of construction processes of potential builders from the local communities
- Integral programs that include the development and application of productive projects for social and economical benefits
- Application of sustainability throughout the construction process

The application of this approach has been proved to be successful in offering people the opportunity to build homes to meet their needs and to have access to a dwelling at affordable costs in the country, whilst preserving and improving the environmental conditions of the selected communities for application of these sustainable alternatives.

As to low cost building materials, Mexico has a large availability and large quantities of indigenous or traditional construction materials, such as earth, adobe, stone, bamboo, thatch, etc., which are available in most locations of the country. However, the use of these materials has been declined due to the loss of capability using traditional construction methods in their application by local builders. Certainly, one of the building materials widely available in the country at a very low cost is *raw earth or adobe*.

4. Environmental Implications of the Energy Use Patterns in Buildings

Most of the energy consumption in the world comes from fossil fuels and this is provoking a severe environmental damage. Global warming, ecosystems deterioration and climate change are some of the consequences affecting our planet. As to the building sector, the majority of modern buildings built after the 1950s consume extensive amounts of energy to heat, cool, ventilate and light the interiors, as well as for water heating and cooking. This provokes a waste of energy and then the buildings become greatly dependent on fossil fuels, which in turn cause high levels of pollution in the environment. This situation needs to be changed and the use of renewable energy resources with a sustainable approach is a key factor to make this change possible and this eventually will contribute to protect the natural environment and to revert the deterioration of our precious blue planet, which in turn can eventually improve the people's quality of living.

5. Case Study. A Sustainable Ecological Habitat: Towards Zero Energy Building

This research work deals with a domestic habitat located and built in a typical rural community in a prevailing temperate region of Mexico (Figure 1), and focuses on the application of bioclimatic design integrated with sustainable technologies, based on the use of renewable energies, using local low energy intensity raw earth building materials and appropriate construction systems.

Figure 1. Overview of Case Study Building

5.1 Objectives of the project

The objectives of this project are aimed at reducing construction costs whilst providing indoor thermal comfort for the occupants and high levels of self-sufficiency in energy and water, as well as integrating a sustainable sewage system, a waste treatment and food production systems.

5.2 Use of local building material and self-training programme

One of the basic components of this project was the self-training of local builders in the construction process and particularly in the use and application of earth as the main material. The approach has to be applies as local builders have lost the capacity to make adobe and to applied properly. Therefore, local builders were trained on how to build and applied raw earth obtained directly from the construction site, and dried subsequently under the action of the intense solar energy available (Figures 2 and 3). Using adobe as the basic building material resulted in a significant reduction of the cost of the project.

Fig. 2. Local builders preparing the adobe

Figure 3. Adobe ready to be sun dried

5.3 Case Study Project Description

The Case Study Building is located in the community of Villa de Allende, Mexico, in a remote and dispersed location in a typical rural region of Mexico, 120 Km Northwest of Mexico City, where there are no basic services, such as potable water, electricity, sewage, etc. It is expected that the resulting experiences of this project can generate a multiple effect in the region, as well as to improve the environment and to establish the basis for improving the economy of the local inhabitants by means of a systematic training for a directed supervised self-construction programme.

The project has two stories. The lower floor includes a living room, a dining room, a kitchen, a study room, two bedrooms and two bathrooms, as well as a greenhouse and life supporting systems area. The upper floor has a bedroom, a study room and a bathroom (Figure 4).

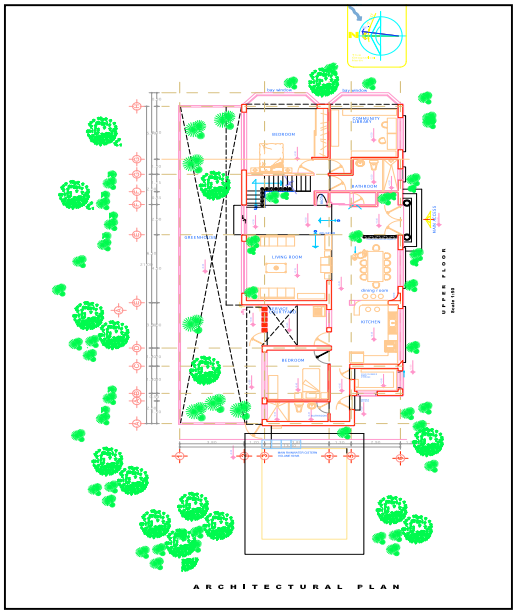

Fig. 4. Ground Floor of Case Study

A 3D model of the project was built and used for solar studies under a heliodon and real skies, which was useful for optimizing the sun control and the solar systems applied in the project (Figure 5).

Fig. 5. 3D model of the project used for solar analysis

5.4 Bioclimatic Design Approach

The project was designed using harmonic proportions, integrated with bioclimatic principles, mainly using a suitable orientation of architectural spaces, other bioclimatic strategies included: Thermal mass properties of the adobe, as well as natural ventilation and solar control for natural climatization of all the spaces of the project. The application of shading devices for solar control in the envelope and the principles of natural ventilation prevented the use of any type of artificial air conditioning systems throughout the year, reducing also the use of electric lighting during the day by applying daylighting design principles in the building.

5.5 Sustainable Approach and Technological Systems of the Case Study Building

The use of low cost and low impact energy local building materials for the construction will prevent the emission of greenhouse gases. The integration, operation and maintenance of systems using renewable energies has a high ratio, relative to energy from fossil fuels. The particular location of the project has a low environmental impact over the project's life cycle. Solar energy, using photovoltaic systems, are applied in the construction for electricity, as well as for cooking using solar ovens, for water heating, solar pumping, among other uses. Pedal power was proposed as a back up system for water pumping. Rainwater collection system will be collected in two cisterns, one located in the roof of the first floor of 12 m^3 and the main one of 60 m^3, located on the external ground floor (Figures 5 and 6).

Fig. 6. View of rainwater storage and sewage systems

The disposal of served waters includes an innovative system called "Zero Discharge", which separates "grey" and "black waters", to be treated in an anaerobic digestor and a wetland. These processes are "passive" and have a very simple and low maintenance procedure (Figure 7). Food is preserved in a "cold chamber" that works with natural physical principles.

Fig. 7. Zero Discharged sewage system of the project

Therefore, this case study building was designed and built to preserve environmental quality, as well as to conserve energy through efficient conscious design, reducing water use and waste and consumption through sensible design. This approach contributes to reduce environmental damage. The next stage of this research includes a monitoring process of the hygrothermal performance of the building for comfort evaluation, as well as of all the sustainable systems for energy, water and the other natural resources applied in the project.

6. Economic Considerations and Benefits

The direct use of the local building materials and their large scale production, as well as the work of hand, also widely available in the location, provides the basis for a good economic and flexible performance of the construction. However, the most significant economic efficiency is achieved during the operation of all the sustainable systems implemented in the construction, as there is no use of conventional electricity from fossil fuels, and the water supply comes from the rain and is consumed without the use of conventional electricity. Pay back period for this project was estimated in 18 months. Therefore, the operation and maintenance cost of the construction are very low. Furthermore, the efficiency of design, construction, maintenance, operation, reuse, and recycling of this sustainable construction, using "free" low-tech natural resources, is oriented to provide long-term economic benefits to improve the economic base of the region, boosting the local economy and promoting the application of the experiences and results in some other regions of the country, which can also be extrapolated globally.

7. Conclusions

This project has been developed to serve as a demonstrative example to become a representative habitat in a low energy community with sustainable regional design, based on the application of building and community integrated appropriate renewable energy technologies, meant to provide a suitable alternative for those communities whose people live under the line of extreme poverty conditions so that building houses applying this approach can be more affordable. Results and experiences have shown that this project can be applied for promoting a multiple effect with global benefits, aimed at reducing the severe environmental damage, whilst providing the basis for a favourable social equity and a better understanding of the responsibility of preserving our planet and its valuable resources and ecosystems, and that the lessons can be eventually learnt and applied in communities for the benefit of the existing and new generations. Furthermore, The sustainable principles of this project were suitably integrated with the architectural and bioclimatic design to come up with a construction that has a sound lasting aesthetic impact on its surroundings, promoting a suitable and balanced environmental, social, as well as an economic performance, which can be applicable on a wide global scale to provide the basis for a sustainable ecological habitat which can be oriented towards a *Zero Energy and Resources Habitat*, aimed at improving the environment and the quality of living of people.

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