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Ecodesign and Construction

An integrated approach for ecological architecture and construction

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Abstract— *In the third millennium due to earth pollution everywhere, world has become more conscious about the environment changes occurring in climate and in earth generally and construction sector especially. It started to pay more attention to the impact of the technological and industrial revolution on the ecology and human health, which resulted in directing all the new researches towards renewable energies and recycling materials. In brief, it directed architects to start using eco-friendly building materials, construction systems, natural ventilation and lighting …etc. this paper is concerned with a main question: How our built environment can, and must, integrate with the natural environment? Therefore, the study aims at providing the architectural design elements and construction materials which involving with the goal of ECODESIGN, to provide designers with a set of instructions, in order to that things we make become an "integral and benign part of life on the planet". So, this paper is introducing comprehensive, technical, matter- integrated methodology for architecture and smart construction materials from an ecologist's perspective. That is one of the ways to preserve the earth for next generations*

Keywords— ecodesign; ecoconstruction materials; smart materials; intelligant building.

I. INTRODUCTION

Ecosystems are the source of important lessons and models for transitioning human activities On to a sustainable path. Natural processes are predominantly cyclic rather than linear; operate off solar energy flux and organic storages; promote resilience within each range of scales by diversifying the execution of functions into arrays of narrow niches; maintain resilience across all scales by operating functions redundantly over different ranges of scale; promote efficient use of materials by developing cooperative webs of interactions between members of complex communities; and sustain sufficient diversity of information and function to adapt and evolve in response to changes in their external environment. In more recent thinking, industrial ecology is being redefined and extended to include industrial symbiosis, design for the environment (DFE), industrial metabolism, cleaner production, eco-efficiency, and a host of other emerging terms describing properties of a so-called "eco-industrial system". Industrial symbiosis refers to the use of lessons learned from the observation of ecosystem behavior to make better use of resources by using existing industrial waste streams as resources for other industrial processes. An emerging discipline, DFE is altering the design process of human artifacts to enhance the reuse and recycling of material components of products. Industrial metabolism examines the inputs, processes, and outputs of industry to gain insights into resource utilization and waste production of industry, with an eye toward improving resource efficiency. Cleaner production is the systematic reduction in material use and the control and prevention of pollution throughout the chain of industrial processes from raw material use through product end of life [1]. Eco-efficiency calls on companies to reduce the material and energy output of goods and services, reduce toxic waste, make materials recyclable, maximize sustainable use of resources, increase product durability, and increase the service intensity of goods and services [2].

Nowadays Ecology has become a wide-ranging term that can be applied to almost every facet of life on earth, from local to a global scale and over various times. Attention to living eco-friendly requires us to actively be aware of the environmental, social and economic needs of our present generation. Ways of living more ecology can take many forms re-organizing living conditions (ecological cities), reappraising economic sectors (green buildings), and using science to develop new technologies (renewable energy) to adjustment in individual lifestyles that conserve natural resources [3]. Buildings are the single most damaging polluters on the planet. However, if buildings are not constructed thoughtfully, they will waste precious natural and financial resources, harm the environment, and endanger the health of those who use them [4].

The concept of ecological building incorporates and integrates a variety of strategies during the design, construction and operation of building projects. The ecological building should be a comfortable, beloved and long lasting building. A large amount of energy and resources for the construction of new buildings can be saved if existing buildings are technically and functionally adaptable to change of needs through time. Air-conditioning systems represent the greatest source of climate change gases of any single technology, (fig. 1).

Within the framework being defined by industrial ecology, construction industry would be well served by the definition of a subset, construction ecology, that spells out how this industry could achieve sustainability, both in the segment that manufactures the products that constitute the bulk of modern buildings and in the segment that demolishes existing buildings and assembles manufactured products into new or renovated buildings. As is the case with other industrial systems, construction would be aided in this effort by an examination of its throughput of resource, i.e. its "metabolism.". In many respects, the construction industry is no different from other industrial sectors. However, there are enough differences, especially the long lifetime and enormous diversity of products and components constituting the built environment, that it requires special attention and treatment. Consequently, attempts to apply ecology to this industry and to understand its metabolism present some unique problems not encountered in other industrial sectors [1].

Construction industry compared with other industrial sectors Buildings, the most significant components of the built environment, are complex systems that are perhaps the most significant embodiment of human culture, often lasting over time measured in centuries. Architecture can be a form of high art, and great buildings receive much the same attention and adoration as sculpture and painting. Their designers are revered and criticized in much the same manner as artists. This character of buildings as more than mere industrial products differentiates them from most other artifacts.

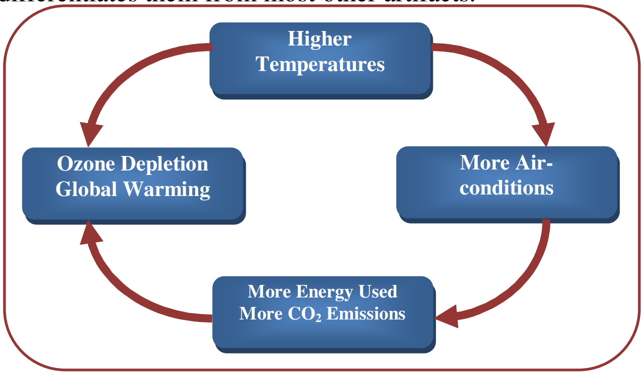

Fig. 1. Climate change problem [5]

A. *Problem Statement*

Recently, developing ecology of construction is an important step in the evolution of eco-building movements around the world. In almost every case, national and international movements indicate ecological design and the adoption of ecological principles. However, theory and practice developed in ecology have had little or no actual connection to green building and, as a consequence, although highly successful, stands a fair chance of ultimate failure because of the lack coherent underpinnings, it must rely on ecology and industrial ecology to provide the coherent structure and science needed to serve as the basis for developing new theory, practices, and experiments; for decision making; and to serve as its general compass. In addition to providing a badly needed basis for green building, construction ecology will require built environment professionals to dramatically increase their understanding of ecology According to that:

- Most architecture were designed disregarding ecological principles. Therefore, incompatible designs usually create problems to the environment and human health.
- Other factors also affect the environment such as energy consumption, water management and materials selection. Therefore, studies and methods to involve ecological and environmental benefits in design and construction materials are urgently needed.
- Importance of ecology building is the protection of natural systems, the re-education of planners, architects, builders, and policy-makers in ecological theory can only result in more sharply focused attention on the important issues of ecological building.
- The introduction of ecological education as a requirement for a professional design or construction license to impact natural systems in the dramatic fashion characteristic of the built environment would seem to be a highly beneficial and worthwhile outcome for society.

B. *Aims & Objectives*

The world needs a new profession, who can design passive buildings that use minimal energy and what energy they do use comes from renewable sources if possible [5]. Therefore, this research aims at introducing integrated methodology for architectural design elements and construction materials according to the surrounding environmental aspects while balancing with ecological benefits. To achieve this aim the following research objectives were developed:

- Study the contemporary eco design models and guiding principles.
- Present guidelines, which could help the architects, designers and the decision makers to turn their buildings towards the eco-friendly.
- Encourage owners and operators of existing buildings to implement sustainable practices and reduce the environmental impacts of their buildings over their functional life cycles.

C. *Research Methodology*

The methodology of this thesis adapted the followi methods to reach its aims and objectives:

- Define the eco system throughout the architectural vision.
- Review the Contemporary Trends in environmental architecture.
- Evaluate these different approaches in terms of their impact on architecture and construction.
- Present guidelines for designers, engineers, contractors and owners to turn their existing building to become more eco-friendly building through architectural design and construction materials (integrated methodology).

II. CONTEMPORARY TRENDS IN ENVIRONMENTAL ARCHITECTURE

A. *Sustainable Architecture*

It refers to giving solutions in physical, environment, social, and cultural fields that can prevent problems such as destruction of natural resources, degradation of ecosystems,

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environmental pollution, increase of population, the prevalence low quality of life and reduce the balance between humans [6]. As Tadoo Ando says: "I build houses that are endurable in nature". In another word, sustainable architecture is responsible for building houses that can be endurable, and not only be a keeper of identity but also accord with mental pictures during history, present and future [7].

On the aesthetic side sustainable design is the philosophy of designing a building that is in harmony with the natural features and resources surrounding the site. There are several key steps in designing sustainable buildings: specify 'green' building materials from local sources, reduce loads, optimize systems, and generate on-site renewable energy [8]. Sustainable Architecture comprises only a tiny component to reducing the carbon footprint of our civilization. In order to truly make an impact, the motivation from these entrepreneurs, policy makers and intellectuals needs to trickle down to the remaining public.

Principles of Sustainable Architecture [7]: In order to achieve sustainable development, there should be some principles to be observed.

- Implementation and sustaining the use of renewable solar and wind resources
- Optimizing the use of resources and minimizing natural resource consumption that proportionately is less than their natural growth.
- Minimum production of wastes and pollution that can be absorbable in local to global environment scale.
- Providing basic needs of human and society and creating a healthy environment for future generations

B. *Ecological Architecture*

Ecological design is defined by Sim Van der Ryn and Stuart Cowan as "any form of design that minimizes environmentally destructive impacts by integrating itself with living processes."[1] Ecological design is an integrative ecologically responsible design discipline. It helps connect scattered efforts in green architecture, sustainable agriculture, ecological engineering, ecological restoration and other fields. The "eco" prefix was used to ninety sciences including eco-city, eco-management, eco-technique, eco-tecture. It was used by John Button in 1998 at the first time. The inchoate developing nature of ecological design was referred to the "adding in "of environmental factor to the design process, but later it was focused on the details of eco-design practice such as product system or individual product or industry as a whole.[2] By including life cycle models through energy and materials flow, ecological design was related to the new interdisciplinary subject of industrial ecology. Industrial ecology meant a conceptual tool emulating models derived from natural ecosystem and a frame work for conceptualizing environmental and technical issues [9], (fig.2).

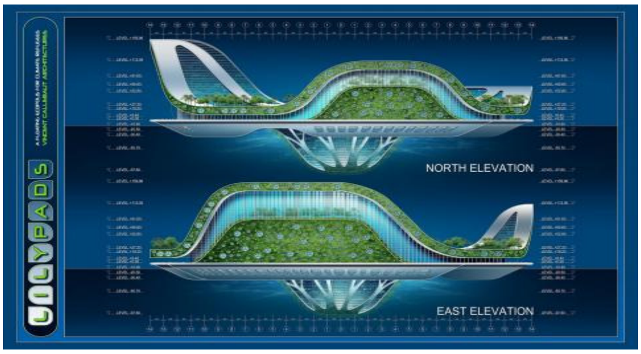

Fig. 2. Lilypad, a Floating Ecopolis designed by Vincent Callebaut Architect, style is Contemporary eco-design [10]

C. *Bio Architecture: Biological Architecture*

Bio-Architecture is the art and science of designing buildings and spaces which create, support and enhance life and living system. It is the holistic process and product of planning, designing and constructing space that integrates natural form, biologic function and environmental, social and aesthetic considerations. It requires knowledge of living systems, natural harmonics and fractal geometric relationships expressing as form, pattern, rhythm, ratio and proportion. Bio-Architecture involves the use of organic materials, green technology and appropriately skilled labor [11]. Bio-Architecture integrates all aspects of the design-build process; including project planning, cost analysis, construction administration and final certification. A broader definition comprises all design-stage activities from the macro to the micro level. (fig.3)

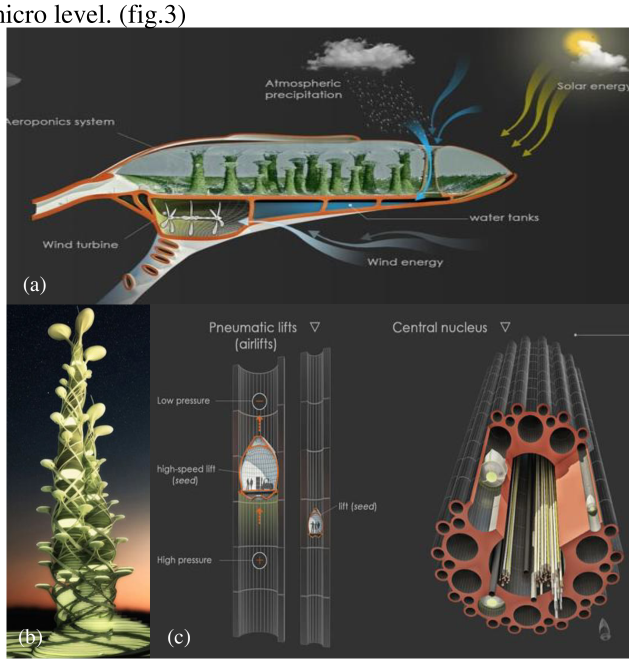

Fig. 3. Bio architecture[12]: a The outer greenhouses (fruits). b-tree of Life Skyscraper. c- the central nucleus.

D. *Nano Architecture*

Refers to the use of **Nanotechnology + Architecture = Nano Architecture**

Nanotechnology Science that works on the molecular scale set to transform the way we build. The biggest changes that led to shaking up architecture in a long time have their origins in the very small Nanotechnology. The understanding and control of matters at a scale of one- to one hundred-billionths

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of a meter brought incredible changes to the materials and processes of building. Yet the question how ready we are to embrace these changes that could make a big difference in the future of architectural practice.

Nano Architecture will allow having designs that interact better with the human senses. Experiencing this type of architecture could feel more "natural" and less forced than many of the designs we experience today. Overall, it still seems fairly optimistic that most scientists think that nanotechnology will unveil more solutions that are needed to meet some of the biggest challenges of our time [13]. (fig.4)

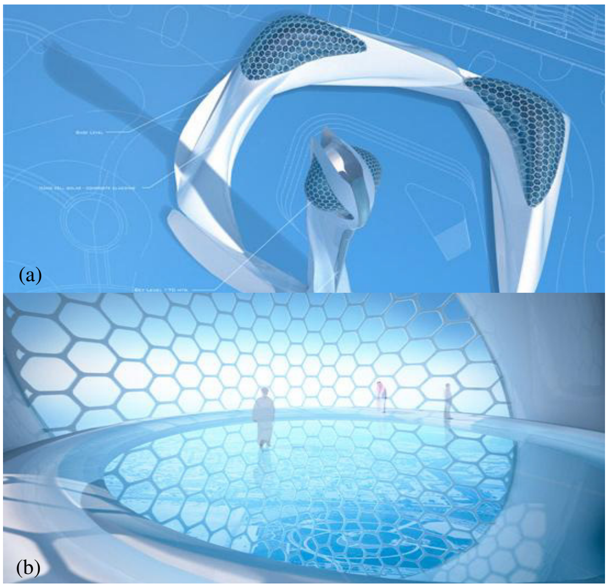
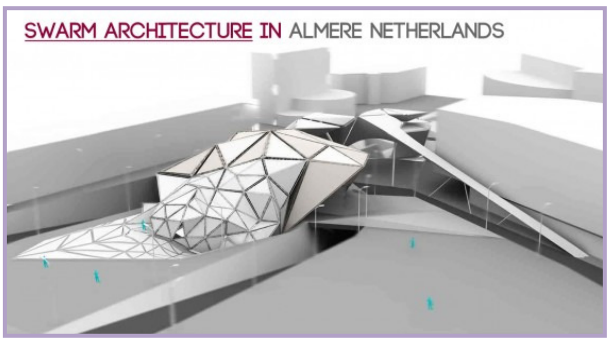


Fig. 4. Utopia One tower [14]: a- Site plan. b- Interior view.

E. Swarm Architecture (SA)

Is a true trans architecture since it builds new transaction spaces, which are at the same time emotive, trans active, interactive and collaborative. Swarm architecture feeds on data generated by social transactions economy. Swarm architecture is design, construct and operate in real time [15]. Architecture becomes the discipline of building transactions. Architecture becomes the science of fluid dynamic structures and environments running in real time. Swarm architecture manifests itself as the inevitable evolution of architecture and the building industry. The innovative architect applies swarm theory in to the very fabric of society [16]. (fig.5)



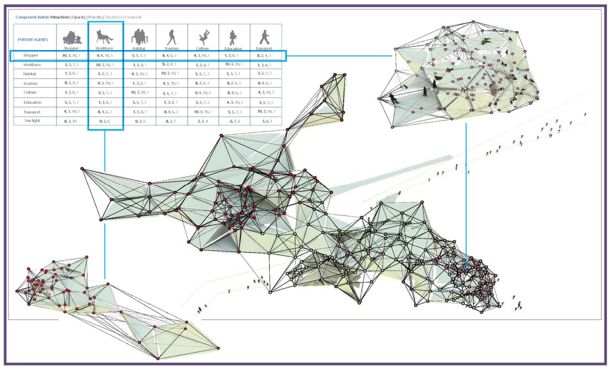


Fig. 5. Swarm architecture (SA) [17].

III. ECO-DESIGN AND CONSTRUCTION: ENVIRONMENTAL CREATION

A. Eco-System Definition

In the Longman dictionary, the ecosystem is defined as the way that plants, animals, and people affect their environment and how the environment can be kept healthy. Ecology is defined as the study of the interactions of organisms and their physical and biological environment [5].

In architecture field the eco-design is how to exploit the existing energy improving, the integration between environment and human being needs and how they should tie together to achieve the ideal performance for building, environment and human welfare.

B. Ecological Architecture Definition:

Also Ecological design (Ecological architecture) could be defined as buildings that are built with the environment in mind, i.e. energy efficiency, earth friendly building materials, etc. we can conclude that in order to fully appreciate the ecological implications of any design the designer will need to analyze the built environment in terms of its flow energy and materials throughout its life cycle from their source of origin to their sink. Following from this analysis, the designer must simultaneously anticipate at the design stage all the desirable impacts on the ecosystems along this route. This analysis can be conveniently conceived using the concept of an open system, i.e., in terms of inputs to the system, functions within the system, outputs from the systems, and the relationship of the environment to the system [18] [19].

C. Ecological Architecture Principles

We can now begin to ask how does the understanding of the three ecological principles may change the way in which we perceive and design buildings?

- *Fluctuations* suggest that buildings may be designed and perceived as places where different cultural and natural processes interact. The building should reflect the processes that occur on site, and the more it allows the processes to be experienced as processes rather than

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representation of processes, the more it will succeed in connecting people to the reality of the site.

- *Stratification* suggests that the building's organization should emerge out of the interactions between its different properties and levels. This kind of organization allows complexity to be managed in a coherent manner.
- *Interdependence* suggests that the relations between the building's properties are reciprocal. The 'observer' (designer and user) as well as the site are inherent properties in the building. The interdependence between the properties is ongoing throughout the life of the building.

D. Ecological Design Criteria

Eco- building design is a matter of involving design from the following (fig. 6):

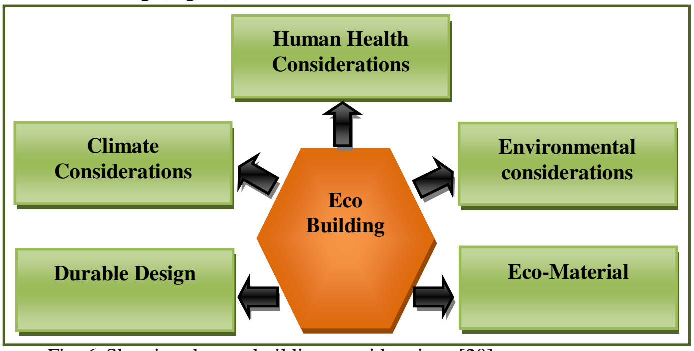

Fig. 6. Showing the eco building considerations [20]

According to previous eco-building considerations and ecological architecture principles the main Ecological Design Criteria could be specified in the following items:

E. Eco-Design Strategies: [21]

The International Energy Agency, keen to promote the use of the most abundant energy source of all, the sun, has started a Solar Heating and Cooling program. Solar thermal energy is appropriate for both uses. Key applications for solar technologies are those that require low temperature heat, such as domestic water heating, space heating, pool heating, drying processes, and some industrial processes, Solar cooling works where the supply of sunny summer days is well matched with the demand – the desire for coolness indoors. The Agency says the main barriers preventing the greater use of solar energy are cost, the way current government policies benefit non-solar technologies, and the failure to take into account the environmental costs of using fossil fuels. (table 1)

TABLE I. ECOLOGICAL DESIGN STRATEGIES TABLE SHOW THE ECO-DESIGN STRATEGIES[22].

Super insulation	insulation High efficiency insulation materials, often including gases with extremely low heat transfer values
High-performance windows	Windows combining high level of light penetration with low level of heat transfer, for example double-glazed windows.
Ventilation heat recovery systems	Ventilation system that uses outgoing heated indoor air to pre-heat incoming cold air.
Ground couple heat exchangers	Uses the more stable ground temperature (cooler on hot days and warmer of cold days) to adjust the temperature of incoming air.
Sunspaces	Spaces heated by direct sun light.
Materials with high thermal storage capacities	Materials that keep their temperature for extended periods of time, even if the surrounding air temperature changes, hence storing heat gained during a hot day to heat the building during a cold night, and vice versa.
Active solar water systems	Water heating through direct sunlight, for example by leading water through pipes located in the centre of concave steel mirrors focusing sun light on the pipes.
Photovoltaic systems	Panels with semi-conductor cells convert sun light to electricity Integrated
mechanical system	Automated features of a building, e.g. sunshades, responding to incoming sun light or indoor temperature so as to maintain comfortable conditions.
Home automation systems	Computer controlled heating, cooling and ventilation adjusting the indoor temperature and ventilation according to pre-set parameters, often designed to minimize energy use.
Energy-efficient lights and appliances	Appliances and lights meeting minimum criteria for energy use per output. For example, low-energy lamps often use about 30-40% less energy to provide the same levels of light as ordinary lamps do.

1) The Passive solar building design: [23] Passive and Active Solar Design: Submissions shall demonstrate as full a range as practical, of passive or active design principles, aimed at the designed structure providing a comfortable internal living environment without mechanical supplement. Passive solar building design uses a structure's windows, walls, and floors to collect, store, and distribute the sun's heat in the winter and reject solar heat in the summer. It can also maximize the use of sunlight for interior illumination. Passive solar buildings aim to maintain interior thermal comfort throughout the sun's daily and annual cycles whilst reducing the requirement for active heating and cooling systems. Passive solar building design is one part of green building design, and does not include active systems such as mechanical ventilation or photovoltaics [24]. (fig.7).

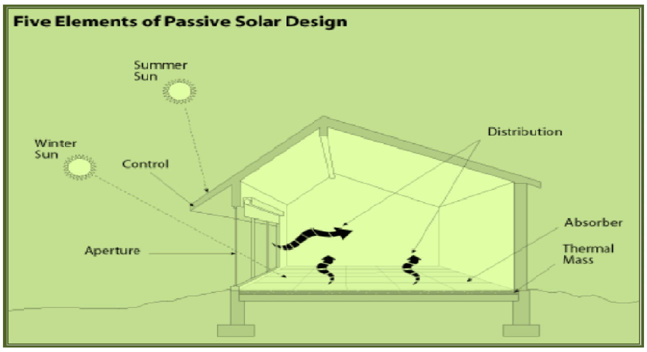

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Fig. 7. Elements of passive solar design‹ shown in a direct gain application.

2) Energy Efficiency: Submissions shall demonstrate strategies, which have been adopted to reduce energy demand for air and water heating, cooling, and lighting. Consider primary energy sources and recycled sources

3) Daylight: [25] Daylight is the combination of all direct and indirect sunlight outdoors during the daytime. This includes direct sunlight, diffuse sky radiation, and (often) both of these reflected from the Earth and terrestrial objects. Daylight is present at a particular location, to some degree, whenever the sun is above the horizon at that location. Daylight is the practice of placing windows or other openings and reflective surfaces so that during the day natural light provides effective internal lighting.

4) Light tubes (Advanced eco-design): [26] Light tubes or light pipes are physical structures used for transporting or distributing natural or artificial light for the purpose of illumination, and are examples of optical waveguides. In their application to daylighting, they are also often called tubular daylighting devices, sun pipes, sun scopes, or daylight pipes. Light pipes may be divided into two broad categories: hollow structures that contain the light with a reflective lining, and transparent solids that contain the light by total internal reflection. They do not allow as much heat transfer as skylights because they have less surface area. (fig.8)

Fig. 8. a- Light tubes. b-The Copper Box, venue for Handball at the 2012 Summer Olympics, makes use of light tubes to reduce energy use.

5) Trombe Walls: [27] Since ancient times, people have used thick walls of adobe or stone to trap the sun's heat during the day and release it slowly and evenly at night to heat their buildings. Today's low-energy buildings often improve on this ancient technique by incorporating a thermal storage and delivery system called a Trombe wall. (fig.9)

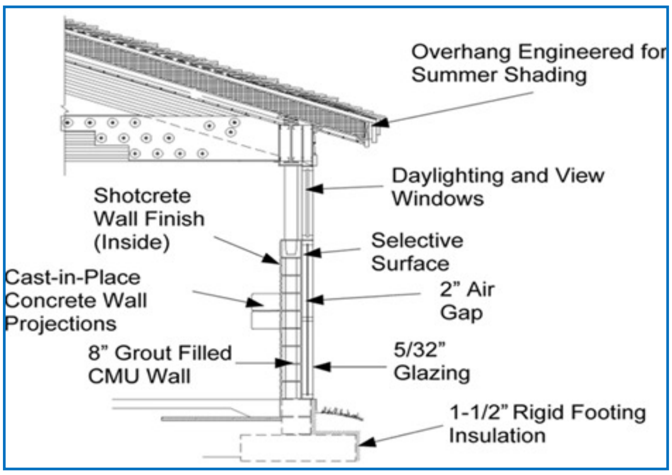

Fig. 9. Trombe Walls concept

6) The Green Roofs: [28] A green roof is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. A roofing membrane covers the natural roof to protect the structural supports of the roof. The membrane protection and root barrier protects the roof membrane and prevents roots from penetrating the roof. Insulation helps insulate the building, keeping it cooler during the summer and warmer in the winter [29]. (fig.10)

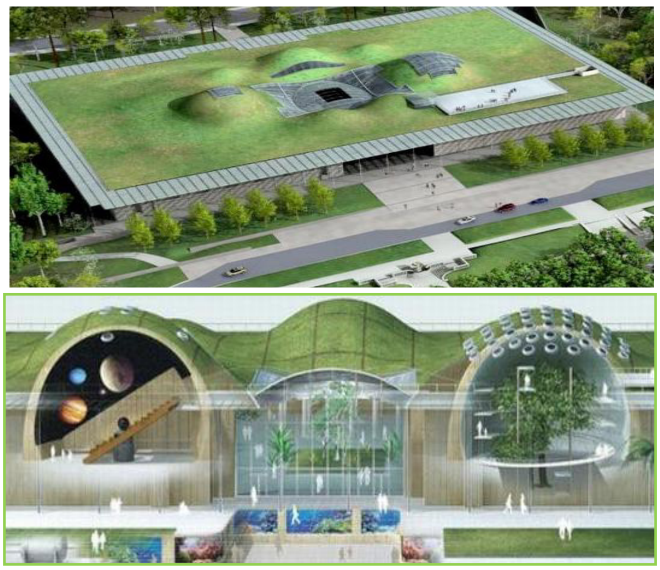

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Fig. 10. California Academy of Science Green Roof and solar panels [29].

7) Water Management: Submissions shall demonstrate design strategies aimed at reducing potable water demand, as against a common methods. All wastewater generated by the home and its user should be considered.

8) Climate Appropriate: Submissions shall demonstrate knowledge of climate appropriate material and design making sure that likely climate change hazards and daily conditions are accounted for to create a resource efficient building

F. Eco construction Building Materials (Defining construction ecology and metabolism)

Efforts to change the materials cycle in construction ate hampered by many of the same problems facing other industries. The individuality and long life of buildings poses some additional obstacles. Three fundamental difficulties arise when considering closed-loop materials cycles for buildings [1]:

- Buildings are not currently designed or built to be eventually disassembled.
- Products constituting the built environment are not designed for disassembly.
- The materials constituting building products are often composites that make recycling extremely difficult.

These difficulties also increase resource consumption by the construction industry, because building components must be frequently replaced, buildings may experience different uses during their lifetimes, and they periodically undergo renovations or modernization. In each case, the inability to readily remove and replace components results in significant energy inputs to alter building systems, and large quantities of waste are the result.

Clearly, a new concept for materials and energy use in construction industry is needed if **eco-construction** is to be achieved. Industrial systems in general are beginning to take the first steps toward examining their resource utilization or metabolism, and beginning the process of defining and implementing industrial ecology. In this same spirit, a subset of these efforts for construction industry, construction ecology, would help accelerate the move toward integrating in with Nature and behaving in a "natural" manner. Construction ecology should consider the development and maintenance of a built environment

- with a materials system that functions in a closed loop and is integrated with eco-industrial and natural systems;
- depends solely on renewable energy sources; and
- fosters preservation of natural system functions.

Construction metabolism is resource utilization in the built environment that mimics natural system metabolism by recycling materials resources and by employing renewable energy systems. It would be a result of applying the general principles of industrial ecology and the specific dictates of construction ecology.

The Outcomes of applying these natural system analogues to construction would be a built environment [1]:

- that is readily deconstructable at the end of its useful life;
- whose components are decoupled from the building for easy replacement;
- composed of products that are themselves designed for recycling;
- whose bulk structural materials are recyclable;
- whose metabolism would be very slow because of its durability and adaptability; and
- promotes health for its human occupants.

The deconstruction or disassembly of buildings and material reuse is one area of endeavor in which there has been a great upswing in activity and interest in the past few years.

1) Eco Building Materials: the Environmental Impact of Building Materials Submissions shall demonstrate application of low embodied energy materials, low ongoing maintenance levels, and potentially recyclable selections

a) Low Embodied Energy Materials and Minimal Environmental Effect.: (Selecting Low Embodied Energy Materials) In order to select the lowest embodied energy materials, the basic rules for material selection are [20]:

- Use materials that are as natural as possible.
- Use materials that are local as possible.

Embodied energy of materials are measured through the whole process starting from excavation to processing it from raw materials to finished products to transportation to construction to demolition and recycling of materials. The embodied energy of the main materials used in construction as follows [20] [30]:

TABLE II. EMBODIED ENERGY OF MATERIALS

Concrete	It has low energy content but reinforced concrete has greater energy content. (Anink, 1996)
Solid stone, manufactured and synthetic stone	The main environmental effect is the damage made to the countryside caused by quarries and related infrastructure and because of their large quantities, transport is an issue too (Anink, 1996). Use the thermal mass of stone to enhance passive solar strategies. Look for local sources and attempt to minimize transportation distances wherever possible (Wilhide, 2003)
Sand lime brick	The energy content of sand lime brick mainly comes from the burning of the lime and the high-pressure compression involved in forming bricks or blocks. Sand lime brick is unsuitable for reuse as reclaimed aggregate in concrete
Ceramics	The energy content of ceramics is a result of the high temperature required for firing the clay and adding the glaze
Loam	The energy content is low as the material is not chemically or

	thermally processed and provided that no cement is added, loam is well suited for reuse.
Aluminum	The energy content of aluminum comes from extraction and conversion of raw material, bauxite, into a semi-manufactured product. Aluminum is recyclable
Steel	Compared to other metals the energy content per kg of steel is relatively low. Steel is suitable for reuse though this is less successful than with aluminum.
Zinc	Extraction of zinc involves emission of cadmium, which is damaging to the environment. Reduction of theses cadmium emissions can only be achieved practically by limiting the use of zinc.
Lead	Depletion of reserves is expected within decades. Its production causes pollution, but it is recyclable.
Copper	The use of copper in pipes causes pollution but it is recyclable.
Polyethylene PE, Polypropylene PP	Polyethylene PE, Polypropylene PP is recyclable
PVC (Polyvinylchloride)	PVC has low energy content, but its production process causes environmental problems and their extraction causes harmful emissions.
Bitumen	It can be easily reused, though in practice bitumen is not yet recycled because of pollution of the material.
Wood	selecting wood are: - Forestry management - The need for preservatives - Transport distance

The energy is being used in the following [31]:

The extraction from the earth of raw materials

- The processing of the raw material into finished products
- The transportation to the supplier.
- The construction process.
- Demolition and recycling of materials.

According to this, attempts have been made to put numerical values to energy intensiveness, so that material can be ranked.

b) Recyclable and Renewable Materials: The basic selection will be added to conclude with and recommend because the basic selection is a practical solution, having low environmental impact and being easy to implement, without giving rise to practical problems. The following selection is according to David Anink selections [20] [30].

2) Smart Materials (ecological new materials): Smart material is a new terminology for material and productions that have capability of perceiving and processing environmental events and show proper reaction to them. In other word, these materials has capability to change and are able to reversible change their form, color, and internal energy in response to physical or chemical effects of surrounding. If materials are classified in three groups of non- smart, semi-smart and smart. First group, non-smart materials don't have above-mentioned special characteristic. Semi-smart materials are just able to change their form in response to environment effect, for once or short time; while in smart materials these changes will be repeatable and reversible. Smart materials are also known as "flexible" and "adaptive", and this is due to their particular feature in adjusting with environmental conditions. The effect of chemical and physical variables is stimulants that smart materials react against them [7].

In third millennium, we confront new modernization in more efficient multi-functional material. More efficiency means increase of resistant, formability, durability and more ability than traditional material [32]. The materials (smart material) feel environmental events and process information and appropriately react to environment and its circumstance [33]. In other word, they have natural ability in rapid response to the environment. These materials not only increase useful life of houses, but have significant role in reducing maintenance costs of buildings.

In fact, classification of smart material suggestions is presented based on three following features [7]:

Capability to change intrinsic properties:
- Modifying smart material
- Color changing smart material
- Bounding changing smart material.

Capability of energy exchange:
- Light emitting smart material.
- Electricity producing smart material.
- Energy saving smart material.

Capability to change internal material exchange
-Conductive smart material

a) Temperature responsive smart materials [7]: This type of materials has intrinsic property that enables them to reversibly react to surrounding temperature. Temperature changing may have an inactive effect; so that materials constantly balance their inner temperature with natural surrounding by their outer skin and if the effects are active a kind of active heating is created with applying and electricity field by contact.

b) Color changing smart materials [7]: These materials are able to reversely change their color or visual features in response to one or several external stimulant. With respect to its stimulations these materials contain different types but the most applicable types in architecture include: photo chromic, thermo chromic and electro chromic material.

c) Energy Saving Smart materials [7]: Transparency and heat conductibility can be used simultaneously. Whenever the internal temperature of the building is more than external temperature, a bidirectional flow will be established; radiance energy transfer into inner space while inner heat energy lead to outer. Changing the amount of absorption of glasses finally effect their pure conductivity and change equilibrium of these flows.

3) Intelligent Building (Smart Building)

Intelligent Building and construction automation in one form or another have been in existence for decades. Open source communication protocol standards such as BAC-net have been instrumental in the profilation of intelligent building technologies while yielding many benefits. Most notably, Intelligent Building Automation Systems (IBASs) can have a direct effect on the energy profile of a building. In

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addition, they can promote residential quality of life through refined lighting and automated environmental controls. Large complexes can utilize intelligent building infrastructure to lower energy costs and increase quality of life through air monitoring. The optimal amount of external (fresh) air is introduced into a building as needed. This regulated introduction not only saves energy, but also assures a habitable and productive work environment for occupants. Secure buildings utilize intelligent building technologies for provisioning of localized access control within buildings or complexes. This access control typically includes biometrics, or RFID access cards. In addition, access control can be fully regulated and automatically changed as needed. This location information provides the intelligent system and thus first responders with valuable and accurate personal location information. (fig.11)

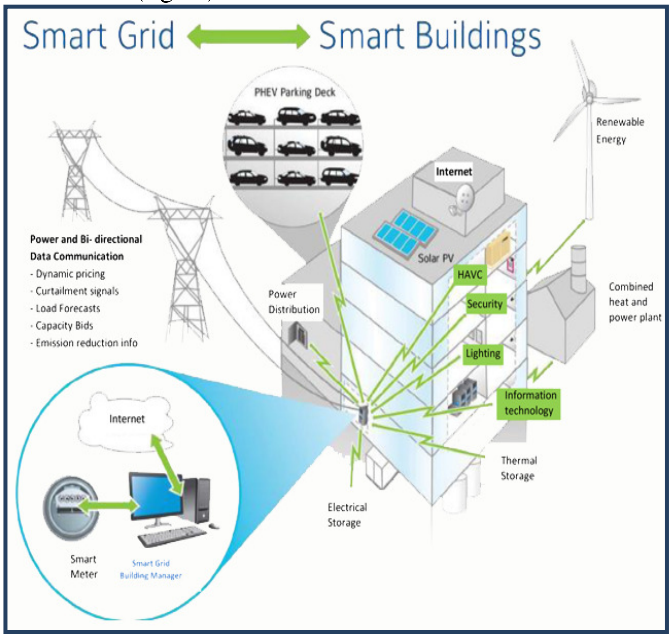

Fig. 11. Connecting to Smart Grids[29]

4) *Smart Environments*

The Smart covers are systems that during operation are able to present information about thickness and defects. Active covers are smart covers able to give the optimal response to external stimulus like temperature, stress, and strain or environment corrosive factor and in some cases if there were a defect can repair in the part of its own cover.

In the future the atmosphere of house will communicate with its inhabitants, what is hard to imagine now. Small Nano-sensors place in the construction materials, soon can trace movements and recognize changing temperature, moisture, toxins, weapons and even money. The sensors collect the request of user and answer them with adjusting light or temperature change. Soon, a network of information and smart things from the photo chromic windows and sensitive to light to equipment will be used in design and constructions. The building will not be motionless but they will change because the components of buildings regularly are related to users. One of the reasons of using the Nano-technology in the architect is its high energy efficiency [7].

IV. INTEGRATED METHODOLOGY APPROACH OF ECOLOGICAL ARCHITECTURE AND CONSTRUCTION MATERIALS

According to all items which have been studied and analytically evaluate in this paper, the study has been concluded to the comprehensive, technical, matter- integrated methodology for architecture and smart construction materials from an ecologist's perspective. (fig.12)

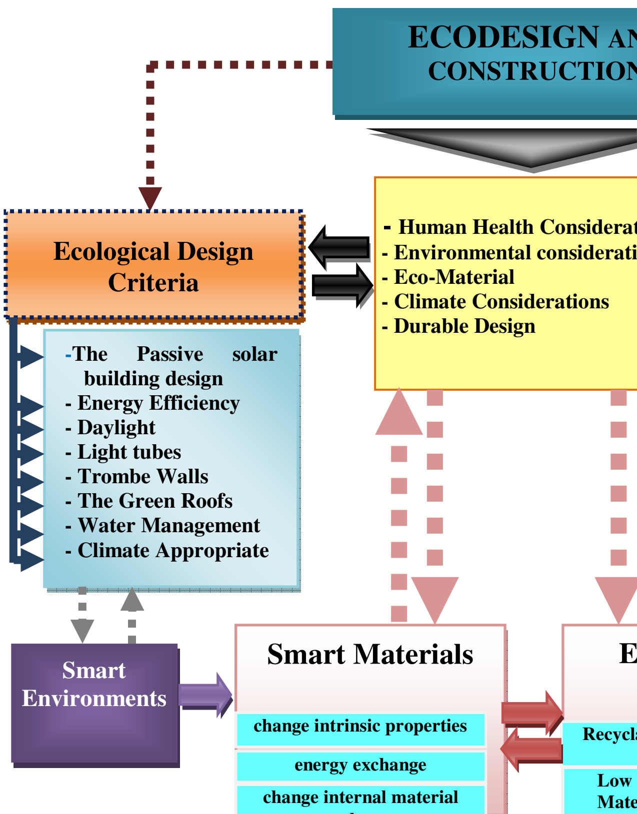

Fig. 12. Suggested integrated methodology for architecture and smart construction materials from an ecological perspective

CONCLUSIONS

The result of a shift toward architecture and construction ecology and its corresponding metabolism creates a host of issues and problems to be resolved. Can construction be readily dematerialized in the sense recommended by the Factor 10 Club? Can a construction ecology and metabolism be implemented without significant changes in national policy that alter national accounting systems and internalize environmental costs? What lessons from' natural systems are feasible for application to the built environment? What are the roles of synthetic materials in construction ecology? How can construction materials production and recycling be integrated with the other components of the industrial production system? These are all difficult questions that must be answered to move forward into an era approximating ecology in the built environment. Nonetheless, examining nature and ecological systems for patterns of energy and materials metabolism for their potential adoption into human systems can provide a substantial improvement on current methods of attempting to green the built environment.

The smart materials which have the ability to respond to different environmental changes. Some of these materials are for the external usage such as for external layer for the building to prevent the transmission of the harmful environmental changes inside the building. Also it can absorb all the useful environmental characteristics which could be helpful inside the building such as the smart windows which works to prevent the heat transmission into the building, harmful rays and transmit only the useful sunlight rays. All of this can be applied through its characteristics which resist the harmful rays and absorb the useful one. Also it can control the light amount entered in the space without being glare or darkness.

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