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TOWARD A SUSTAINABLE METAL BUILDING LIFE CYCLE

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ABSTRACT:
Sustainability, as a concept, has become the one that links the current actions to the future expectations. It brings us to a comprehensive understanding to the future in the shadow of our recent actions. And so, it has become a very important consideration to be taken in account in dealing with any development process . Although sustainability, as a global concept and approach, gained a lot of momentum in the last three decades, in general, it still does not have an equivalent influence on the practice of metal building design all over the globe. Application of sustainable ideas is not yet the mainstream. The risk usually associated with adopting new trends and ideas coupled with the higher cost of new technologies is hindering. So this research aims to apply the sustainability considerations to the metal building life cycle, by the aim of investigating its ability to stand against the future Sustainability challenges .
The research is divided into three parts. First, the introduction offers a general review of concepts and principles of Sustainability and architectural sustainable development. The idea of sustainable metal building life cycle as one of architectural design field is addressed in the second part. Finally ,the future of metal building sustainability as practices, strategies and implementation processes will be discussed. The research findings concluded that each phase of the metal building life cycle involves many operations related to environmental aspects and pollution prevention techniques, and the sustainable metal building life cycle can only be achieved by reducing consumption of non-renewable resources, minimizing environmental loads of waste and pollution, optimizing the management of economic resources, and dramatically affecting metal buildings' environmental performance.
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The research methodology : Theoretical and Analytical methodology

1. Sustainability and Architectural Sustainable Development

Sustainability, as a concept, has become the one that links the current actions to the future expectations. It brings us to a comprehensive understanding to the future in the shadow of our recent actions. And so, it has become a very important consideration to be taken in account in dealing with any development process .

Among the various definitions of the word "sustain" are "to give support or relief," "to supply with sustenance," or "to keep up or prolong. Implicit in these definitions is a need to

extend the life of, in the case of architecture, the natural environment. Thus sustainability is about seeking ways in which we can prolong the life and enhance the features of our natural surroundings. This dictum seems to hold some contradictions within its practice as the built and natural environments are in direct opposition to each other.

The World commission on Environment and Development has put forth a definition of "sustainability" as Meeting the needs of the present without compromising the ability of future generations to meet their own needs. This definition of sustainability does not specify the ethical roles of humans for their everlasting existence on the planet. It also fails to embrace the value of all other constituents participating in the global ecosystem, "the need for finding long-terms solutions that warrant continuing human existence and well-being is far more compelling than that of finding a proper terminology to describe Ac human need, In [his respect the debate on the terms "green," "sustainable" or "Ecological" architecture is not terribly important. (Jong-Jin, 1999)

1.1 Sustainable Development Dimensions

The notion of sustainable development is going around the prime objective of providing lasting and secure livelihoods that minimize resources depletion, environmental degradation, cultural disruption and social stability. To reach such objectives there are some basic principle that can be considered as of crucial importance to the concept of sustainable development , So sustainable development can be presented through the diagram presented in figure 1 It presents the basic tools for achieving a three-dimensional sustainable development

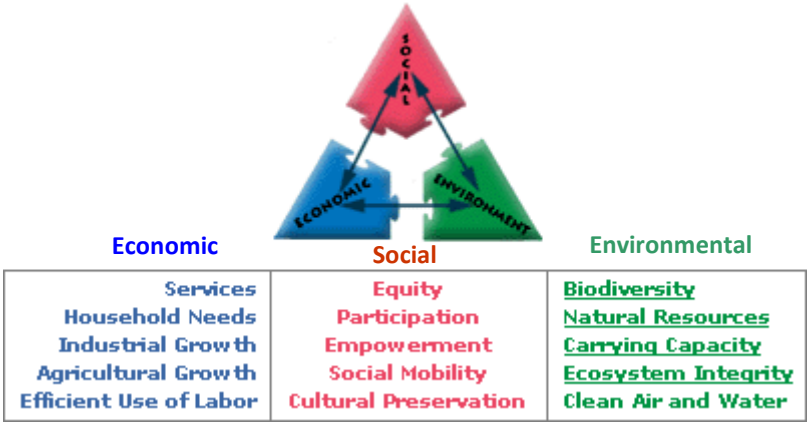


Figure No. 1- Three dimensions of sustainability

1.2 Goals of Sustainable Development

The goal of sustainable development is achieving overall human & ecosystem well being without compromising the ability of future generations & ecosystems to meet their own needs. From this comes parallel care & respect for ecosystems & people within. Market activities (economy), non-market activities, and governance are means to achieving well being. Necessary elements of the desired future state are economic development and prosperity, growth with minimum negative impacts on ecosystems, improved human health, reduced resource extraction, and greater equity in the distribution of resources and services for human development.

Sustainable development, thus can achieve a quality of life (or standard of living) that can be maintained for many generations because it is:

- socially desirable, fulfilling people's cultural, material, and spiritual needs in equitable ways.
- economically viable, paying for itself, with costs not exceeding income.
- Ecologically sustainable, maintaining the long-term viability of supporting ecosystems.

Embedded in the criteria of sustainable development is environmental sustainability. The idea of environmental sustainability is to leave the Earth in as good or better shape for future generations than we found it for ourselves. By a definition, human activity is only environmentally sustainable when it can be performed or maintained indefinitely without depleting natural resources or degrading the natural environment. In order to achieve sustainability some environmental goals are essential :

- Minimal resource consumption
- Materials consumed would be made entirely of 100% post-consumer recycled materials or from renewable resources (which were harvested without harm to the environment and without depletion of the resource base)
- Recycling of waste streams would be 100%
- Energy would be conserved and energy supplies would be entirely renewable and non-polluting (solar thermal and electric, wind power, biomass, etc.) (Yaldiz Y. Eid:2004)

1.3 Sustainable Building

According to the OECD Project, Sustainable buildings can be defined as those buildings that have minimum adverse impacts on the built and natural environment, in terms of the buildings themselves, their immediate surroundings and the broader regional and global settings.

Sustainable buildings may be defined as building practices, which strive for integral quality (including economic, social and environmental performance) in a broad way. Thus, the rational use of natural resources and appropriate management of the building stock will contribute to saving scarce resources, reducing energy consumption, and improving environmental quality. The OECD project identified five objectives for sustainable buildings; (Godfaurd John , 2005)

1. Resource efficiency;
2. Energy efficiency (including greenhouse gas emissions reduction);
3. Pollution prevention (including indoor air quality and noise abatement);
4. Harmonization with environment;
5. Integrated and systemic approaches.

Sustainable building involves considering the whole life of buildings, taking environmental quality, functional quality and future values into account. Sustainable building design is therefore the thoughtful integration of architecture with electrical, mechanical and structural engineering resources. In addition to express concern for the traditional aesthetics of massing, orientation, proportion scale, texture, shadow and light, the facility design team needs to be concerned with long-term costs: environmental, economic and human. Buildings contribute to the quality of life much more than we realize. (Godfaurd John , 2005)

A sustainable building also defined as technology which meet the multiple requirements of the people and society in an optimal way during the life cycle of the building facility3. Factors that affect the design of a sustainable building include Economy, Functionality, Durability,

Aesthetics, Ecology, Health, and Socio-cultural aspects (Figure No.2). The designer should consider all these factors in order to design a sustainable building. (Ahmed Fathi : 2004)

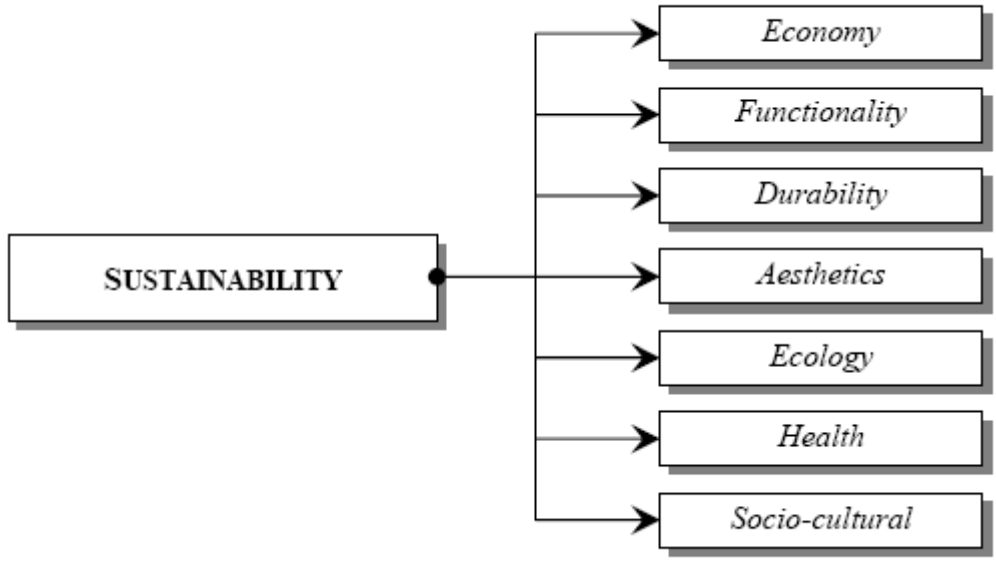


Figure No.2 Factors affecting Sustainability

2. The Idea of Sustainable Metal Building Life Cycle as One of Architectural Design Field:

Sustainability and architecture is not about becoming "green". Environmental degradation is among the most difficult and complex problems ever faced by modern society. We have come to recognize that the laws of nature are not negotiable and setting a course for global sustainability is essential for the long-term survival of the planet. No other problem during the 20th century has mobilized the public and private sectors worldwide in such a short time.

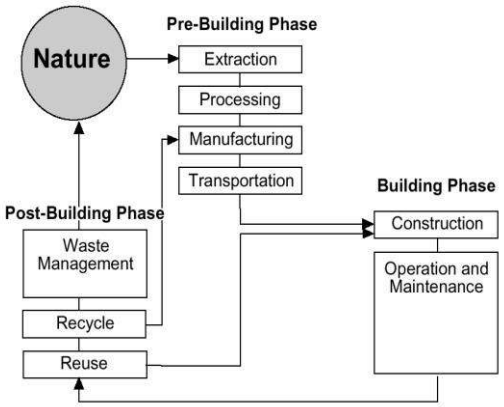
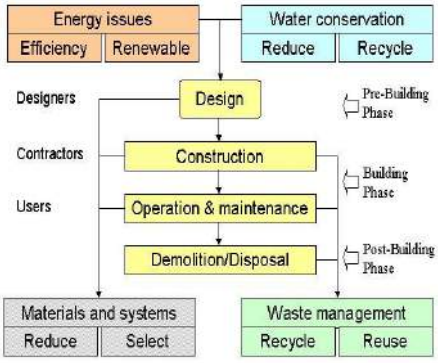
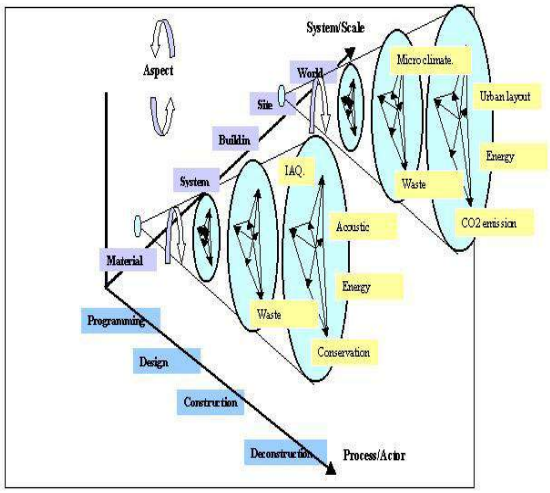
2.1 Definition for A Sustainable Life Cycle for Buildings

Life cycle building is the art of designing the building life cycle through choices about building concept, structure, materials and processes . (Leo Alting : 1995)

Sustainable Life Cycle Design (SLCD) is a holistic building design and development approach which seeks to minimize social and environmental burden, over the whole of a building's life cycle , whilst achieving economic viability and encouraging Sustainable Development at the local, national and global levels. In broader terms, it is the moral and ethical extension of Life Cycle Design (LCD), which considers all life-cycle stages from concept development to end-of-life treatment, integrating environmental aspects as well as building design criteria such as cost, quality and service. SLCD extends beyond eco-design which focuses only on reducing environmental impacts and seeks to balance economic and environmental aspects . (Alireza V. : 2008)

So sustainable life cycle for buildings is the art of designing the building life cycle through balance economic and environmental aspects.

Thinking of searching for a definition for a sustainable life cycle for buildings is recently becoming in the core interest for many research agenda. The following table is showing a demonstration for some important examples.

Table 2 : examples of definition for a sustainable life cycle for buildings		
University of Michigan:	The sustainable life cycle of university of Michigan study categorizes "the life cycle of a building into three phases: pre-building, building, and post-building (FIG. 2). These phases are connected, and the boundaries between them are not obvious. The phases can be developed into strategies that focus on minimizing the environmental impact of a building. Analyzing the building processes in each of these three phases provides a better understanding of how a building design, construction, operation, and disposal affect the larger ecosystem". (Jong-Jin : 1998)	 **Figure No. 3 University of Michigan sustainable building life cycle.**
Sustainable Architecture and Building Design (SABD):	Reference for sustainable buildings prepared by Sam M. Hui suggested a building life cycle which is divided also into three phases: pre-building, building, and post-building, as shown in (FIG.3). It considers four major linked issues to the cycle: Energy (efficiency & renewable), Water (reduce & recycle), Materials and Systems (reduce & select), and Waste (recycle & reuse). This cycle takes in consideration the role of the designers, contractors and users. (Hui, S.M : 2002)	 **Figure No. 4 (SABD) Building life cycle**
Georgia Institute of Technology :	(FIG. 4) shows a sustainable construction life cycle in a "methodological framework, consisting of three main axes: System (boundary), Process (actor) and Aspect (sustainability). It expresses that in different life cycle phases of a building, different actors are dealing with the designed or built artifact, each of them within distinct system boundaries while responsible for different sustainability aspects "Each system boundary poses its own set of sustainability issues apart from the issues resulting from the aggregation of its subsystems. An acute challenge is finding the system boundaries, process phases and actors that in current practices have the greatest impact on the resulting performance of the built environment".(Augenbroe, G : 1998)	 **Figure No. 5 Georgia institute of technology (Sustainable life cycle).**

2.2 Sustainable Metal Building Life Cycle Phases

In natural life cycle, each unit process has its inner cycle and all processes in the system are interrelated to other processes to complete the natural life cycles. Considering the balance between all systems, those rules could be adopted in our case if we could implement them on the building life cycles each in its place. So , we could simplify the metal building life cycle into five main phases related to the sustainability aspects , Pre-manufacture phase , Manufacture / prefabricate phase, Transportation/construction phase, Metal Building Use phase, End Life & Disposal phase, presented through the next table.

Table 2 : Metal Building Life Cycle Phases

	Relevance	Strategy
Pre - Building	**Phase 1 : Pre-manufacture**	
	Resource depletion, environmental burdens	Use of recycled materials
	Environmental burdens	Use of less energy intensive materials
	Supplier performance, environmental burdens	Environmentally conscious component selection
	Resource depletion	Use of renewable materials
	Phase 2 : Manufacture / prefabricate	
	Environmental burdens, working environment	Use high-through put processes
	Resource depletion, environmental burdens	Use material saving processes
	Environmental burdens	Overhead reduction
Building	**Phase 3 : Transportation/construction**	
	Resource depletion	standardization
	environmental burdens	Improved logistics
	environmental burdens	Low volume/weight
	Phase 4 : Metal Building Use	
	Resource depletion, environmental burdens	Low energy consumption
	Resource depletion	Design for maintenance/ long
Post- Building	**Phase 5 : End Life & Disposal**	
	Resource depletion	Design for disassembly
	Resource depletion, environmental burdens	Material quality preservation
	Resource depletion, environmental burdens	Design for recycling

3. The Future of Metal Building Sustainability :

3.1 The Future of Metal Building Sustainability From The Design Perspective:

Metal building as one of architectural design field involves considering the entire life cycle of buildings, taking environmental quality, functional quality and future values into account, So from the design perspective we concludes that :

a- **Smaller is better**; Optimize use of interior space through careful design so that the overall building size- and resource use in constructing and operating it- are kept at a minimum.

b- **Design an energy-efficient building**; Use high levels of insulation, high-performance windows, and tight construction. In southern climates, choose glazing with low solar heat gain.

c- **Design buildings to use renewable energy**; Passive solar heating, day lighting, and natural cooling can be incorporated cost-effectively into most buildings. Also consider solar water heating and photo-voltaic - or design buildings for future panel installation. If wood heating is an option, specify a low-emission wood stove or pellet stove.

d- **Optimize material use**; Minimize waste by designing for standard sizes. Avoid waste from structural over-design (use optimum value-engineering/advanced framing).

e -**Make it easy for occupants to recycle waste**; Make provisions for storage and processing of recyclables: recycling bins near the kitchen, under sink door mounted bucket with lid for compost able food waste, etc.

f -**Design for future reuse**; Make the structure adaptable to other uses, and choose materials and components that can be reused or recycled.

g -**Design for re-use existing buildings and structures** wherever possible (provided their energy costs in use can be reduced to an acceptable level).

h -**Design buildings for long life**, with ease of maintenance and adaptability to changing needs.

i - construct buildings and infrastructure out of local and low- energy materials where possible.

j -**Design for reduce the proportion of high rise**, detached or single-storey developments.

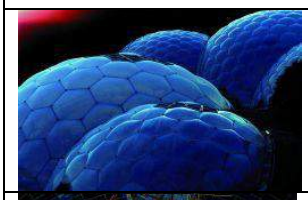
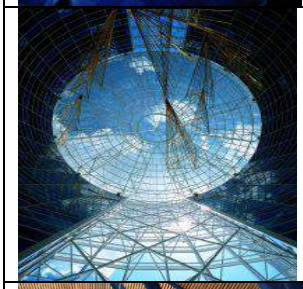
k -**Design for recycling** construction and demolition materials.

l - **Design for architectural reuse** (include adaptive reuse, conservative disassembly, and reusing salvaged materials).

m -**Design for material recovery** (durability, disassembly, adaptive reuse).

3.2 Sustainability Considerations of Metal Buildings

Sustainable metal building creates responsible management of a healthy built environment based on resource efficient and ecological principles. Sustainable metal buildings have minimum adverse impacts on the built and natural environment, in terms of the buildings themselves, their immediate surroundings and the broader regional and global setting , The sustainability considerations of metal buildings shown in Table 3, stressing on environmental& economical elements that should be dealt with

Table 3 : Sustainability Considerations of Metal Buildings			
	sustainable development	***Properties***	***Sustainability Consideration***
	*Sustainable environmental development*	*The possibility of combining flexibility in configuration and functions Achievement for a streamlined, dynamic forms compatible with environmental and climatic characteristics of the site.*	***Environmental Compliance (flexibility formal and functional)***
	*Sustainable environmental development*	*Access to spaces to allow free and unimpeded flow of air inside.*	***Methods of natural ventilation***
	*Sustainable environmental& economical development*	*The possibility of achieving high levels of transparency to allow the day light for periods greater.*	***Energy Saving***
	*Sustainable economical development*	*Efficiency in the use of materials to achieve the completion of construction with light weight.*	***Economy in materials***
	*Sustainable environmental& economical development*	*The use of construction materials from materials can be recycled or re-use components.*	***Re-use - Recycling***
	*Sustainable economical development*	*Appropriate methods of construction for the purposes of the interim and the possibility of removal and installation, and the future extension.*	***the future extension***

	*Sustainable economical development*	*Use of prefabricated systems & standard sections*	***Rely on prefabricated***
	*Sustainable environmental development*	*The possibility of applying advanced technologies such as controlling kinetic and intelligent systems in the design of roofs and facades to achieve greater environmental compatibility*	***The use of technology to achieve environmental compatibility***

3.3 Sustainable Metal Building Life Cycle

Sustainable life cycle of the metal building can be explained by the following diagram presented in figure.6 which divides it into three basic parts (Pre – Building , Building , Post – Building) include five main phases (Pre-manufacture phase , Manufacture / prefabricate phase, Transportation/construction phase, Metal Building Use phase, End Life & Disposal phase) :

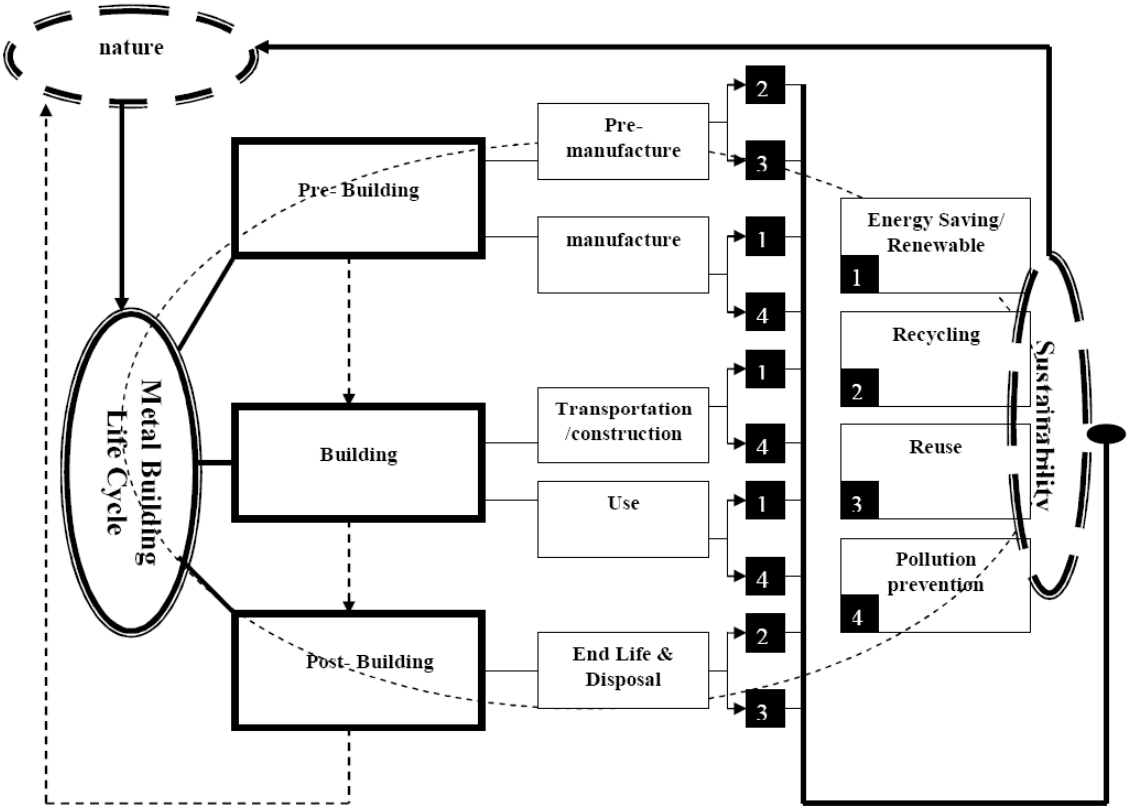


Figure No.6 Sustainable Metal Building Life Cycle Phases

4. Conclusion

The research findings concluded that:

- **each phase of the metal building life cycle involves many operations related to:**
  1. environmental aspects
  2. pollution prevention techniques,
- **the sustainable metal building life cycle can only be achieved by:**
  1. reducing consumption of non-renewable resources,
  2. minimizing environmental loads of waste and pollution
  3. , optimizing the management of economic resources,
  4. dramatically affecting metal buildings' environmental performance
- **The sustainability considerations of metal buildings can be achieved by:**
  1. dynamic forms compatible with environmental and climatic characteristics of the site .
  2. Access to spaces to allow free and unimpeded flow of air inside .
  3. The possibility of achieving high levels of transparency to allow the day light for periods greater .
  4. Efficiency in the use of materials to achieve the completion of construction with light weight .
  5. The use of construction materials from materials can be recycled or re-use components .
  6. the possibility of removal and installation, and the future extension .
  7. Use of prefabricated systems & standard sections .
  8. The possibility of applying advanced technologies such as controlling kinetic and intelligent systems in the design of roofs and facades to achieve greater environmental compatibility .

References

1. Ahmed Fathi Waly (2004) **Improving the design of sustainable buildings through Value Engineering**- the first conference of Sustainable Architectural and Urban Development- Cairo university.
2. .Alireza V. and Adeola O. (2008). **Survey of Sustainable Life Cycle Design and Management** . 14th CIRP Conference on Life Cycle Engineering.
3. Augenbroe, G., and Pearce, A.R., ,(1998)" **Sustainable Construction in the United States of America - A perspective to the year 2010**", Georgia Institute of Technology, College of Architecture, Construction Research Center, CIB-W82 Report, Georgia,
4. Godfaurd John_, Derek Clements-Croome, George Jeronimidis (2005) **Sustainable building solutions: a review of lessons from the natural world** - Building and Environment 40 , 319–328
5. Hui, S.M., (2002)"**Sustainable Architecture and Building Design** - (SABD)", Building Energy Efficiency Research project, Department of Architecture, The University of Hong Kong, Hong Kong, Apr.
6. Jong-Jin, K., and kigdon, B.,,(1999), "**Assailable Design**", National Pollution Prevention Center for Higher Education, University of Michigan
7. Jong-Jin, K., and kigdon, B., ,(1998) " **Sustainable Architecture Module - Introduction to Sustainable Design**," College of Architecture and Urban Planning, The University of Michigan and National Pollution Prevention Center for Higher Education, Michigan, Dec.
8. Leo Alting, Jens Brabech Legarth (1995)- **Life Cycle Engineering and Design**- Annals of the ClRP Vol. 44/2/1995
9. Yaldiz Y. Eid (2004)-**re-thinking concepts of sustainable architecture** the first conference of Sustainable Architectural and Urban Development- Cairo university.