GUARROTXENA, NERE / ORDUZ, ALEJANDRO /
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SUSTAINABLE VS. CLIMATE ARCHITECTURE

INDEX

1.1 BIO-CLIMATIC ARCHITECTURE
DEFINITION

Author: Alejandro Orduz

Publishers comment: The author of this article mainly combine varies parts of other publications to give the reader a first glance on the topic. Unfortunately this article do not work with quote notes. The last pages provide the reader with a list of sources on which this article refers.

Bio-climatic construction and design processes are based on a climate and environmental aware architectural practice oriented to achieve an efficient use of energy during a building's lifetime.

The term 'bio-climatic architecture' was coined by the architects' Victor and Aladar Olgyay in the early 1960s at the School of Architecture and Urban Planning of Princeton University. Thereby, both scholars aimed to respond to the emerging environmental concerns of growing sectors of society in the late 1960s. However, with the Peak Oil Crisis of the early 1970s, this approach gained significant momentum and became widely implemented.

Thereby, practitioners designing bio-climatic architecture seek to generate optimal comfort conditions on the smallest energy budget possible, thus reducing the building's overall carbon footprint and maintenance costs to a minimum during the building's lifetime. Therefore, practitioners constructing bio-climatic architecture often use high-tech components to increase the building's energy efficiency. Nonetheless, it is of crucial importance mentioning that the bio-climatic architectural discourse is centered on the energy performance of erected buildings, disregarding the

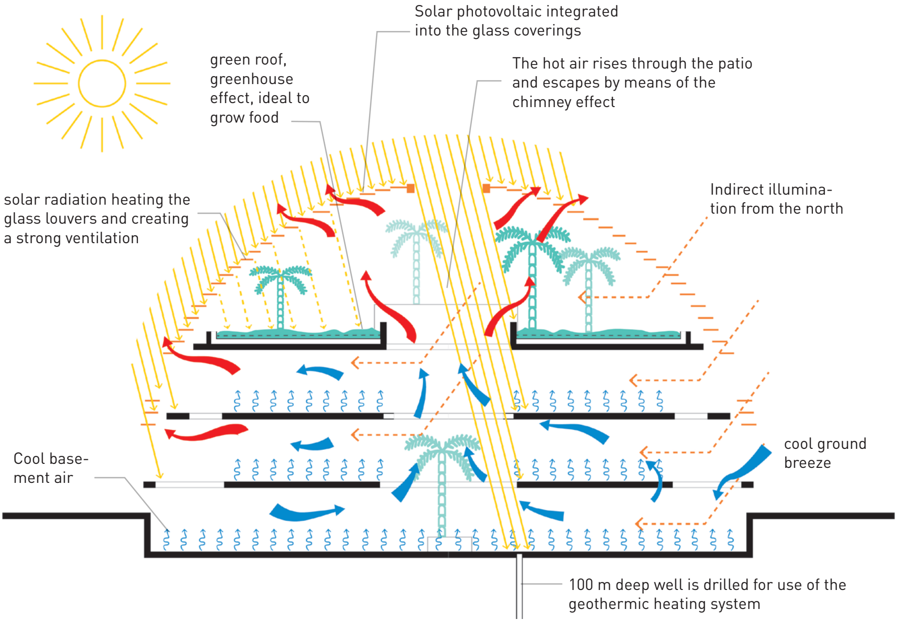

Fig. 1 Principles of bio-climatic Architecture

energy flows running into the material's extraction & transportation and the building's demolition.

In general, some of the key common practices that frame bio-climatic architectural practice are:

[1] Exhaustive site study: topography, wind direction, sun trajectory, precipitations and vegetation of the specific to the site's micro-climate.

[2] Efficient building's formal solution [compact vs. extended]. The volumetric solution of a building has a decisive impact on its energy expenditure. Cold zone: a compact building mass means a lower energy expenditure, since heat retention is optimized. Hot zone: a greater amount of facade exposed to the exterior enables a better ventilation, reducing the building's the energy expenditure on air cooling systems.

[3] Use of plants in exterior areas, facades and roofs in the quest of cooling the building and purifying the air.

[4] Use of efficient insulation systems in all the building's envelopes.

In addition to these considerations, it is crucial to mention that bio-climatic architecture has a strong linkage with leading technological developments in the construction field: a growing number of buildings have integrated complex computational systems that seek to ensure the most efficient use of energy by strongly regulating the interaction of building and micro-climate.

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The concept of sustainable architecture is rooted on the notion of sustainable development promoted by Norway's Prime Minister Go Harlem Brundtland, World Commission on Environment and Development in 1987. In the so called 'Brundtland report' or 'Our Common Future', the United Nations proclaimed Brundtland's concerns on sustainable development. Thereby, thy aimed to reconfigure the relation between economic growth and environmental and social concerns in a local and planetary scale. Thus, the report 'Our common future' declared that ‚sustainable development' is:

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

This report was an important turning point to re-frame the conception of society's development, by placing economic growth on the same level than environmental and social concerns. Since 2015, the wide concerns of the 'Brundtland's report' were compiled in the 'Sustainable Development Goals', which are 17 interrelated planetary goals to be achieved by 2030. Sustainability became hereby and due to the

Fig. 2 Sustainable Development Goals

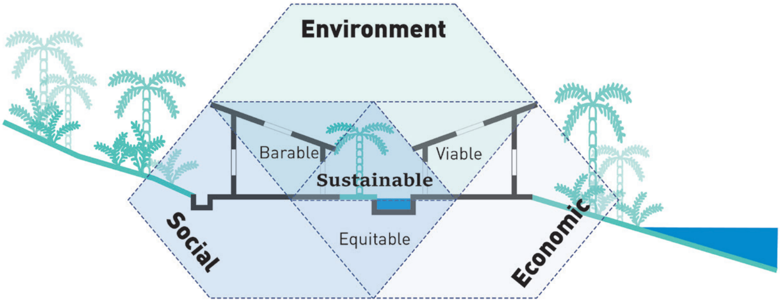

Fig. 3 Principles of sustainable architecture

deep environmental crisis, an important milestone in the Global Agendas.

In the realm of architecture, sustainable construction and design is the application of sustainable development principles to the design, construction, and operation of buildings. After the current discourse, the aim of sustainable practice is to minimize the consumption of material resources and energy in the material life of a building. Thus, there are big concerns on the material extraction, construction, deconstruction, disposal and reuse processes related to the building's site. Thereby, sustainable architectural practice has a systemic approach conceiving the building not only as a built momentum, but as part of a broader material life cycle.

In terms of the design process, common practices to the architects designing and building sustainable architecture are:

[1] Site study: topography, wind direction, sun trajectory, precipitations and vegetation of the specific to the site's micro-climate.

[2] Innovation and use of traditional construction techniques.

[3] Awareness of the complexity of material supply chains to the specific building's site.

[4] Systemic design of the building's material flows. Focus on water recycling loops, alternative sources of energy and construction material reuse.

However, the current discourse on sustainable architecture oftentimes doesn't approach the social related aspects with the same preponderance of the economic and ecological components. Thereby, the material and economic decisions made for a building are deeply entangled to social problematics. A big part of the materials are extracted via precarious supply chains around the world that trigger grave social inequities. Therefore, an important claim for future sustainable architecture practitioners is to deeper analyze the social consequences triggered by material and operational decisions. This might enrich the debate on the field and truly contribute to achieve the urgent goals set by the Global Agendas.

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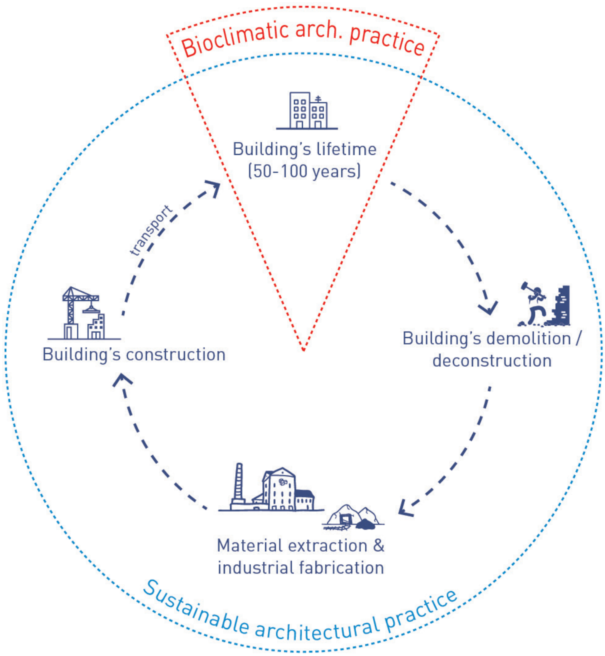

Fig. 4 Diagram sustainable vs. bio-climatic architecture

So which are the main differences between bio-climatic and sustainable architecture?

The first major difference arising is the 'systemic' approach of the sustainable architecture practice vs. the 'momentum' approach of bio-climatic architecture. As seen in fig. 5, the bio- climatic buildings only regard the 'built momentum' of a construction's lifetime. In contrast, the sustainable architectural practice regards the material's systemic loops, from the extraction to the demolition and reuse.

Thereby, in the ideal vision of a sustainable building, the building's components get recycled after it is demolished and are reused for the fabrication of new construction items for future buildings. Thus, the recycling, up-cycling and natural degradation processes are central to a building's environmental sustainability. However, sustainable and bio-climatic architecture are strongly linked to the immediate climate cycles. Practitioners of both strands are concerned in having for example efficient energy systems and circular water flows.

Nonetheless, the relation to efficiency is different in both types of architectural practice. Whereas the bio-climatic designer is centered in achieving the most energy efficient building that technology allows, the sustainable practitioner is also concerned in achieving a good energy balance i, but it is not his/her only goal. As aforementioned, the sustainable architecture practitioner regards the building construction in a more holistic way, taking into account the complete material cycle and a wider set of interests relating the entanglement of social, environmental and economic problematics related to a precise building context.

Adding to that, even if regarding the complete energy expense of a building during its whole life cycle (see fig. 6), the energy expenses of bio-climatic buildings tend to be dramatically higher if regarding the building's material life before and after the building's operation. This is due on the one hand to the use of high-tech and/or standardized building components that always rely on long supply chains and travel thousands of kilometers to arrive to the building site; and on the other hand, to the use of highly polluting materials that take decades to biodegradate. Thus, bio-climatic architecture tends to be more an architecture of 'green gestures' that in many cases are not very influential in terms of energy efficiency and end up triggering high energy expenses along the overall material cycle of a building.

Contrastingly, sustainable buildings in the ideal case tend to use low energy rates along the complete mate-

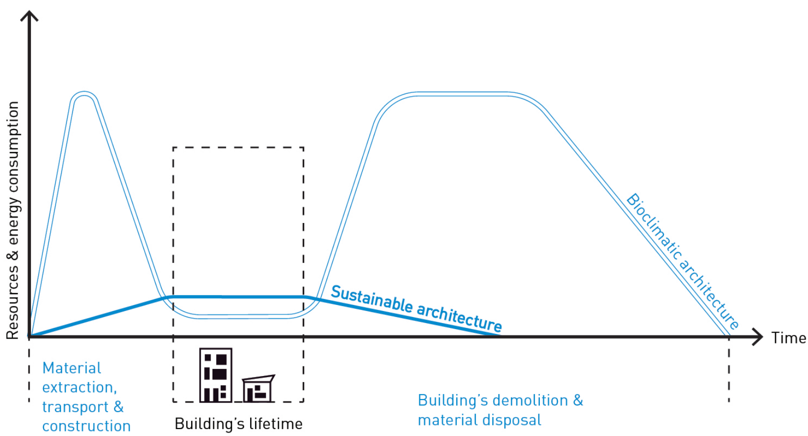

Fig. 5 Energy ratio sustainable vs. bio-climatic architecture

rial cycle of a construction (see fig 6). Practitioners of this strand tend to use local materials and passive energy approaches that end up having a better overall balance throughout the whole material cycle. Adding to that a sustainable architecture practice uses mainly local production chains, which ends up not only in a better energy performance, but also enabling innovation in the traditional production techniques and the strengthening of the local economies and community ties. Hereby, in the ideal case, the building becomes a true milestone for its community.

Albeit, it is crucial to mention that architecture projects can profit from both approaches. A proper dialogue between the both might trigger a more innovative sustainable architecture practice on the one hand and a more social aware bio-climatic architecture framing ways to dignify all workers along the construction supply chains on the other. All in all, the debate on sustainable and bio-climatic design approaches opens numerous questions on how the built environment interacts with the environmental crisis, the social inequities and the systemic material flows.

To conclude this chapter, it is important to emphasize the importance on having a deep discussion on bio-climatic and sustainability concerns at the very beginning of the architecture project. (see fig. 7). As time passes by and the project becomes consolidated, the practitioner can make less decisions, while the economic and environmental costs start running. Once the building starts its construction the decision's spectrum is already very narrow.

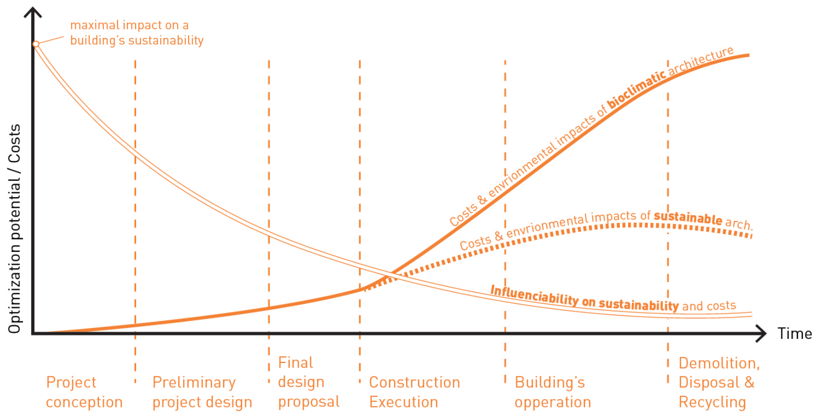

Fig. 6 Life cycle and possibilities of influence sustainable and bioclimatic architecture.

3.1 SUSTAINABLE AND BIO-CLIMATIC ARCHITECTURE IN CUBA
HISTORICAL PERSPECTIVE

Author: Ihordan Ernesto Miro

Cuban bioclimatic design is strongly associated with the architecture developed by the indigenous folks before the Spanish colonization. This theme responds to a typology of rural essence which is currently being replaced by new models related to concepts of development, modernity, quality and well-being" (Couret, Bioclimatic architecture in Cuba, January 2015).

Bioclimatic development in Cuba has been evidenced in all stages of architecture. An example of this topic is the vernacular architecture which responds to the context in which it is located: climate and available natural resources, being a reflection of traditions and ways of life; rural architecture built from locally available materials, is satisfactorily adapted to the climatic conditions of the environment: maximum protection against sun and rain, "minimum thermal gain in interior spaces due to the use of organic materials with a low global coefficient of thermal transfer , and maximum permeability to the passage of air as the thermoregulatory mechanism par excellence in hot and humid climates. In coastal architecture, the house directly linked to the coast was raised on stilts to assimilate the changes of the tides and avoid humidity by capillarity; The roofs, although light and inclined, were not made with palm guano, but with other materials, such as pottery tile or galvanized steel plates (always on wooden supports and with high struts), and the house was surrounded by a portal or perimeter gallery that guaranteed sun protection and allowed you to enjoy the sea breeze. The houses that used mixed codes of a higher standard were surrounded by perimeter galleries that protected the interior spaces from the Sun, generally organized in three bays that allowed total spatial transparency in the central module of a social nature (the sleeping rooms were located in both lateral bays). In the sloped roofs, usually hipped, some additional resources of bio-climatic design were used, such as convective ventilation with monitors or skylights in the upper part, or the double ventilated roof with openings in the upper plane." (Couret, Bioclimatic architecture in Cuba, January 2015)

Following the above, the traditional compact city model was gradually transformed "to better adapt to the conditions of the tropics. The balconies appeared to enjoy the outside breeze; the portals, in principle, giving the squares as a transitional space to protect themselves from the sun and rain; the stained glass windows to sift the intense sunlight, and the dimensions of the openings closed with blinds that allowed to regulate the passage of light, wind and visuals were increased. The patios were filled with vegetation that provided the necessary shade to maintain an interior microclimate that was cooler than in the exterior spaces (streets and squares), also thanks to the thickness of the walls, little exposed to the sun" (Couret, Bioclimatic architecture in Cuba, January 2015).

"The original model of garden city emerged at the end of the 19th century, although it was not totally applied, in practice it influenced some urbanizations developed in Cuba at that time, such as El Vedado, in Havana, and Vista Alegre, in Santiago de Cuba. In them, there is a predominance of the green area, both in public spaces (streets with flowerbeds and wooded parks), and in the built plots (gardens and patios). The positive influence of vegetation in these cases is very well known. The effect of living shade, which reduces solar radiation and heat absorbed by buildings and pavements, counteracts the effect of the urban heat island, improves the thermal microclimate, purifies the air and modifies wind flow patterns" (Couret, The bioclimatic architecture in Cuba, January 2015).

In the 40's, the modern movement in architecture and urbanism arrives in Cuba, "which had a justifying interpretation in humid tropical climates, in which the buildings had to be narrow to facilitate crossed ventilation and sufficiently separated from each other to guarantee the recovery of the wind after it affected each building" (Couret, La arquitectura bioclimatica en Cuba, January 2015).

Within the modern movement of architecture in the fifties, "contributions such as interior-exterior spatial transparency, mediated by textured wefts of light and shade, such as the lattices, or adjustable mobile ones such as the multiple blinds, or direct ones through clear or coloured glass, stand out; solar protection through large eaves, portals, terraces, galleries and balconies, and the presence of vegetation, which dilutes the limit between interior and exterior space" (Couret, La arquitectura bioclimatica en Cuba, January 2015).

The development of massive housing after the triumph of the Revolution was based on the modern movement and despite achieving a cross ventilation, the conditions of the interior microclimate are more unfavorable in the buildings of these developments. "Therefore, in the urbanizations and buildings of this type, the thermal gain is increased, which is the original cause of discomfort" (Couret, La arquitectura bioclimatica en Cuba, January 2015).

CURRENT TRENDS

"Although there is a real need to save

resources and a willingness to move towards more sustainable forms of development that include the efficient use of energy, there is not yet widespread awareness of the impact of architectural design on the achievement of these objectives, or at least not of how this aspect should be addressed. In rural housing, traditional models and materials (natural and local) are being replaced by thin, horizontal reinforced concrete roofs as a more durable and higher quality solution, without taking into account their poor thermal performance and difficulty in evacuating rainwater. On the other hand, tourism is mainly developed from air-conditioned hotel accommodations (except for the lobby in some cases), where energy consumption in air-conditioning rises beyond what is advisable, due to the absence of an adequate bioclimatic design, which is manifested in the lack of solar protection of the exterior enclosures and excess of glazed openings exposed to the sun" (Couret, La arquitectura bioclimática en Cuba, January 2015).

FUTURE PROJECTION

"We are currently working on the revision and updating of the standards for bioclimatic design, with a view to adapting them to the new concepts and facilitating their use by professionals, as well as on the development of software. Many professionals will have to be "recycled" in their postgraduate training, in order to seek a greater understanding of these aspects, as well as a sufficient level of knowledge to allow their practical application in projects, with the help of appropriate standards and software" (Couret, La arquitectura bioclimatica en Cuba, January 2015).

"The future Cuban architecture will necessarily have to be bio-climatic so that it can also be sustainable, and for this purpose, it will have to take up again the essence of the best Cuban architecture of all times, which is, beyond its formal and temporary manifestations, in the interior-exterior spatial transparency, mediated by light and shadow wefts, permeable to the passage of air and light, and protected from sun and rain, where vegetation plays a leading role. Future generations deserve a legacy of equal or superior quality than that inherited from previous ones. This is also an essential principle of sustainable development" (Couret, La arquitectura bioclimatica en Cuba, January 2015).

CONTEMPORARY ARCHITECTURE IN CUBA

At present, there is a regression in contemporary architecture regarding this topic. "The works present excess of glazed surfaces exposed to the sun without protection, which do not comply with the current standards (NC 220.2009) and generate undesired reflections toward the urban context, as well as the penetration of direct solar radiation in the interior spaces, which causes dazzling and increases the energy consumption of artificial air conditioning systems" (Couret, Arquitectura y bioclimática: Contradicciones en Cuba, November 2014).

Despite the development and training of architects together with research and the normative system, contemporary architecture does not offer adequate solutions to the climate "because it is not precisely architects who ultimately decide the design solution, but investors or other decision makers who generally start from preconceived ideas about the desired project from their own paradigms, which are generally conditioned by images coming from the architecture of developed countries, whose climates are generally cold and therefore totally different from Cuba's. In fact, a good part of the projects considered in the case study do not respond to designs elaborated in Cuba, but to imported solutions, imposed by the foreign party. That is precisely the fundamental cause that underlies both the professor's opinion that bio-climatic design limits the architectural expression and creativity of students, or of the investor or decision-maker who dreams of the glass box that he associates with the image of development. It is a confluence of ignorance and lack of self-evaluation, which generates a high vulnerability to foreign paradigms, which in many occasions are not even appropriate in the societies where they come from" (Couret, Arquitectura y bioclimática: Contradicciones en Cuba, November 2014).

3.2 REFERENCE PROJECTS IN CUBA

BIO-CLIMATIC ARCHITECTURE

Author: Ihordan Ernesto Miro

Fig. 7 Main facade of the Santa Isabel &Olga Pérez Apartments´ building, 1955

"This work of the modern movement located in Nuevo Vedado, Havana reflects the new aesthetic codes in correspondence with the site and the environmental conditions at that time. This house shows a repertoire of elements derived from taking up again the climatic conditions according to the internal comfort. In its development, 30 percent of the plot's total uncovered area is prioritized. It is linked to lateral corridors with three meters of separation, garden and patio which are essential for the climatic regulation of the housing since it allows the ventilation in a natural and crossed way what homogenizes the thermal conditions and guarantees widely the exchange of the air and the evacuation of the heat in the interiors. The presence of vegetation in the courtyards does not significantly influence the increase of the relative humidity of the air but it does reduce the temperature. In the building generally predominate concrete surfaces, repellent, smooth and of clear colors and in smaller degree of dark surfaces, this leads to that in occasions it can prevent that a visual comfort is obtained on the part of the passers-by that circulate next to the house when producing dazzle, this

Fig. 8 Interior of the house, 1955

is counteracted by the contrast of the polychrome of materials like the wood and the ceramics united to the vegetation. In the construction, the openings occupy more than fifty percent of the exterior surface, which shows a predominance of permeable areas over opaque surfaces, which constitutes a fundamental resource for the exchange of air and light. The window used is Miami used from floor to ceiling forming large cloths. In the interiors, carpentry is used, most of the time folding, which makes it possible to convert a single space into a large living room. The protection element used is the eaves allowing protection from the rain and the most critical times of the sun's journey, shades the top of the openings that in small occasions are made of glass and give the building a strong contemporary expression as an aesthetic characteristic. The roof, whose design and material affect the thermal environment of the premises, since it constantly receives solar radiation, is 20 cm thick and has a rough-hewn structure that prevents the transmission of heat absorbed from the inside in smaller quantities" (Rodriguez, 2011).

“This house with its patio, garden and other open spaces provides adequate air movement and natural lighting of the house which favors the comfort and carpentry of wooden blinds and glass shaded by the wide eaves manages to combine the climatic need with the aesthetic and perceptual of the user” (Rodriguez, 2011). Among the advantages of bioclimatic architecture in this building is the optimization of energy consumption which represents a minimum impact on the landscape. Saving energy in an ecological way will bring much lower bills. As for the disadvantages of this construction was present the high cost of their materials, at that time were imported.

Fig. 9 Access to the building on the first floor, 1955

3.2 REFERENCE PROJECTS IN CUBA

SUSTAINABLE ARCHITECTURE

Author: Ihordan Ernesto Miro

Fig. 10 Physical model of the Hotel Albatros Guardalavaca project, 2018

Among the efforts made by Cuba on the basis of an efficient and sustainable development program, the Albatros Guardalavaca Hotel in the completion phase located in the province of Holguín stands out. The hotel based on the concept of sustainability implies the creation and maintenance of the built environment, that is, directing all the efforts to minimize the natural resources.

"In the hotel, the participation of the client, the operator, the project company and the design team is practiced in the decision-making process of the project during all its phase from design to commissioning, evidencing a sustainable management with the objective of promoting responsible construction practices during the execution of the building, by ensuring that the impacts of the construction it generates are as low as possible. In terms of health and welfare, all hotel lighting should be LED, the specification and use in the project of materials containing asbestos is prohibited; minimizing the risk of water pollution in the facilities and ensuring the supply of users of buildings with water source; it must have a safe access to the parking lot and access to the hotel, among other specifications that ensure the comfort of the user from different points of view: lighting, comfort (thermal and acoustic) and safe access to the building. An increase in the building's energy efficiency beyond the required standards was planned in order to promote constructions that minimize operational energy consumption through adequate design, thus reducing CO2 emissions. A specialized bus service for employees has been set up, as well as solutions for clean transportation, thus improving people's mobility by providing alternatives to the private vehicle and encouraging projects on foot or by bicycle in the interest of healthier lifestyles. Strategies are employed to limit the consumption of drinking water in sanitary appliances and kitchens. Effective waste management is carried out on site. During the preparation and execution of the work, adequate protection of all the elements with ecological value existing around the work area was established in order to maintain and improve it before and after the construction of the work. Use of ecological refrigerants in all the hotel's facilities to avoid pollution caused by the building, taking into account the emission of greenhouse gases and ozone depletion" (Zayas, Gomez, & Rodriguez).

"As for the disadvantages of the hotel associated with sustainable architecture is in the short term budget, given that green building is more expensive than normal construction due to the

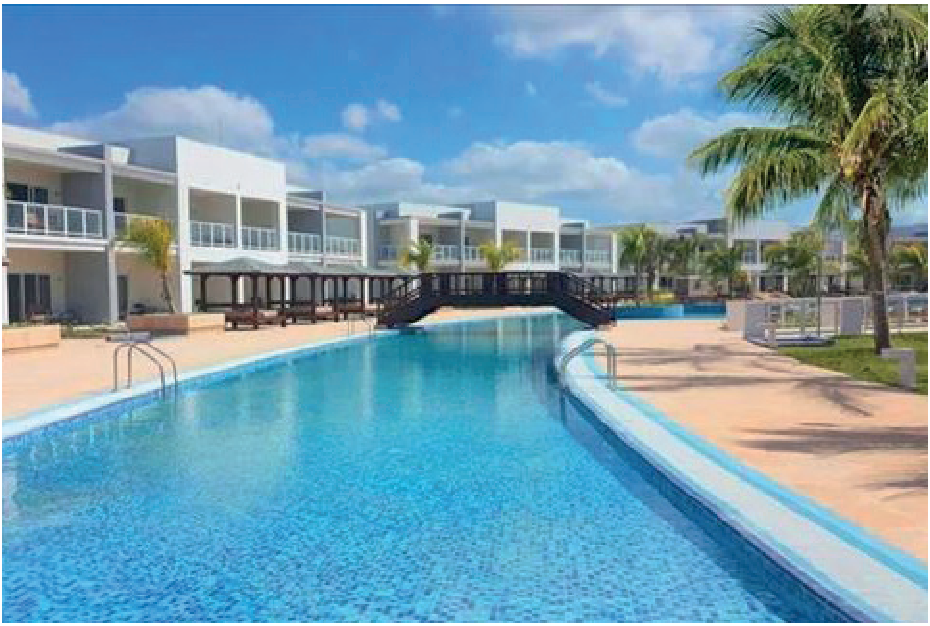

Fig. 11 Facilities of the Hotel Albatros, 2019

use of uncommon materials, which is expected to change in a few years, by demand. In addition, there is a delay in the knowledge of sustainable construction, because it is a new method. Many architects and builders may not be familiar with this type of architecture, so it is difficult to find suitable professionals" (Advantages and disadvantages of sustainable architecture, April 17, 2013).

"With respect to the advantages of sustainable architecture, it implies long-term savings in the budget over time associated with ecological design. It is worth mentioning its healthier impact on the environment, with the use of ecological materials: natural and made without polluting chemical products. It plays an important role in the reduction of waste, taking into account that in ecological architecture reuse and recycling are equivalent to a reduction and optimization (Advantages and disadvantages of sustainable architecture, April 17, 2013).

There are adaptations in Cuba regarding the concept of sustainable due to the geographical location and the existing bioclimatic conditions that are not the same as those of other regions, so there are contradictions between what is sustainable and bioclimatic. In this project, it is evident a great work regarding the unification of these two concepts

Author: Santiago Sánchez

**Mayan Tz'utujil
Comunitarian Educative Center
(San Pedro la Laguna, Guatemala)
Esperanza e.V., OYAK e.V. & Freundeskreis Zentralamerika e.V**
Sustainable Architecture

The Mayan Tz'utujil Comunitarian Educative Center (Cecot'z) was created by various German non-profit associations that promote education and the modernization of schools in Guatemala. It was also supported by a local architect who was the bridge of communication and coordination between the associations and the San Pedro la Laguna's indigenous community.

From a traditional vision of sustainable architecture, the project makes use of traditional construction techniques and materials typical of the region, also responding adequately not only to the climate of the place, but to the challenges given by the geography of this part of Guatemala, such as earthquakes, cyclones, and landslides. A mixed structure of clay and bamboo was used to achieve this, which is resistant to earthquakes and extreme winds. The first floor is built with clay bricks, while the upper level is light and flexible thanks to bamboo. All these materials are extracted from the area, which allows, on the one hand, to reduce costs and avoid extensive supply chains, foster the local production, but also allows to work directly with local techniques

Fig. 12 - Education center Cecot'z, Bamboo Structure. URL https://nabek.de/projekte/lehm-und-bambus-in-schulbau

Fig. 13 - Education center Cecot´z, Interior. URL https://nabek.de/projekte/lehm-und-bambus-in-schulbau

known in the community and opens the opportunity to include local labor.

This project's sustainable character goes beyond the material aspect, as the initiative seeks to promote education in Guatemala but does not seek to impose foreign educational models. Instead, it seeks to promote education from the indigenous Mayan vision, allowing for the empowerment and strengthening of a community victim of violence, state neglect, and an intense cultural assimilation process that puts the indigenous Mayan population in danger of disappearing. That is why working together with the Association of Mayan Educational Centers guarantees that a traditional education model will be sustained in the long term, one that promotes the practices and beliefs of the population. Finally, European organizations are working to promote a traditional educational model in a population that has been hit by wild tourism (mostly European and American) in urban, economic, and cultural terms. This is a small way to compensate for the tourism industry's damage to the region's indigenous people. (Heringer, A (2007) METI school)

Author: Santiago Sánchez

METI School (Rudrapur, Bangladesh)
Anna Heringer
Bioclimatic Architecture

The METI School in Rudrapur, Bangladesh, was designed by architect Anna Herninger for the NGO Dipshikha, which seeks to address the lack of educational and cultural infrastructure in the countryside to face the constant migration to the cities and provide the population with independence and a sense of identity around their education[2]. On numerous occasions, the project has been recognized as an example of sustainable architecture, both in technical and social aspects. However, in this case, we will focus on its also outstanding bioclimatic answer.[2]

Rudrapur is located in northern Bangladesh. Its climate is characterized by high temperatures throughout the year (annual average of 24.3 °C) accompanied by heavy rainfall between June and October and cool winds from the Himalayas.[3] As a response to this climate, open architecture is required to allow the passage of fresh air and generate large covered surfaces, capable of providing shade and rain protection.

The METI School proposal begins with the correct orientation for the particular lot and differentiated facade solutions according to the orientation. While the main facades are directed to the east and west, perpendicular to the sun's path to receiving the most light to the interior, they are critical facades in terms of the solar radiation they receive.

The western facade, which is the most critical, is protected by lush vegetation that substantially reduces the sun's impact during the afternoon. Besides, the facade is quite closed

Fig. 14 - METI School, Exterior view. URL https://www.anna-heringer.com/projects/meti-school-bangladesh/

Fig. 15- METI School, Interior view

and is built with rammed earth, a material with low heat transfer capacity. As for the east facade, the response is similar on the first floor, while the first level creates a wide corridor with a woven facade that serves as a thermal buffer and protects the wall of the classrooms inside from the sun. In general, both facades allow the passage of air currents that come mostly from the west. Either through the openings in the earth wall or through the bamboo fabrics that encloses the first floor.

This mixed façade response on the east side of the building also aims to make the structure stable at its base, through the volume of earth from which a lighter structure of columns and bamboo beams emerges. This light structure in the roof allows a big spans roof with double function eaves. On the one hand, to protect the bamboo and the rammed earth from rainwater, and on the other hand to generate shade on the facades to reduce solar radiation and thus better control the interior temperature. The roof also has a double layer with an air gap: zinc tile on the top and a fabric ceiling inside. The air flows between these two layers to insulate the classrooms of the heat absorbed by the metal surface.

5.0 SOURCES
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Figure 10. Physical model of the Hotel Albatros Guardalavaca project. Construction of the Alabatros-Guardalavaca Hotel in Holguín progresses. (2018). CubaDebate.

Figure 11. Drafting DC [2019] Render of the Facilities of the Hotel Albatros, 2019

Figure 12. NaBEK (2013) Education center Cecot´z, Bamboo Structure. URL https://nabek.de/projekte/lehm-und-bambus-in-schulbau

Figure 13. NaBEK (2013) Education center Cecot´z, Interior. URL https://nabek.de/projekte/lehm-und-bambus-in-schulbau

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