Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia - Social and Behavioral Sciences 68 (2012) 735 – 751

Procedia
Social and Behavioral Sciences

AicE-Bs 2012 Cairo
ASIA Pacific International Conference on Environment-Behaviour Studies
Mercure Le Sphinx Cairo Hotel, Giza, Egypt, 31 October – 2 November 2012
"Future Communities: Socio-Cultural & Environmental Challenges"

Protect our Environment through Developing Architectural Design towards Sustainability by Applying its Principles into Design Tools

Wael Ahmed Shaaban Abo Neama*

Architectural department, Faculty of Fine Arts, Helwan University, Zamalek, Cairo, Egypt

Abstract

Sustainability is based on protecting green fields and creating sustainable sites. Furthermore, increase the efficiency of water and energy consumption besides using local materials, and implement recycling programs. Projects that achieved high rates using sustainable rating system are environmentally friendly. The research objective is to stimulate all architects to protect the planet through applying sustainability criteria. The methodology focused on applying the sustainability principles into design tools. The outcome is focused on extracting sustainability database from existing rating systems and proofs that computer programs as design tools can review architectural design input data against saved database.

Selection and peer-review under responsibility of the Centre for Environment-Behaviour Studies (cE-Bs), Faculty of Architecture, Planning & Surveying, Universiti Teknologi MARA, Malaysia.

Keywords: Environment protection; architectural design; sustainability, architectural design tools

1. Introduction and Background

Nobody can deny that there is no building design or construction document is not produced using one of the computer programs. Engineering and BIM "Building Information Model" programs are nowadays the design tools beside ruler, pencil, and protractor. If we input the sustainability principals into those architectural programs database, we will ensure that the outcome of that program is revised against

* Corresponding author. Tel.: +20-100-142-6210.
E-mail address: wael.aboneama@gmail.com, wael.shaaban@ecgsa.com.

1877-0428
Selection and peer-review under responsibility of the Centre for Environment-Behaviour Studies (cE-Bs), Faculty of Architecture, Planning & Surveying, Universiti Teknologi MARA, Malaysia.
doi:10.1016/j.sbspro.2012.12.263

sustainability guidelines. That means we can protect our environment through enhancing the outcome of architectural design tools by applying sustainability principals into their database.

Architectural design tools specially BIM have many structural and constructional database to enhance building construction and coordination between different disciplines (Fig. 1).

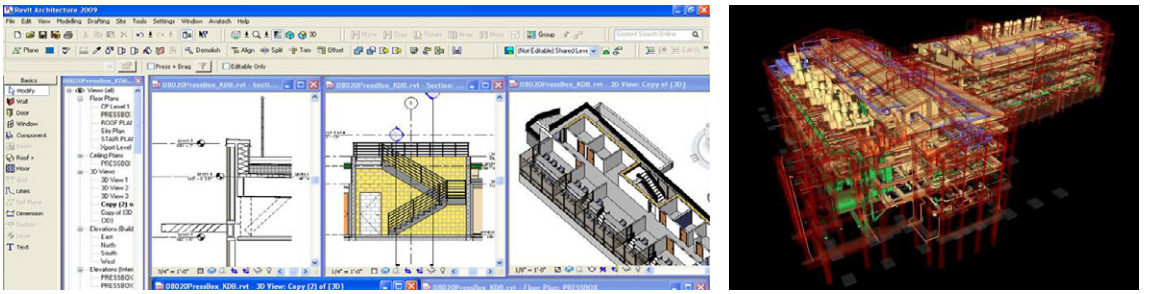

Fig. 1 (a) Picture on the left illustrates Revit as BIM tool; (b) Picture on the right illustrates a building with all its equipments as data input to model that building
(Source: Author)

Architecture today does not suffer from too much technology, but from the inappropriate application of the technology. The program database should have required data by the architect to be reviewed against available codes, environmental criteria, and sustainable principals of a certain rating system. It should not be the paradigm for CAAD to design the most complex artifacts of civilization with drafting programs simulating the computer as an electronic pencil only. Instead, architects should take advantage of simulation and communication technology on the best possible level during the design process and use them to as helpful tool to push their design forward towards sustainability to protect our planet..

If architects want to keep and improve their role in the planet future, they need to employ the computer more effectively towards sustainability. This could include its use as a design support medium when it includes all sustainability principals. They can assist designers in areas where they do not have sufficient knowledge or competence themselves for sustainability (1).

The question now is how we can improve engineering and architectural tools towards sustainability. Moreover, what kind of knowledge that this paper should discuss to move this step? In the following, the paper will discuss information as base concept of any design tool.

2. Literature Review for Information as the Fifth Dimension of Architecture and Sustainability Tools

2.1. Literature review for information and architecture

In 1946, *Sigfried Giedion* announced time as the fourth dimension of architecture. With the end of the 20th century and the role of the computer programs in architecture field, information has proven its position as the fifth dimension of architecture. (2) Information can be categorized into the following:

---

(1) Gerhard Schmitt – INFORMATION ARCHITECTURE basis and future of CAAD Basel : Birkhauser , c1999
(2) Gerhard Schmitt, with addition and modifications by the researcher.

2.1.1. External references

They are the information and codes from outside those affecting the design. They are the information used in the design and construction process consists of the building regulations along with information about the site and context. The formalized information describes patterns and agreements of buildings and physical laws that designers must know.

2.1.2. Integration information

They are the information generated in the design and construction process itself. Designing and constructing a building creates new information. Besides the spatial and physical result, the design and building processes generate an information database. The building in its entirety represents new information in the sense of collecting data unified into a meaningful structure.

2.1.3. Sustainability

It is the information related to long-term maintenance of responsibility, which has environmental, economic, and social dimensions, and encompasses the concept of stewardship, the responsible management of resource use. In ecology, sustainability describes how biological systems remain diverse and productive over time, a necessary precondition for the well-being of humans and other organisms. Long-lived and healthy wetlands and forests are examples of sustainable ecological systems[3]. It is the information coming into existence during the lifetime of the building.

This classification of information and the combined use of it in design offers a better future for architecture. Now, the computer is mainly used to translate and improve existing ways of thinking, and to build faster and more efficiently. This research is focused on input the sustainability as information in the database of the architectural computer programs.

2.2. Literature review for applying sustainability on computer programs

There are many helping tools for energy modeling which help the architect to minimize required energy for building cooling or heating and subsequently, minimize the carbon emissions for that building (Fig. 2).

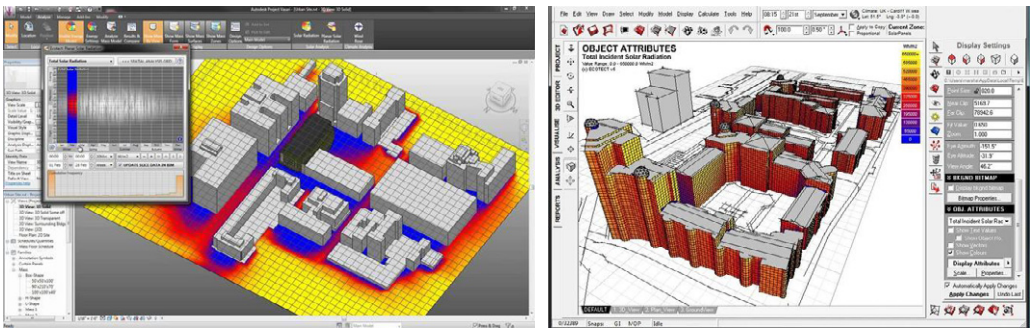

Fig. 2. (a) Picture on the left illustrates Project Vasari; (b) Picture on right illustrates Ecotect for energy modeling (Source: Author)

[3] http://en.wikipedia.org/wiki/Sustainability

3. Methodology Steps for Applying Sustainability Principals into Architectural Design Tools

As presented in the literature review that the design tools help in one category of the sustainability which is energy modeling. There are some steps to have all sustainability principals applied into computer program database, which will lead the architect to enhance building performance towards sustainability for planet protection. These steps could be summarized into the following:

3.1. Step one: Define sustainability

Since 1991, there are many efforts, which have been done by sustainability rating systems to define sustainability in buildings and still under development process. This paper will take two of them as references, which are LEED as one of the most famous international rating system in the world and GREEN PYRAMID as local Egyptian rating system table 1. The aim of having two is discussing the differences of sustainability definition between different regions. The paper will present the way of applying sustainability categories for each place in the world.

3.2. Step two: Presenting the way of measuring the sustainability for buildings

After defining sustainability into categories as presented in table 1, this paper should present the way of measuring those categories and their classifications for any architectural design. The aim of this step is to summarize all sustainability categories and sub-items to be transformed into database.

3.3. Step three: Applying sustainability categories into design tools database

After defining sustainability categories items and measurement concept, this paper should study the implementation of those categories into design tool database.

3.4. Step four: Test the implementation

Final step is to test this theory implementation. The aim of this step is only to ensure the interaction between the user and the design tool. For sure, this paper will not be ended by an application for sustainable design. It is only to proof that the computer program can interact with the user based on certain database inside it, and the user has the ability to input certain database for flexibility, which is important because each place has certain weight for each category.

4. Results and Findings of Sustainable Design

The sustainability rating system is a method for calculating the sustainability level in any building. It is based on calculating, for example, the amount of electricity consumption for an entire building against an old building in certain code. The amount of electricity saving means the level of sustainability in this category. We need first to know the sustainability categories in global rating systems such as LEED in the US, and Green Pyramid for Egypt. LEED and Green Pyramid present sustainability in building in seven main categories. The whole categories in each rating system have (110 points) as presented in Table 1.

Table 1. LEED & green pyramid categories & their weighting[4], [5]

LEED Categories	LEED Category weighting	Green Pyramid Categories	Green Pyramid Category weighting
Sustainable sites	26 points	Sustainable Site, Accessibility, Ecology	15 points
Water efficiency	10 points	Water efficiency	30 points
Energy & Atmosphere	35 points	Energy Efficiency	25 points
Material & Resources	14 points	Material & Resources	10 points
Indoor Environmental Quality	15 points	Indoor Environmental Quality	10 points
Innovation in Design	6 points	Innovation and Added Value	10 points
Regional priority	4 points	Management	10 points
SUM	110 points		110 points

We can notice that both have approximately the same categories, but the weight of each one reflects the importance and the need for each region. For example, Water Efficiency has only 10 points in LEED, but it has 30 in Green Pyramid as an Egyptian rating system. Each region in the world should define its problems based on its environmental and ecological studies to set the sustainable attributes. We can get the benefit of having the same categories for different rating systems by creating a database of a computer program. The user will define the location of his project, which will determine the weight for each category. Moreover, some categories can have zero weights because there are defined for other regions.

5. Sustainability as an Information for Engineering Program

The research will study and transform the sustainability categories as presented in table 1 in a database. It will take LEED credit forms as a helping material to formulate the information territory of sustainable design.

5.1. Category one: Sustainable sites as an information in database

The following table will present the credits and the weight of each one for sustainable sites in LEED:

Table 2. Sustainable sites credits & their weighting in LEED [4]

No.	Sustainable Sites credits	Credit points in LEED
1	Site Selection	1 point
2	Development Density and Community Connectivity	5 points
3	Brownfield Redevelopment	1 point
4.a	Alternative Transportation - Public Transportation Access	6 points

[4] Green Building Education Services, *LEED Green Associate study guide*, 2010
[5] The Housing and Building National Research Centre, *The Green Pyramid Rating System, First Edition* – April 2011, for public review (First Revision: following Draft document dated May 2010)
[4] Green Building Education Services, *LEED Green Associate study guide & LEED Checklist*, 2010

4.b	Alternative Transportation - Bicycle Storage and Changing Rooms	1 point
4.c	Alternative Transportation - Low-Emitting and Fuel-Efficient Vehicle	3 points
4.d	Alternative Transportation - Parking Capacity	2 points
5.a	Site Development - Protect or Restore Habitat	1 point
5.b	Site Development - Maximize Open Space	1 point
6.a	Storm water Design - Quantity Control	1 point
6.b	Storm water Design - Quality Control	1 point
7.a	Heat Island Effect - Non-roof	1 point
7.b	Heat Island Effect - Roof	1 point
8	Light Pollution Reduction	1 point
	Total	26 points

The questions now are:

- How can we transform these credits into the database?
- How the user will input all site data for evaluation?
- The answers of above inquiries will be extracted from the required documents, which the architect should submit to any rating system[6]. The research depends on LEED forms as a main source of database. See (Fig. 3)

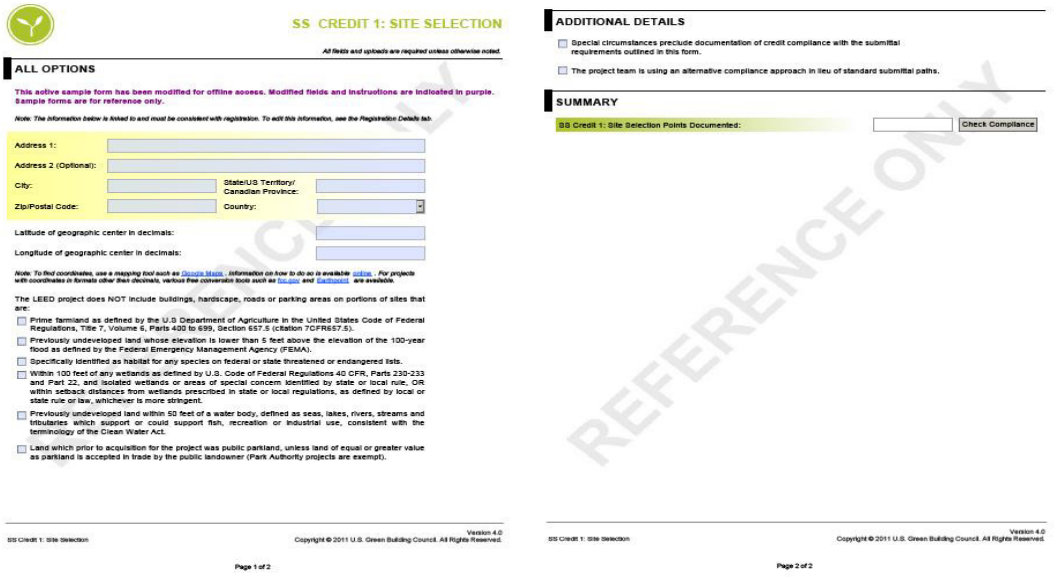

Fig. 3. Both pictures on left & right illustrate LEED form sample (ss1_dya.pdf) that should be submitted for site selection credit of sustainable sites
(Source: Author)

[6]) The research will depend on LEED forms as a good sample. The source is the following website: www.usgbc.org

5.1.1. Required data to be implemented as information for sustainable sites

In the beginning to can set certain system that user will review his design; it should contain all required data for natural reserves, prime farmlands, wetlands, lakes, parks and national gardens … etc. The program should be connected to the internet to can review against the updated information settled by the local authorities. In addition, the program can give for each question of the following its points related to table 2. Each rating system has a different credit weight, and this could be added as per selected one.

5.1.1.1. Input data for site selection credit

The user should submit the following data during the stage of data input to can develop the architectural design towards sustainability for site selection credit:

Site coordinates to be revised against natural reserve places.

Are there any building, hardscape, roads or parking areas on the portion of sites, which are:

- Prime farmlands as defined by country codes and regulations[*].
- Previously undeveloped land.
- Specifically identified as habitat for some species.
- Within (100 feet[**]) of any wetlands.
- Previously undeveloped land within (50 feet) of water bodies, defined as seas, lakes, rivers, streams and tributes, which support or could support fish, recreation or industrial use.

5.1.1.2. Input data for development density and community connectivity credit

The user should submit the following data during the stage of data input to can develop the architectural design towards sustainability for Development Density and Community Connectivity credit:

- Is the project in a community with a minimum density defined by the local codes?
- Is the project within half-mile of the residential zone?
- Is the project within half-mile of basic services[***]?

5.1.1.3. Input data for Brownfield redevelopment credit

- Does the project site define as a Brownfield by local code or regulation?
- Does the project site is documented as contaminated by one of the local authorities?

5.1.1.4. Input data for alternative transportation credit

- Does the project site located within half-mile walking distance measured from the main building entrance of a commuter rail, light or subway station?
- Does the project site located within half-mile walking distance of bus stop?
- Does the project have a Bicycle Storage and Changing Rooms?
- Does the project site is near alternative-fuel station for low-emitting vehicles?

---

[*] For example in USA prime farmlands defined by the U.S Department of Agriculture in the United States Code of Federal Regulations, Title 7, Volume 6, Parts 400 to 699, Section 657.5 (citation 7CFR657.5)

[**] As defined by LEED which extracted from the U.S. code of Federal Regulations 40 CFR, Parts 230-233 and part 22.

[***] Basic services: are those services that are open to the public, and are common services that people might use regularly. People must be able to walk between the project and the services without being blocked by walls, highways, or other barriers (this is called pedestrian access). LEED encourages building near a variety of basic services, not just one type of service. The basic-services such as: Bank, Masjid, Supermarket / convenience store, Day care, Dry cleaner, Fire station, Salon, Hardware store, Library, Medical / Dental, Park , Pharmacy, Post office, Restaurant, School, Theatre, Museum, Community centre, Gym, Church

- How many car parking lots are more than required by code?

5.1.1.5. Input data for site development credit
- Does the project protect or restore habitat?
- What is the oversize open space achieved by the design more than required by local codes?

5.1.1.6. Input data for storm water collection credit
- What is the volume of gathering storm water per annum?
- What is the volume of potable water saved from using the gather storm water per annum?

5.1.1.7. Input data for heat island effect credit[*]
- Does the site hardscape have a combination of shading, high reflectance, and/or open-grid paving and is provided for at least 50% of the site hardscape?
- Does 50% or more of upper ground parking is under cover.
- Does 75% or more of the roof area is covered by high-albedo materials.
- Does 50% or more of the roof is vegetated.

5.1.1.8. Input data for light pollution reduction credit[*]
- Does all non-emergency interior luminaries with a direct line of sight to any openings in the building envelop, input power reduced by at least 50% between 11pm and 5am via an automatic device(s)?

5.1.2. Conclusion of sustainable sites database:

In brief, after input, all previous data through applying all strategies of sustainable site category the user will determine the level of sustainability that his design achieves and the number of points can be scored. It means that we can reduce CO2 emissions and protect our planet through developing architectural designs towards sustainable sites through applying its principles on designing tools.

5.2. Category two: Water efficiency

The following table will present the credits and their weight of water efficiency in LEED:

Table 3. Water efficiency prerequisite, credits, & their weighting [(2)]

No.	Water Efficiency credits	Credit points
	Water use reduction by 20%	Prerequisite
1	Water Efficient Landscaping	4 points
2	Innovative Waste Water Technologies	2 points
3	Water Use Reduction	4 points
	Total	10 points

[*] Given percentages of all credits are related to LEED
[*] Given percentages of all credits are related to LEED
[(2)] Green Building Education Services, *LEED Green Associate study guide & LEED Checklist*, 2010

5.2.1. Required data to be implemented as information for water efficiency

The system should contain a database for efficient water consumption to can measure against it. In addition, it should have base limit water consumption.

5.2.1.1. Water efficient landscaping

- The landscaping and irrigation systems have been designed to reduce irrigation water consumption from a calculated baseline actual building.
- The landscaping installed does not require permanent irrigation systems. Temporary irrigation systems used for plant establishment.

5.2.1.2. Water use reduction

To calculate the reduction of water use, we must calculate the fixtures' actual annual volume against the baseline case and get the reduction percentage.

- Total calculated fixture water uses annual volume, baseline case.
- Total calculated fixture water uses annual volume, performance case.
- To calculate the reduction of water use for all fixtures, and get the percentage.

5.2.1.3. Innovative wastewater technologies

- To calculate waste water annual volume of drainage to the municipal's tie-in point, baseline case
- To calculate waste water annual volume of drainage to the municipal's tie-in point, performance case
- To calculate treated wastewater used annual volume and compare it with a water-use reduction.

5.2.1.4. Using storm water, gray water, & processed water

- To calculate the annual volume of storm water, gray water, and processed water used to save municipal's water.

5.2.2. Conclusion of water efficiency database

In brief, after input, all previous data through applying all strategies of water efficient category the user will determine the level of sustainability that his design achieves and the number of points can be scored. It means that we can protect our planet's resources by saving water consumption in buildings through developing architectural designs towards water efficient through applying its principles on designing tools.

5.3. Category three: Energy & atmosphere

The following table will present the credits and their weight of energy and atmosphere in LEED

Table 4. Energy & atmosphere credits & their weighting [(2)]

No.	Energy & Atmosphere credits	Credit points
	Fundamental commissioning of building energy systems	Prerequisite
	Minimum energy performance	Prerequisite
	Fundamental refrigerant management	Prerequisite

(2) Green Building Education Services, *LEED Green Associate study guide & LEED Checklist*, 2010

1	Optimize Energy Performance	19 points
2	On-site Renewable Energy	7 points
3	Enhanced Commissioning	2 points
4	Enhanced Refrigerant Management	2 points
5	Measurement and Verification	3 points
6	Green Power	2 points
	Total	35 points

5.3.1. Required data to be implemented as information for energy and atmosphere

To let a computer system analyze energy performance of architectural design, an energy modeling and thermal analysis should be created. In addition, the local codes should have a baseline for energy consumption. The following database should be implemented for this category:

5.3.1.1. On-site renewable energy

- To input completely building energy simulation for the renewable-energy devices and their performance. The system will compare it to the baseline building performance per local code such as (ASHRAE/IESNA Standard 90. 1-2007).

5.3.1.2. Refrigerant management

- The system will refuse any use of ozone-depletion substances (CFCs, HCFCs or Halons) to be used as fire suppression or refrigerant.

5.3.1.3. Measurement and verification

- The user should input developed and implemented a measurement and verification plan for energy consumption.
- The system will provide the user by energy performance rating and CO2-eq emissions (metric tons per annum). HVAC & R systems, lighting and day lighting controls, hot-water devices and renewable-energy systems are involved.

5.3.1.4. Conclusion of energy & atmosphere database

In brief, after input, all previous data through applying all strategies of Energy & Atmosphere category the user will determine the level of sustainability that his design achieves and the number of points can be scored. It means that we can protect our planet by reducing CO2 emissions and protect the ozone layer. It can be done through developing architectural designs towards efficient energy consumption and minimizing the use of ozone depletion substance through applying their principles on designing tools.

5.4. Category four: Material & resources

Each region of the world has local construction materials that are different from place to place. The following table will present the credits and their weight of material & resources in LEED:

Table 5. Materials and resources credits & their weighting [2]

No.	Materials & Resources credits	Credit points
	Storage and collection of recyclable	Prerequisite
1	Building Reuse – Maintain Existing Walls, Floors, and Roofs	3 points
1.a	Building Reuse – Maintain 50% of Interior Nonstructural Elements	1 points
2	Construction Waste Management	2 points
3	Materials Reuse	2 points
4	Recycled Content	2 points
5	Regional Materials	2 points
6	Rapidly Renewable Materials	1 point
7	Certified Wood	1 point
	Total	14 points

5.4.1. Required data to be implemented as information for Material & Resources

The following database should be implemented for this category:

5.4.1.1. Building reuse, maintain existing walls, floors and roofs

- Using a drawing tool for existing walls, floors, roofs or any other material for reuse.
- Using a drawing tool new walls, floors, roofs and any other material for reuse.

5.4.1.2. Recycled content, regional, and low-emitting, rapidly renewable materials

- Using a drawing tool for any recycled content.
- Using a drawing tool for storage and collection of recyclable materials.
- Using a drawing tool for any regional material.
- Using a drawing tool for certified wood.

5.4.2. Conclusion of material & resources database

In brief, after input, all previous data through applying all strategies of material and resources' category the user will determine the level of sustainability that his design achieves and the number of points can be scored by developing designing tools.

5.5. Category five: Indoor environmental quality

The following table will present the credits and their weight of indoor environmental quality in LEED

[2] Green Building Education Services, *LEED Green Associate study guide & LEED Checklist*, 2010

Table 6. Indoor environmental quality credits & their weighting [2]

No.	Indoor Environmental Quality credits	Credit points
	Minimum indoor air quality performance	Prerequisite
	Environmental tobacco smoke control	Prerequisite
1	Outdoor Air Delivery Monitoring	1 point
2	Increased Ventilation	1 point
3.a	Construction IAQ Management Plan – During Construction	1 point
3.b	Construction IAQ Management Plan – Before Occupancy	1 point
4.a	Low – Emitting Materials – Adhesives and Sealants	1 point
4.b	Low – Emitting Materials – Paints and Coatings	1 point
4.c	Low – Emitting Materials – Flooring Systems	1 point
4.d	Low – Emitting Materials – Composite Wood and Agrifiber Products	1 point
5	Indoor Chemical and Pollutant Source Control	1 point
6.a	Controllability of Systems - Lighting	1 point
6.b	Controllability of Systems – Thermal Comfort	1 point
7.a	Thermal Comfort - Design	1 point
7.b	Thermal Comfort - Verification	1 point
8.a	Daylight and Views - Daylight	1 point
8.b	Daylight and Views - Views	1 point
	Total	15 points

5.5.1. Conclusion of indoor environmental quality database

In brief, after, input all previous data through applying all strategies of indoor environmental quality category the user will determine the level of sustainability that the design achieves and the number of collected points in this category.

5.6. Category six: Innovation and design process

Any detail that saves energy, water, material, and resources or enhances indoor environmental quality is an innovation in design.

5.7. Category seven: Regional priority

The regional priority database is in all previous categories.

---

[2] Green Building Education Services, *LEED Green Associate study guide & LEED Checklist*, 2010

6. Implement Design Bases into Design Tool Database

The research will present the way of transforming design bases as the first information category into a database in an application based on the engineering program AutoCAD using Autolisp*.

6.1. Define site limits

The site limit is very important for any rating system. In this application, AutoCAD presents the illustrated dialogue box in (Fig. 4) when the user type "site" in the command bar, then it defines the project limits. If any space intersects with these limits, the application immediately will present an alert that this space intersect with project limits or outside it (Fig. 5).

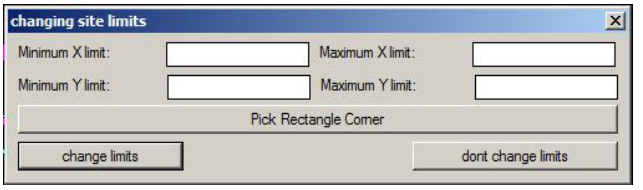

Fig. 4. Illustrates site limits box

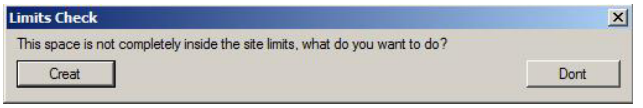

Fig. 5. Illustrates alert for site limits if the space is out of the site limits or intersect it

6.2. Space manager

A space manager is created to allow the user to create his own database for the building functional spaces. He can define the required space names, dimensions, ratio, and the relation between all spaces. The aim of this ability is to present ability of creating unique database for each user. On the other hand, sustainability categories are constant and related to those spaces (Fig. 6). The research will take a residential example to create its spaces and apply the sustainable basis for it. In the spacer manager tool for defining functional spaces as the following (Fig. 7):

- Minimum recommended dimension of the space.
- The maximum recommended dimension of the space.
- Best ratio between length and width of this space.
- Preferable function spaces those could be attached to the entire space.
- Preferable function spaces those should not be attached to the entire space.

- Symbol command for this space.
- Point symbol for this space.

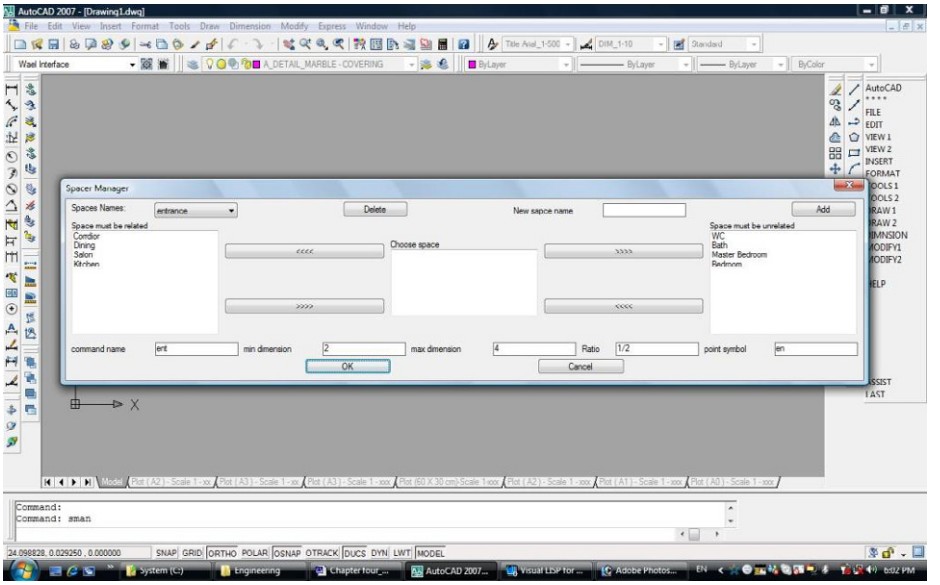

Fig. 6. Illustrates space manager window inside the AutoCAD program

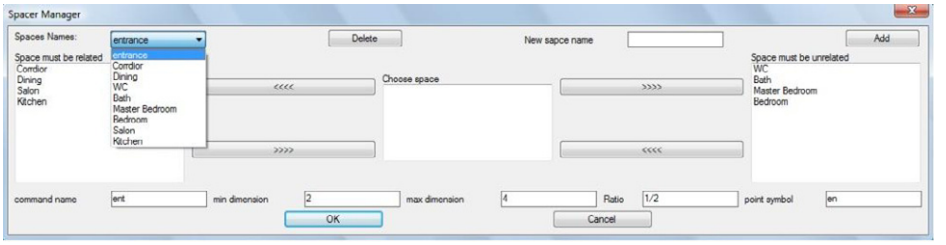

Fig. 7. Illustrates functional spaces, and related data for max. & Min. Dimensions, ratio, related and unrelated spaces

6.3. Database benefits

We can explore from this example of the space manager that information in architecture can give the flexibility to the user to define whatever function he wants and space relationships. In addition, we can use the database to set boundaries that the user cannot penetrate or modify. In the following the research will present two cases for information flexibly and boundary restrictions.

- When the user starts to enter the length and width of the space, the program immediately reviews the entry data with its database, and calculates the ratio between length and width. In some cases when the input data are different of the database, the computer will present a revised alert to continue or modify the input data. See (Fig. 9)

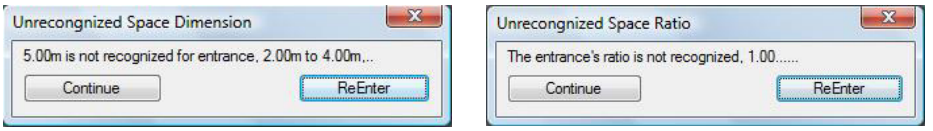

Fig. 8. (a) Picture on the left illustrates dimension input alert; (b) Picture on the right illustrates unrecognized ratio

- The user should complete all required data for full revision. With missed input data, the computer program will not continue until completing all information. Please see (Fig. 8)

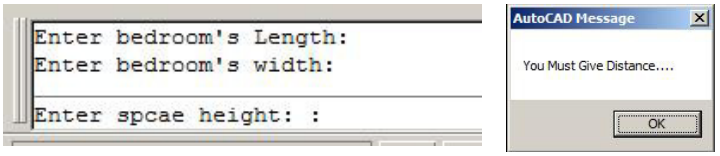

Fig. 9. (a) Picture on the left illustrates input data requirement; (b) Picture on the right illustrates the obligatory alert for data input

- In some cases, the user makes fatal mistakes such as creating an architectural space inside another space. The program can refuse to do such input data and presenting a message to the user to redefine the space. Please see (Fig. 10)

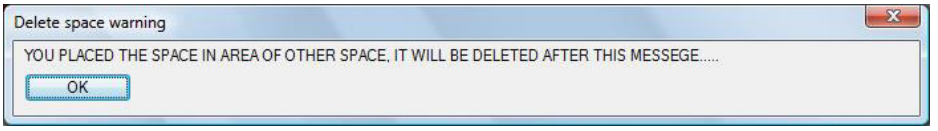

Fig. 10. Illustrates a restriction boundary that the user cannot do

7. Discussion and Analysis

The following part will discuss and analyze the effectiveness of design tools to review architectural design against sustainability:

- Design tools have plenty of drawing and construction database specially BIM programs. They can help the architect against sustainability only for energy modeling but not for all sustainability principals that defined by different sustainable rating systems.
- Sustainability rating systems define certain forms for each category with reference numbers to can calculate building performance for this item (Fig. 3). All those forms could be transformed into database information inside the design tool and present them sequentially to the user. It will help the architect to be closer to sustainability gradually in the project to achieve high level of sustainability.
- Design tools should be more interactive towards the architect in the field of sustainability. Figures 6 & 7 illustrate the way of defining spaces in a wide aspect of relationship between spaces, which should be related to sustainability principals. It will analyze each space against site orientation, building material and if it is local or not, level of energy and water consumption, etc. They can compare them against local sustainability requirement and help the architect to achieve better environmentally friendly building.

8. Conclusion and recommendations

- Architects have a big role to protect our planet through following sustainable principals during the design process. Architectural programs that are used to produce design and construction documents can help to review their project against sustainability guidelines.
- Each country should require sustainability study for each building with the permit documents to protect our planet. This study could be prepared as templates in design tools.
- Rating systems should define certain categories that can be implemented in all regions, and the difference between them will be on the weight of each category and its credit. This action will facilitate transforming them to the database.
- Each country should define a base case for different types of buildings and their consumption of water, energy, etc. It will help architects and engineers to define the sustainability level, which they should achieve.
- BIM "Building Information Model" programs will be more helpful for sustainability review because they have plenty of constructional databases and can produce a list of used material. They are more prepared for sustainability database.

Acknowledgment

The researcher really appreciates and wishes to thank the British Research Establishment (BRE), United States Green Building Council (USGBC), and The Housing and Building National Research Center for their efforts to spread sustainability principles in the world to protect our planet. Furthermore, the researcher wishes to thank the staff of architectural department, faculty of Fine Arts, Helwan University for their efforts to gain a step forward in sustainability for architectural education. The first one of them was architect Hassan Fathy who founded the poor architecture in Egypt and left for us a big heritage in the eighties of the last century for sustainable design using local materials. In addition, the researcher has deeply appreciated the efforts of Prof. Dr. Fatma Al-Nabaweya Mohammad Abdu El-Quesny, Botany in National Research Center, Giza, Egypt and architect. Reem Hesham Mohammad Namera for their help to push this research steps forward.

References

BRE. BREEAM New Construction. 2011. *Non-Domestic Buildings,* Technical Manual. (SD5073 – V.2.00), P.13.

Gehard Schimitt, *"Design and Construction as Computer-Augmented intelligence processes*", Swiss Federal Institute of Technology, ETH Zürich, schmitt@arch.ethz.ch

Gerhard Schmitt – *Information Architecture basis and future of CAAD Basel : Birkhauser* , c1999, ISBN:3764360925.

Harri Haapasalo, "*Creative Computer Aided Architectural Design, An internal approach to the design process*", Found at (URL: http://herkules.oulu.fi/issn03553213/) (Accessed on Feb 2006) Oulu 2000, ISBN 951-42-5754-5.

http://en.wikipedia.org/wiki/Sustainability

http://www.usgbc.org

Isaac Vector Kerlow - "*The art of 3D-Computer animation and imaging*" - John Wiley and Sons, New York:,Inc, c1996, ISBN:0471286494.

Jens Pohl, Art Chapman, and Kym Jason Pohl,"*Computer-Aided Design Systems for the 21st Century: Some Design Guidelines*" - Collaborative Agent Design (CAD) Research Centre - Cal Poly State University, San Luis Obispo, California, USA.

The Housing and Building National Research Centre, *The Green Pyramid Rating System, First Edition* – April 2011, for public review (First Revision: following Draft document dated May 2010).

United States Green Building Council. 2010. *Green Building Education Services, LEED Green Associate study guide*.

United States Green Building Council. 2010. *Green Building Education Services, Checklist for LEED for New Constrcution & Major Development* - Docs5719.
United States Green Building Council. 2010. *Green Building Education Services, LEED Green Associate study guide*.