The environmental impact of buildings

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The environmental impact of buildings is huge, however assessment methods of such impact lack behind. This paper explores environmental aspects, their impact and some indicators to assess buildings environmental impact including some site oriented indicators in order to help ameliorate such environmental threats. Some architectural design considerations are highlighted to help realize more environmentally friendly buildings and designs, along with reporting some environmental architecture design features. Design considerations include the choice of site; materials; massing of the project; special architectural feature; special electrical and mechanical considerations; waste management considerations; traffic impact considerations; and landscape features. In addition four illustrative case studies are reported. Each major building needs to be seen in the context of not only its individual location, but also the wider area. Major building schemes have to be preceded by an environmental impact assessment/statement, at which all the possible ramifications of a particular design and location are considered before construction can proceed.

التأثير البيئي للمباني كبير غير أن طرق تقييم مثل هذا التأثير لازالت غير متقدمة. ويهدف هذا البحث للتعريف بالجوانب البيئية للمباني وتأثيرها وبعض مؤشرات التقييم البيئية شاملة تأثيرات موقع المشروع لامكان الحد من أثر التهديدات البيئية. وتم التأكيد علي وابراز بعض اعتبارات التصميم المعمارية للوصول إلى مباني وتصميمات صديقة للبيئة بقدر الإمكان فضلا عن التأكيد علي بعض خصائص العمارة البيئية. واعتبارات التصميم هذه تتضمن اختيار الموقع ومواد الإنشاء ووضع المبني والخصائص المعمارية وبعض اعتبارات التصميم الكهربائية والميكانيكية الخاصة ونظم إدارة المخلفات والتأثير علي المرور والطرق وخصائص تنسيق الموقع العام. فضلا عن أنه تم عرض أربع حالات وتصميمات ميدانية لمشروعات مختلفة. ويجب أن يقيم كل مشروع ليس في إطار موقعه فحسب بل في محيط تأثيره الأوسع. ويجب أن يسبق إنشاء أي مشروع هام تقييم لتأثيره البيئي يبحث فيه ويتم تقييم جميع التأثيرات البيئية والمفاضلة بين بدائل مختلفة من التصميمات والمواقع.

Keywords: Architecture, Building, Ecological buildings, Environment, Green buildings

1. Introduction

The environmental impact of construction is huge. The construction and building industry (buildings, streets, bridges...etc.) consumes and changes landscape drastically; uses up nature, living space and raw materials; and brings about a high degradation and transection of ecosystems [1]. Besides, buildings may have all sorts of repercussions on the environment. The factors that influence the environment are numerous, besides they interact with one another, and their impact is interdependent on different components. Such complex interactions within the environment are at a variety of scales including the global level; countries level; city planning level; and local regions levels...etc [2].

The development of a building will involve changes to the existing land use and traffic patterns within the complex area of influence; uses up soil; and consumes space, besides degrades living space; and damages the ecosystems and landscape. The environmental impact of a building is enormous and is more than just the addition of the impact of its constituent building materials. Hence a method for assessment through well organized environmental profile including its site aspects is required [1]. The careful assessment of how much is a building an environmental burden will help to reduce the environmental impact effects of a building, and to ameliorate it threats. In addition it will help to mitigate bad effects generated by the building and to realize more environmentally friendly buildings and designs. This will imply several architectural design considerations to be adhered to.

This paper is directed towards such endeavor and to explore the environmental aspects of buildings, and some indicators to identify and assess such impact in order to help alleviate such threats. Some architectural design considerations are highlighted to help realize more environmentally friendly buildings and designs. In addition four illustrative case studies are reported.

2. Assessment of the environmental impact

The impact on the environment may be measured [2] by several indicators:

- Natural environment: pollution (air, sound, water, waste-water, land, view/optical); consumption of natural resources
- Social environment: habits, customs, behavior, and life-style (e.g. environment conservation, getting rid of waste, recycling, making use of natural sun light, conservation of drinkable water, and not polluting it)
- Constructed environment: all that is constructed by man including buildings and infra structure must be suitable for the environment and use architectural views in design and innovation to ascertain environmentally friendly architecture satisfying the thermal and living requirements without consuming natural resources and raw materials.

2.1. Life Cycle Assessment (LCA) methodology

Building materials impact on the environment is huge. For example [1,3,4]; polystyrene insulation is blown from ozone depleting chlorofluorocarbons (CFCS), wood products are treated with formaldehyde, paints are made from volatile organic compounds, cement industry creates fine dust, and aluminum is made from the mining and conversion process of bauxite, all these damage the environment.

The evaluation and classification aspects of the environmental aspects of building materials may be determined by means of an environmental Life-Cycle Assessment methodology (LCA) through incorporating all the material flows and other inputs and outputs on the environment [1]. The LCA across the entire life span of products is a quantitative objective valuation of the environmental impact of products. This requires determining the inventory of physical and measurable environmental inputs and outputs as quantitative measurable adds to or retrievals from the environments (e.g. total mass of CO_2 (carbon dioxide) emissions, followed by a classification step into the environmental effects. The potential damage to the environment may be categorized [1] in 3 domains with environmental aspects and changes caused by mankind; pollution, depletion, and impairment.

2.1.1. Pollution

Pollution can be; the emissions of hazardous substances into the air, water, waste water and soil; view/optical; consumption of natural resources. One or more of the following causes pollution:

- Green house effect/gases: (CO_2 & CH_4 emissions); traffic from and to a building and energy used during building in use.
- Ozone layer depletion: CFK from materials cause CFK emissions.
- Fotochem oxidant: (SO_2 emissions) transportation from and to and the use of energy of a building main factors causing smog.
- Acidification: (NH_3 emissions) traffic from and to a building and energy use during the building use are the main causes of acidification emission, the oxygen balance is a neutralization indicator.
- Eutrophication: phosphates caused by emissions to air.
- human toxicity: benzol emissions by the production of building materials and by traffic from and to the building.
- Ecotoxicity: benzol toxicity emissions by the production of building materials and by traffic from and to the building.
- Water pollution: drainage and overflow to surface water.
- Disturbance (noise, smell): decibels caused by cars.
- Soil contamination: dumping.

2.1.2. Depletion

One or more of the following causes depletion:

- -Use of biotic; wood (trees), plants, and animal.
- A biotic; petroleum, metal, stone, minerals (salts), fossil fuels, and raw materials.

2.1.3. Impairment

Impairment is environmental effects that lead to direct structural change in the environment to a degree in which living space of man, animal and plant is negatively influenced. Impairment can be:

- Impairment of ecosystems
- Impairment to landscape

However, the environmental impact of a building is far more than the sum of its materials and a broad environmental assessment of a building are not possible with LCA.

3. Building environmental impact

The development of a building (complex) will involve changes to the existing land use and traffic patterns within the complex area of influence. Buildings use up soils (top layer that has a high degree of biological activity and materials) that is the main substrate for all life on land. They consume space besides they degrade living space and damage the ecosystems and landscape. In addition, buildings impair site as ground is irreversibly used and a return to natural state is impossible.

Some environmental aspects are influenced including accessibility, as buildings are used by people hence this induces transport flows and thus additional environmental impact, and an infrastructure is necessary for accessibility. Besides, the human comfort in and around a building (sick building and micro-climate) is affected [1]. The ground water is influence by depletion; draining of water; and overflows to surface. Large structures affect the frictional characteristics of the ground surface [5]; absorb more solar radiation and retain reflected radiation by high walls and dark colored roofs; and heat is stored during the day and released at night.

However the problem is how to quantify such impairment, and how to assess the environmental impact of a building. The careful assessment of how much is a building an environmental burden, and do certain measures make larger or smaller contributions to such burden will help to reduce the environmental impact effect of a building. In addition it will help to mitigate bad effects generated by the building and to realize more environmentally friendly buildings.

3.1. Environmental profile method for assessment of building impact

The direct environmental impact of a building is enormous. As previously mentioned, the impact of a building on the environment is more than just the addition of the impact of its constituent building materials. Hence a method for assessment through well organized environmental profile may be required. Environmental valuation with a larger assessment area than that covered by LCA with more insights in the environmental load aspects is needed. Eight indicators were proposed [1]:

Three site oriented indicators

-Use of space: impairment of use of living space.

-Oxygen balance: for vegetation in and around a building to counter measure green house effect; trees, shrubs and flower beds to contribute to remedying air pollution; and filter function towards a balanced micro-climate.

-Accessibility: the traffic to and from a building (by foot, bike or public transport) and relative disturbance to public transport stops.

Three building oriented indicators

-Water balance: drinking water and draining of water, overflows, and sewage; pollution of surface and ground water and soil.

-Energy balance: air pollution by external energy use.

-Sick building syndrome (SBS): extent users can influence interior climate.

Two building parts and materials oriented indicators

-Material use balance: harmfulness of construction materials for man and environment like air pollution damages to ecosystems and human health.

-Reuse balance: the use of raw materials and waste and to what degree the building parts and materials can be reused after demolition.

It has to be noted that there are problems regarding the definition of physical and quantifiable environmental measures; assessment of use; consumption of nature (space) and land; and acquiring objective input data.

3.2. Comparisons with LCA

An integral building assessment by means of indicators should encompass all relevant environmental aspects from the LCA. In LCA the building impact is seen as the sum of the materials impact. LCA is incapable of weighing the site aspects of a building; the location where the construction is to take place and the direct surrounding of the building. LCA for buildings does no adequately account for four indicators out of which three are site oriented indicators i.e. use of space; oxygen balance; and accessibility, in addition to the water balance indicator. On the other hand, it can be seen that in the previous 8 indicators, the relevant LCA aspects have been incorporated. Detailed comparisons between the 8 indicators method and the LCA can be found elsewhere [1].

3.3. Integral assessment method

As both LCA method with its 3 indicators and the supposed more comprehensive method with its 8 indicators [1] do not adequately account for the physical aspects that influence the human well being in a building. The social effects (i.e. habits, customs, behavior, and life-style e.g. environment conservation, getting rid of waste, recycling, making use of natural sun light, conservation of drinkable water, and not polluting it), hence they may not provide an integral assessment for the environmental impact, which is still lacking behind awaiting development.

In addition even for the previous indicators to be quantifiable, unambiguous definitions of the reference values for the indicator are required in order to develop building related environmental synthesis.

3.4. Environmental impact assessment report

Each engineering scheme needs to be seen in the context of not only its individual location, but also the wider area. Major construction schemes have to be preceded by an environmental impact assessment (EIA) or statement, at which all the possible ramifications of a particular design and location are considered before construction can proceed. Assessment methodologies may include [6]: indoor air quality audit; life cycle energy audit; initial embodied energy; greenhouse gas assessment; lighting, thermal and ventilation (LTV) audit; hydraulic audit; life cycle costing audit; and post occupancy (operating) evaluation.

4. Ecological and green buildings

Sustainable construction may be defined [6] as "the creation and responsible management of a healthy built environment based on resource efficient and ecological principles". Sustainably designed buildings aim to lessen their impact on the environment through energy and resource efficiency. It includes the following principles: minimizing non-renewable resource consumption; enhancing the natural environment; and eliminating or minimizing the use of toxins. "Sustainable building" can be defined [6] 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 setting. Besides, "sustainable building" may be defined as building practices, which strive for integral quality (including economic, social and environmental performance) in a very 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 (energy conservation), and improving environmental quality. Sustainable building involves considering the entire life cycle of buildings, taking environmental quality, functional quality and future values into account. Several objectives may be identified for sustainable buildings including pollution prevention (including indoor air quality and noise); harmonization with environment (including environmental assessment); integrated and systemic approaches (including environmental management system).

4.1. Ecological building

Ecological Building is a movement in contemporary architecture. This movement aims to create environmentally friendly, energy-efficient buildings and developments by effectively managing natural resources [6]. This entails passively and actively harnessing solar energy and using materials which, in their manufacture, application, and disposal, do the least possible damage to the so-called 'free resources' water, ground, and air.

4.2. Green Building

A green approach to the built environment involves a holistic approach to the design of buildings. All the resources that go into a building, be they materials, fuels or the contribution of the users need to be considered if a sustainable architecture is to be produced. Producing green buildings involves resolving many conflicting issues and requirements. Each design decision has environmental implications. Measures for green buildings can be divided into [6] four areas:

- reducing energy in use;
- minimising external pollution and environmental damage;
- reducing embodied energy and resource depletion; and
- minimising internal pollution and damage to health.

A "green" building places a high priority on health, environmental and resource conservation performance over its life cycle. These new priorities expand and complement the classical building design concerns: economy, utility, durability, and delight. Green design emphasizes a number of environmental, resource and occupant health concerns. These include: reducing human exposure to toxic materials; conserving non-renewable energy and scarce materials; minimizing life-cycle ecological impact of energy and materials used; protecting and restoring local air, water, soils, flora and fauna; and supporting pedestrians, bicycles, mass transit and other alternatives to fossil-fueled vehicles. Most green buildings are high-quality buildings; they last longer, cost less to operate and maintain, and provide greater occupant satisfaction than standard developments. Good green buildings often cost little or no more to build than conventional designs. Commitment to better performance, close teamwork throughout the design process, openness to new approaches, and information on how these are best applied are more important than a large construction budget.

5. Some design considerations

Environmental architecture may include five features [6]:

- *Healthful Interior Environment*: Measures are to be taken to ensure that materials and building systems do not emit toxic substances and gasses into the interior atmosphere. Additional measures are to be taken to clean and revitalize interior air with filtration and plantings.
- Energy Efficiency: Measures are to be taken to ensure that the building's use of energy is minimal. Cooling, heating and lighting systems are to use methods and products that conserve or eliminate energy use.
- Ecologically Benign Materials: Measures are to be taken to use building materials and products that minimize destruction of the global environment. Materials and products are to be considered based on the toxic waste out put of production.
- Environmental Form: Measures are to be taken to relate the form and plan of the design to the site, the region and the climate. Measures are to be taken to heal and augment the ecology of the site. Accommodations are to be made for recycling and energy efficiency.

Measures are to be taken to relate the form of building to a harmonious relationship between the inhabitants and nature.

• Good Design: Measures are to be taken to achieve an efficient, long lasting and elegant relationship of use areas, circulation, building form, mechanical systems and construction technology. Symbolic relationships with appropriate history, the Earth and spiritual principles are to be searched for and expressed. Finished buildings shall be well built, easy to use, and beautiful.

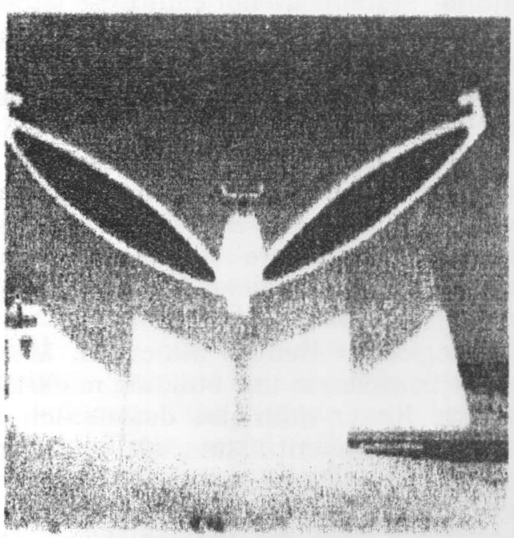
Figs 1 and 2 depict examples of environmental form and energy as a design consideration, respectively.

5.1. Practical design considerations

The expanded design team collaborates early in conceptual design to generate many alternative concepts for building form, envelope and landscaping...etc., focusing on avoiding any negative impact that will be either created or generated from its presence on the surroundings. Also, to reduce the effect of the building visual, climatic, noise, and environmental pollution and minimize peak energy loads, demand and consumption, Several practical considerations may b attempted to keep a building in friendly term with the environment. These consideration may include [6,7]:

- choice of materials,
- choice of the massing of the project,
- special architectural feature,
- special electrical and mechanical considerations,
- waste management considerations,
- traffic impact considerations,
- landscape features, and
- choice of site.

Evaluate site resources and early in the siting process carry out a careful site evaluation (e.g. solar access, soils, vegetation, water resources, important natural areas.. etc.) and let this information guide the design. Locate buildings to minimize environmental impact. Cluster buildings or build attached units to preserve open space and wildlife habitats, avoid especially sensitive areas including wetlands, and keep roads and service lines short. Leave the most pristine areas untouched, and look for areas that have been previously damaged to build on. Seek to restore damaged ecosystems. Besides, situate



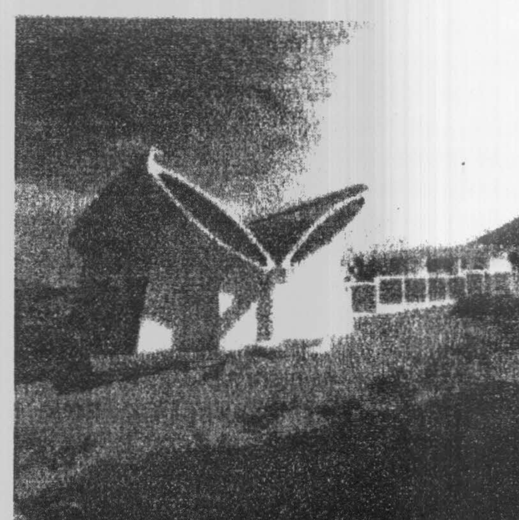


Fig. 1. Camino Con Corazon-Baia California Sur, Mexico (designers: Jersey Devil Badanes,Adammson, Ringel) an example of environmental form to gather rain and dew drops in hot and arid areas (Green Archithecture, Crosbie 1994, (cited in [13]).

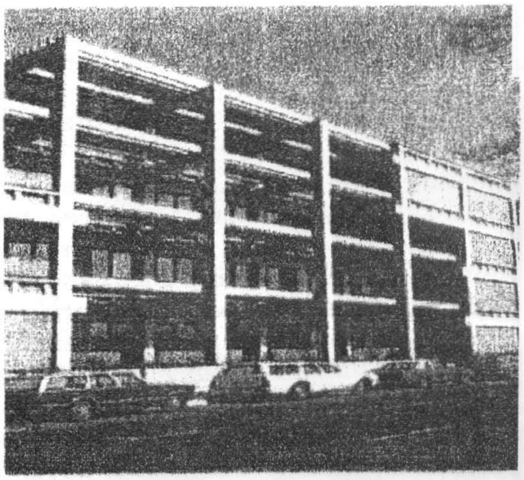


Fig. 2. The Bateson BUIDING-energy as a design consideration.The Bateson Bulding (California, by Sim Van Der Ryn) an example of environmental architecture. The building with its outer façade is coverd with sun breaking louvers is built around a glazed court with operable glass to achieve ventilation; a fabric tube is used to move aire into the court. The basement is filled with rocks used to cool the internal space by storing cool night temperature in summer to release it in building spaces by day. The opposite is done in winter where heat is stored and released to warm the space (cited in [13]).

buildings to benefit from existing vegetation. Minimize automobile dependence by locating buildings to provide access to public transportation, bicycle paths, and walking access to basic services. Buildings with bulky masses may block the view of surrounding buildings. Besides, they may cast undesirable shadow on walls of surrounding buildings and prevent sunrays from reaching windows. Furthermore, they may obstruct the breeze from reach openings of neighboring buildings. Selection of materials and furnishings may control indoor air pollution sources. Central atriums bring daylight reducing heat gains and losses by limiting exterior building perimeter [3]. Use special venting of storage areas and for copier rooms [4].

It may be required to perform a wind study to assess the wind environment around the building in terms of pedestrian comfort and safety and assure that wind tunnel effect does not have a harmful impact on surrounding streets, and to allow the breeze to circulate to the surroundings.

Optimize use of interior space through careful design. Design an energy-efficient building by use high levels of insulation, high-performance windows, and tight construction. In hot climate, choose glazing with low solar heat gain. Design buildings to use renewable energy. Passive solar heating, daylight, and natural cooling can be incorporated cost-effectively into most buildings. Also consider solar water heating and photovoltaic or design buildings for future solar installations. Design for durability to spread the environmental impacts of building over as long a period as possible, the structure must be durable. A building with a durable style ("timeless architecture") will be more likely to realize a long life [6]. Design for future reuse and adaptability by making the structure adaptable to other uses, and choose materials and components that can be reused or recycled.

Consider designing to follow green guidelines for design [3]. Consider the possibility of using water based rather than solvent based products; and implementing virgin and recycled materials [3,4,5]. Make sure that materials are safe e.g. test for lead paint and asbestos. Avoid materials that will offgas pollutants. Solvent-based finishes, adhesives, carpeting, particleboard, and many other building products release formaldehyde and Volatile Organic Compounds (VOCs) into the air. These chemicals can affect workers' and occupants' health as well as contribute to smog and ground-level ozone pollution outside. Avoid potential health hazards e.g. radon, mold, pesticides by following recommended practices to minimize radon entry into the building and provide for future mitigation if necessary. Provide detailing that will avoid moisture problems, which could cause mold and mildew growth. Design insect-resistant detailing that will require minimal use of pesticides.

Avoid ozone-depleting chemicals in mechanical equipment and insulation e.g. avoid foam insulation made with HCFCs. Use durable building materials products and materials, since a product that lasts longer or requires less maintenance usually saves energy. Durable products also contribute less to our solid waste problems. Select building materials that will require little maintenance (painting, re-treatment, waterproofing, etc.), or whose maintenance will have minimal environmental impact. Use building products made from recycled materials to reduce solid waste problems, cut energy consumption in manufacturing, and save on natural resource use. An example of materials with recycled content is cellulose insulation [6]. Buy locally produced building materials, as transportation is costly in both energy use and pollution generation

Typically, heating and cooling load reductions from better glazing, insulation, efficient lighting, daylighting and other measures allows smaller and less expensive HVAC equipment and systems, resulting in little or no increase in construction cost compared to conventional designs. Fig. 3 illustrates the use of photovoltaic solar panels merged in to the architectural design, where dead areas of the building are used and are productive.

The development of a waste management system is required for stored sorted, transferred stored and/or processed and finally collected generated waste. Makes it easy for occupants to recycle waste by making provisions for storage and processing of recyclable: recycling bins near the kitchen, under-sink compost receptacles, and the like. Besides, shrink the amount of construction debris. In addition look into the feasibility of gray-water (water from sinks, showers, or clothes washers) recycling for irrigation in some areas. If current codes prevent gray-water recycling, consider designing the plumbing for easy future adaptation.

Special friendly systems with the environment are required in the electrical and mechanical design. Install high-efficiency heating and cooling equipment, e.g. well designed high-efficiency furnaces, boilers, and air conditioners (and distribution systems) not only save the building occupants money, but also produce less pollution during operation. Install equipment with minimal risk of combustion gas spillage, such as sealed-combustion appliances. Install high-efficiency lights and appliances as these offer both economic and environmental advantages over their conventional counterparts. Install water-efficient equipment as water-conserving toilets, showerheads, and faucet aerators not only reduce water use, but also reduce demand on septic systems or sewage treatment plants. Reducing hot water use also saves energy.

To ease the transportation impact of a proposed development on the transportation network, a study of the traffic access including changes in traffic flow conditions, travel patterns, forecast traffic, traffic generated, may be required. Such study, accommodate any increase in traffic volume, circulation and capacity, to keep general vehicular circulation to acceptable levels of service, including traffic (car users, parking, pedestrian amenities and safety, noise, visual intrusion, visual obstruction, impact on shops and business, and on visitors). Furthermore it is required to reduce the building impact on the on-site and off-site transportation in the vicinity of the area. Moreover, to reduce pressure on the surrounding roads there should not be need for vehicles to stop on surroundings streets to access the property freeing the surrounding streets and easing traffic circulation. Vehicles actuated along surrounding streets to ensure that long queues do not develop, no delays, no conflicting turning movements, links surrounding the complex

Create amenable atmosphere by implementing "green solutions" by using wild flowers and indigenous low maintenance plants requiring less maintenance and less seasonal frequent cutting rather than several

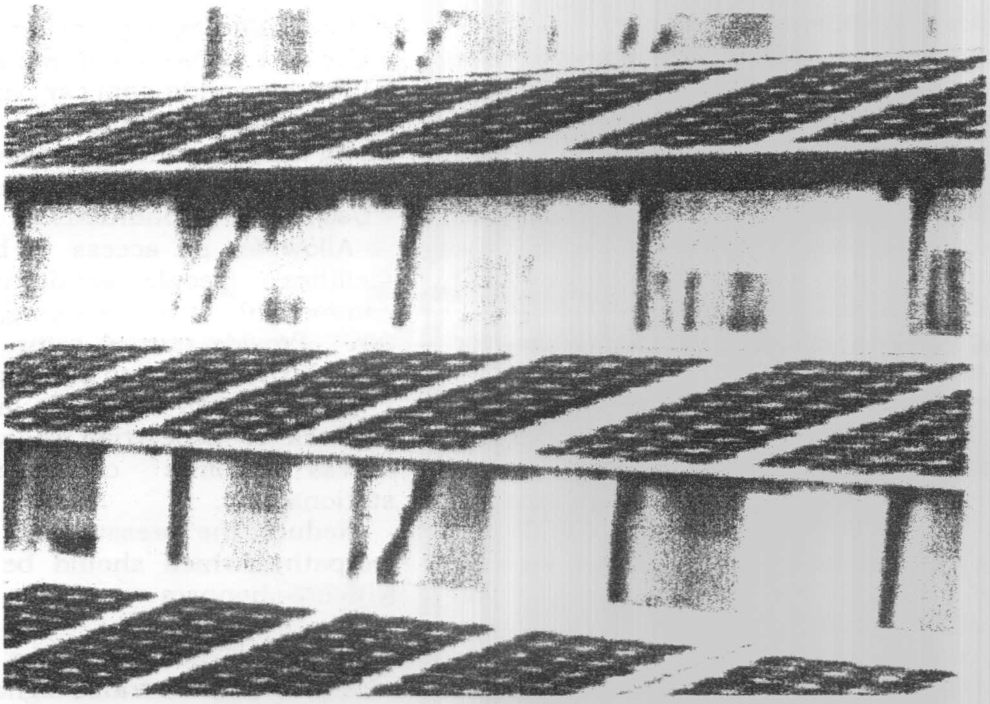


Fig. 3. Photovoltaic solar panels are merged into architectural design, and dead areas of the building are thus used and become productive (cited in [13]).

times cutting for some high maintenance grass, saving carbon dioxide [3]. Design water-efficient, low-maintenance landscaping with low pesticide use, and pollution generated from mowing. Landscape with drought-resistant native plants and perennial groundcovers. Provide responsible on-site water management by designing landscapes to absorb rainwater runoff (storm water) rather than having to carry it off-site in storm sewers. In arid areas, rooftop water catchment systems should be considered for collecting rainwater and using it for landscape irrigation.

During construction minimize job-site waste. Set up marked bins for different types of usable waste (wood scraps, sawdust... etc.). Find out where different materials can be taken for recycling, and educate your crew about recycling procedures. Use the design and construction process to educate clients, employees, subcontractors, and the general public about environmental impacts of buildings and how these impacts can be minimized.

6. Case studies

Four illustrative case studies are reported.

6.1. Case study 1

This case study is reported to illustrate some design issues considered related to easing the environmental impact a proposed building, (fig. 4–a to 4-d). This is the case of a high profile development building complex in the Alexandria area [7]. The complex was designed by a team of prominent local and international consulting offices and architects. It comprises a hotel, apartment component, food and beverage outlets, food courts, a retail mall, a supermarket, cinemas and other support elements. The components design was integrated for easy use and access [7].

6.1.1. Choice of the massing of the project

Invert internal court to the outside in the form of setbacks, fig 4-a.

6.1.2.Special architectural features

Introduce openings in the project shell to avoid acting as a wind shield and allow breeze to cross to all other parts of the complex and surrounding buildings, fig 4-b.

6.1.3. Electrical and mechanical considerations

Special systems friendly with the environment were adopted in the electrical and mechanical design such as:
- Using ozone friendly refrigerant gas for central air conditioning.
- Raising the levels of the exhaust outlets to a remote level above the street level to avoid any harm that could affect the pedestrians.
- Kitchen exhaust to pass through ecology units.
- Using grease interceptors for all kitchen drainage.
- Using oil interceptors for car park drainage
- Using co-detectors and monitors for car park levels.
- Use noise containment for equipment.
- Utilize natural gas for hot water generation.
- Divide parking levels to control operation of fans according to occupation.
- Use heat recovery units to reduce fresh air load.
- Use lightning protection system.
- Use emergency power supply; fire alarm system; car parking system; security system.

6.1.4. Waste management consideration
- Separate generated wastes for recycling (food waste, paper, cardboard, cans, glass, plastic and newspaper) and remove from main garbage stream, fig 4-c.
- Distinguish between wet garbage that requires tempered storage from the volumes of dry garbage that do not require tempered storage.
- Source separation of cardboard and 2 types of glass products
- Use tempered holding room for un-compacted waste.
- Apartment waste collection system include Tri Sorter chute system with remote control panels to distinguish wet garbage, paper fiber products, and cans and bottles, fig 4-c.
- Use self-contained waste compaction system.

6.1.5. Traffic impact consideration
- Use several basement levels as car parking.
- Introduce additional car parking stalls.
- Introduce additional car parking capacit along the surrounding streets.
- Introduce ample car facilities.
- Use free flow conditions.
- Allow for all access to be from off-stree facilities (people set-down and pick up commercial outlet servicing, parking provide for. Provide curved ramp access and wit entry/exit facilities to parking from the ramp.
- Provide well-designed landscape interna network of pedestrian walkways with focuse access points corresponding to bu stations...etc.
- Reduce the pressure on the surroundin footpaths, which should be relatively free o window-shoppers and of pedestria circulation.
- Provide widened pedestrian facilities.
- Use coordinated traffic signals.
- Widen surrounding streets.
- Provide U-turns.

6.1.6. Landscape features

Use heavy plantation to mitigate the effects of the undesirable fumes and gases resulting from the expected traffic, fig. 4-d.

6.2. Case study 2

This case study is for designing a village satisfying the environmental balance in new agricultural communities in Sinai [2] (fig. 5). In a conventional dwelling:

Increase exterior wall thickness, only few facade exterior openings to protect rooms from sun.
- House to oversee the interior (pathio) to reduce the percentage of openings in exterior to protect the dwelling from climate and weather variations since the climate varies drastically between night and day, fig. 5.
- Design compatible with social factors. Use internal pathio as an interior garden for the room, fig. 5. Protect the privacy of the occupants from strangers and provide a place for the family to carry out its activities. Hence the design satisfied internal and external privacy

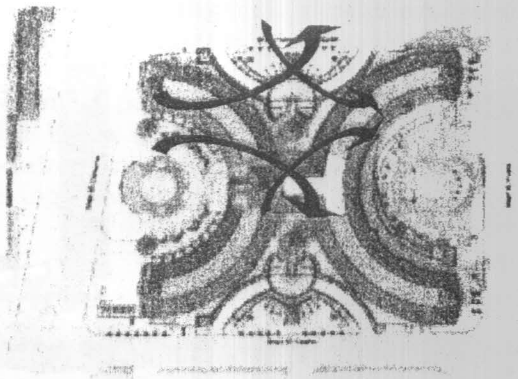


Fig. 4-a. Site plan and circulation of sea breeze.

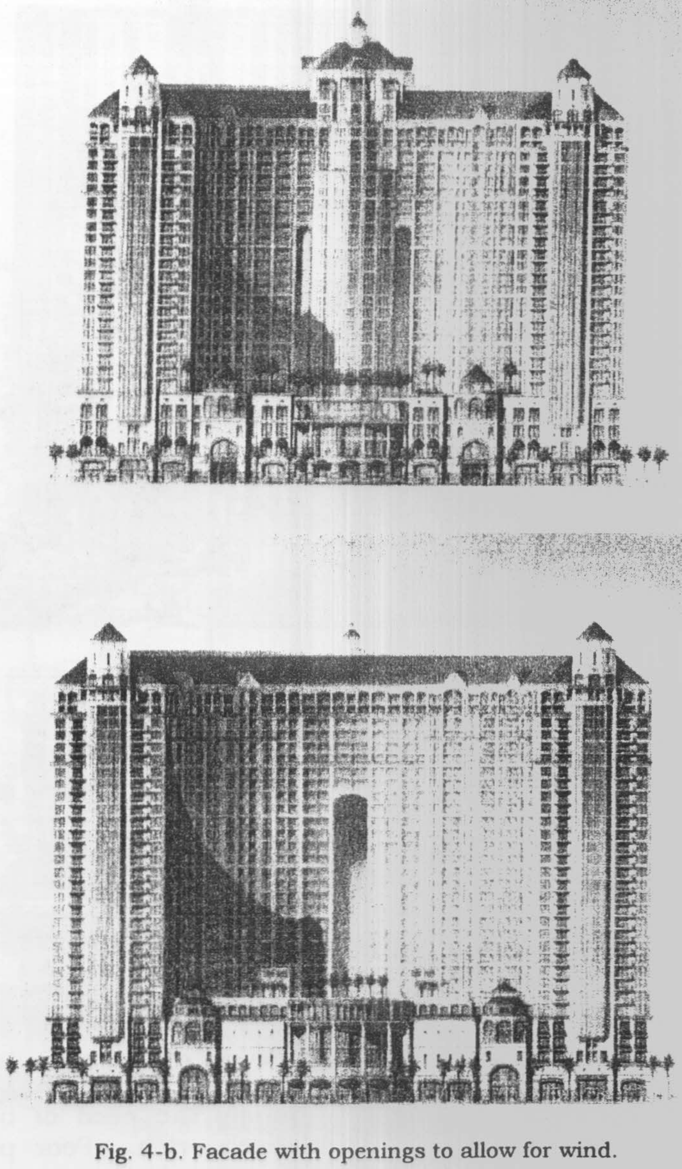


Fig. 4-b. Facade with openings to allow for wind.

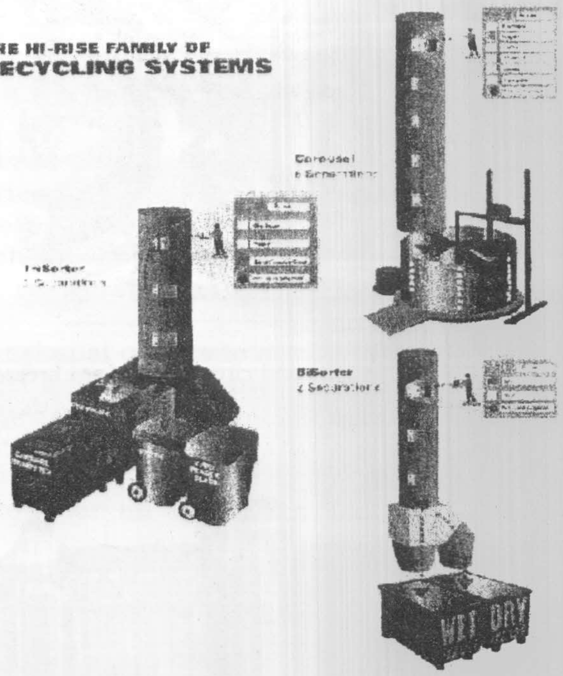


Fig. 4-c. Recycling systems-some types of systems for apartment chutes.

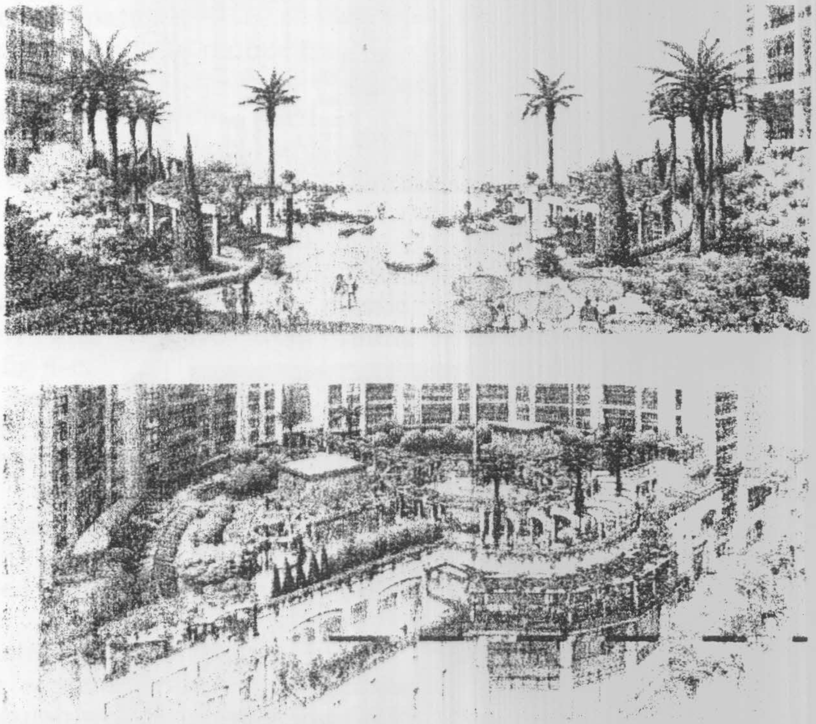


Fig. 4-d. some landscape features (fountains, elevated gardens, plants...etc.).

and was compatible with the local customs and habits and occupants culture.

- Satisfy the need of both the poor and the relatively rich. Poor people dwellings were small and consisted of one room overlooking a patio containing living requirements (furnace) and cooking utilities. Relatively better dwellings contained several rooms, a patio and a stable for domestic animals. Every dwelling contained the necessary requirements for its occupants within their living social and financial standards.

6.3. Case study 3

This case study is of "The Green" building in New York, USA (fig. 6) which is supposed to be one of the first high-rise residential building ever designed to take full advantage of environmentally sustainable, or green, design and construction [8]. It is a twenty- six-story luxury apartment building emphasizing energy, efficiency, water conservation, air quality, and the use of recycled materials. Photovoltaic cells were integrated in the faced and the roof to provide a certain percent of the building energy. A place for a fuel cell power plant was also scheduled. Geothermal heat transfer technology will provide additional energy by circulating water underground in a closed loop. Storage tanks are provided on the roof to collect storm water for use in toilets and landscape irrigation. Besides a gray-water filtration system will be provided to recycle water for similar uses, however this is a very costly solution.

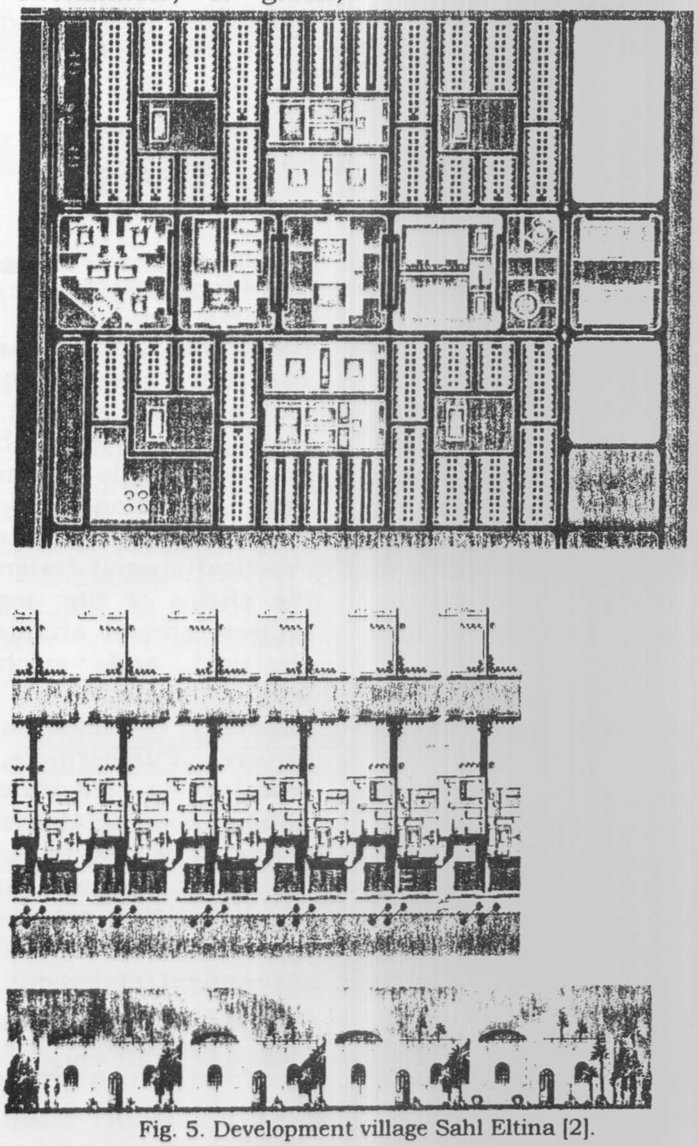


Fig. 5. Development village Sahl Eltina [2].

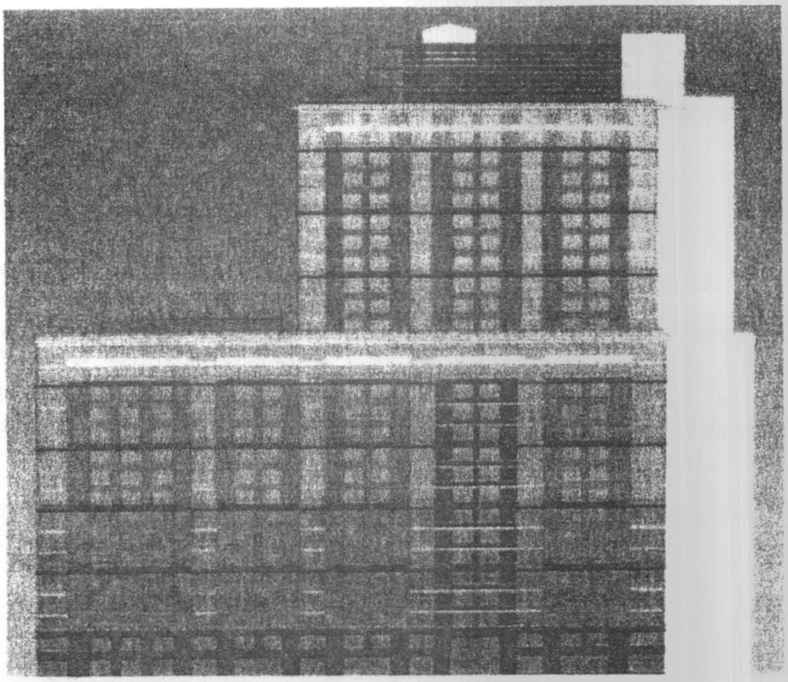


Fig. 6. The "Green Building' in Battery Park City (New Yerk, USA) with photovoltaic cells, geothermal energy, a fuel cell power plant, recycled construction materials, and a gray-watter recycling system [8].

6.4. Case study 4

This case study is of planning and design of a touristic resort in the north western egyptian coast designed by the authors, where the general layout circumvent an existing archaelogical historical site that should be preserved (fig. 7), however still attempting to keep the harmony of the design within the site and economical constraints required by the owner.

7. Conclusions

The environmental impact of buildings is huge, however assessment methods of such impact lack behind. The environmental aspects were explored including their impact and some indicators to assess such environmental impact including some site oriented indicators connected to the building location and the use of nature and living space. Social effects (i.e. habits, customs, behavior, and life-style) should also be considered. Such assessment helps ameliorate such environmental threats. In addition, some architectural design considerations are highlighted to help realize more environmentally friendly buildings and designs, along with reporting some environmental architecture design features. Practical special design considerations include the choice of site; materials; massing of the project; special architectural feature; special electrical and mechanical considerations; waste management considerations; traffic impact considerations; and landscape features. Furthermore, four case studies are reported to illustrate implementing several design considerations. Each major building needs to be seen in the context of not only the individual location, but also the wider area. Major building schemes have to be preceded by an environmental impact assessment/statement, at which all the possible ramifications of a particular design and location are considered before construction can proceed.

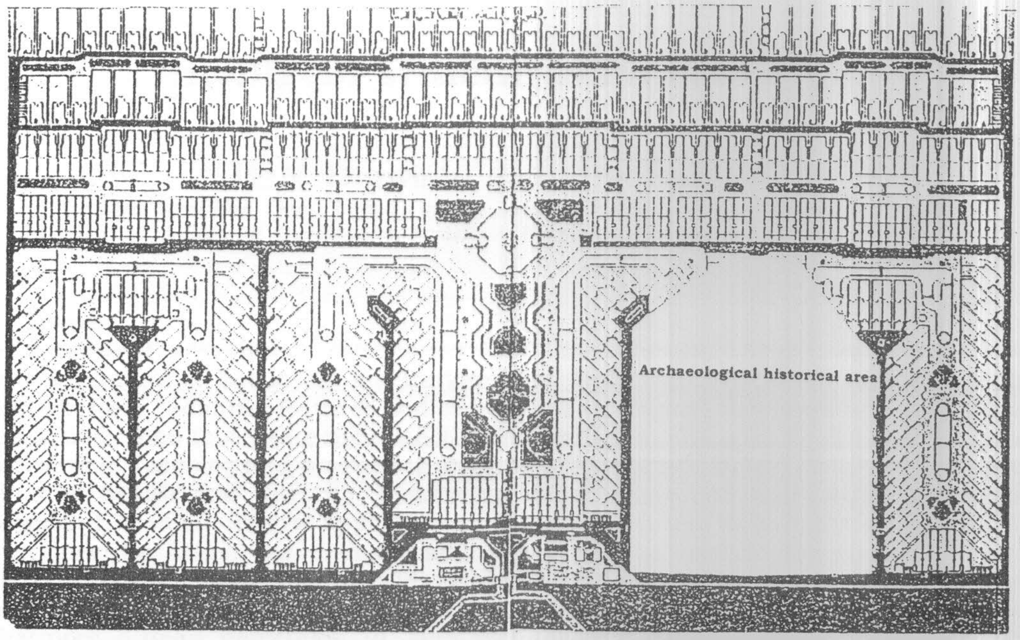


Fig. 7. General layout of a touristic resort on the north western Egyptian coast where the design cirmumvent an archaeological historical area in an attempt to preserve it within the economical constraints.

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