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Determining Building Sustainability using BIM applications: Review

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Abstract

Economic growth of buildings as a result of their continuation and persistence during building activities, new principles and strategies for design and execution of projects have emerged and have not yet been seen, in advanced developed countries. These concepts were referred to as "sustainable development", "Green Architecture" and "Sustainable Building" are two terms that represent an increasing interest in urban economic growth concerns involving environmental conservation, reduced energy use, optimal use of natural resources, and a greater reliance on renewable energy sources. it was useful to compare a range of such systems to draw differences between them and determine which of them is the most comprehensive of the sustainability criteria.

This research seeks to uncover the role of sustainable design in reducing negative effects on the physical environment, as well as to examine some of the architectural literature on the subject in order to develop a detailed theoretical framework for each of sustainability, sustainable design, and sustainable strategies. Also, to reduce the negative effects in the design and operation of the sample's perpetrator, establish designer metrics and collect data.

Keywords: *BIM, Sustainability, Green Construction, High-Rise.*

1. Introduction

"Sustainable development" It was an important point in sustainable development. The United Nations conference on Environment and development, known as the "Earth Summit" held in Rio de Janeiro in the year it raised at the conference the concept of green buildings, the effect of pollutants on buildings. the entire community. Five major agreements on global environmental issues were signed through this conference, one of which dealt with Environment, Development stipulated twelve principles of sustainable development, and another addressed climate change as one of the important environmental issues affecting sustainability.: The Rio Declaration, the forest principles, the convention on climate change, the convention on Biological Diversity, and Agenda 21 were short-lived. Despite the commitment of developed countries to reduce the use of Natural Resources and reduce the burden of pollution so that growth in developing countries can be balanced.(Wong and Zhou 2015)

To negotiate a solution, Brundtland's sustainable development report was appreciated by the UN, both reports did not favor either Conference, but pushed for a balance. "Sustainable development" has been recognized to address contemporary needs without jeopardizing future generations' ability to satisfy their demands.(Attia 2018)(Ding 2008)

The United States emits about a quarter of the world's greenhouse gases, as well as China and India.(Ahmad and Thaheem 2017; Akinade et al. 2017).

1) Introduction to Sustainability

a) Definition of sustainability and sustainable developments

Scientific communities were trying to reach a specific concept of a "Sustainable building "or "Sustainable construction". The main concept of sustainable building is the focus on the environmental impact, which is created by building human systems of housing, commercial, etc. on the other hand the quality of life and preservation for the next generations which is the goal for the "Sustainable Developments".(Zabihi, Habib, and Mirsaeedie 2012; Ding 2008)

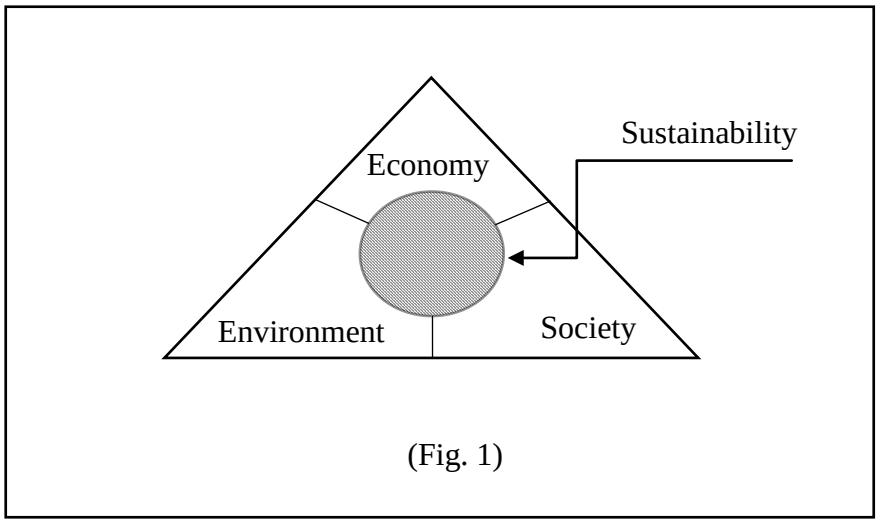
There are some aspects that must be considered when trying to describe sustainability. "Planet, Profit and people" those are the main aspects which are essential to be considered during the assessment process. The building is to be considered sustainable when 1) meet the people's needs,2) The natural resources is carefully used,3) The environment is well preserved and 4) The profit from this building is stable which will lead to stable economic growth.(Zabihi, Habib, and Mirsaeedie 2012)

After meeting these previous four key aspects it became clearer to get a definition for both building sustainability and sustainable development, (Table 1) presenting some of these definitions.

Term	Definition	Author	Year
Sustainable development	"[is based on the borders that] . . . current decisions should not impair the prospects for maintaining or improving future living standards . . . This implies that our economic systems should be managed so that we live off the dividend of our resources, maintaining and improving the asset base.	R. Repetto	1986
Sustainable development	"allow society to manage, in equilibrium and perpetuity, its interaction with the natural system such that society, as a whole, benefits and the natural system keeps a level that permits its recuperation."	San Jose	1993
Sustainability	"Sustainability as a three-legged stool, with a leg each representing ecosystem, economy and society. Any leg missing from the 'sustainability stool' will cause instability because society, the economy and the ecosystem are intricately linked together."	Young	1997
Sustainability	"the concept of sustainability to be used in the corporate community, developing the principle of triple bottom line. Triple bottom line refers to the three prongs of social, environmental, and financial performance, which are directly tied to the concept and goal of sustainable development. They are highly interrelated and are of equal importance."	Cooper	2002

Table 1 (Ding 2008)

The sustainability definition can be summarized in the idea of the intersection between Natural resources, Economy, Long term people needs satisfaction. Fig.1 shows this concept.



(Fig. 1)

b) History of sustainability assessment systems.

For this paper, a comparison was conducted to present the most effective phases in the history of developing the idea of sustainability over time. Assessment tools are different from country to another according to the regulations were put by the responsible organization for the file of environmental issues and sustainability.(AlWaer and Kirk 2012) Assessment tools are used to gather idea about how much sustainability objectives is fulfilled in any given system.(Becker 2004) his paper interest is "Building Sustainability". Many of these tools are controlled for this certain interest, these tools measure the overall performance of the building and compared with the standard weighing system gives a certain index number which indicates the whole performance of the building(AlWaer and Kirk 2012). For 30 years period, created some organization all around the world (Table 2) shows some of them and where it has been created.

Assessment Tool	Year	Country
Breeam (Building Research Establishment's environmental assessment method)	1988	UK
Green Globes™ US	1992	USA
The haute qualite´ environnementale (HQE)	1992	France
Leed (leadership in environmental and energy design)	1993	USA
Sustainable building challenge (SBC)	2008	Australia
The German sustainable building certificate (DGNBSeal)	2009	Germany
Estidama	2010	UAE

Table 2

As shown in the previous table those are the most common tools used in the world until now, however the question still stands. Are those tools being the best to evaluate the sustainability of the building? can those give an accurate indication for the building life cycle in phases of predesign to demolition and recycling?

2) Literature review: Characteristics of Building sustainability assessment tools

All above-mentioned Assessment tools in terms of calculation, estimating, weighing, and benchmarking methods are different from each other. For this issue it is a must to identify a certain framework and certain criteria "baseline" to be met in the investigation.(AlWaer and Kirk 2012). Yet another problem is to be considered is that baseline is almost difficult to make and that is because each element inside each tool is calculated and weighted differently. For example (i.e., Breeam, Estidama) both have the same objective element (e.g., Water Consumption) but for each of them different weighing system. (AlWaer and Kirk 2012; Becker 2004)To get to know the systems we need first to know the main objective and scope for each (Table 3) presenting the main common systems and each scope not rather to mention that these main criteria is the same but the sub criteria for each may differ.(Ding 2008)

Criteria	Breeam	Green Star	Leed
Water	5	12	5
Energy	25	20	25
Material usage	10	10	19
Land and ecology	15	8	5
Pollution	15	5	11
Transport	25	10	25
Management	15	10	8
Health	15	10	13
Sustainable site	0	0	16

(Table 3)

3) Indicators of sustainable architectural design:

Green sustainable design supporters count on the various advantages and benefits of this movement in a big administrative structure

In addition to reducing energy use and the environmental consequences, the incorporation of green design principles and intelligent technology in buildings also reduced construction and maintenance costs.

It creates a pleasant, comfortable working environment, improves the health of the customer, enhances productivity, and reduces legal responsibility that can arise from local diseases, increases the building property value and rental income, and thus the green currents of the construction industry strive to save energy costs in the long term.

Greenhouses in the United States spend 30 percent less energy than identical conventional structures, so that any additional costs paid during design and construction may be recovered rapidly, and by contrast over-perceptions may be recovered.(Ramzy and Fayed 2011)

Traditional efforts to decrease early building costs can lead to waste and constantly increased energy charges, but the advantages In addition to minimizing energy costs, green buildings are not restricted to the direct environmental and economic implications, for example the use of natural light in offices.

The study carried out by Rachel and Stephhen Kaplan, environment psychologists at the University of Michigan indicated employees were more satisfied with the job and less stressed in view of the natural areas of their workplace. One of the space corporations (Lockheed Martin) observed that the rate of absentéism was also reduced in their exposure to diseases.

After it has transferred 2,500 employees to a newly built green building and payouts are reduced to 15 percent %, the extra amounts spent on building construction are being compensated for by productivity gain in just a year.(Vangimalla et al. 2011)

a) Main necessities for sustainable design

A method in sustainable design is called Sensitive Design, which is one of the methods used to describe design Sustainable by comparing it with other forms of resource management by evolution and design requires the following points to achieve this indicator.

(1) promote new values and methods of human life to achieve a more harmonious relationship with local, regional sources and environments،And global.
(2) provide public awareness about appropriate technologies.

(3) The creation of living culture to immortalize the natural response and natural harmony with local environmental factors.
(4) respect the natural and cultural resources of the site and minimize the negative impacts of any design.

b) General indicators for sustainable design

From that review, general indicators for sustainable design could be included as follows:

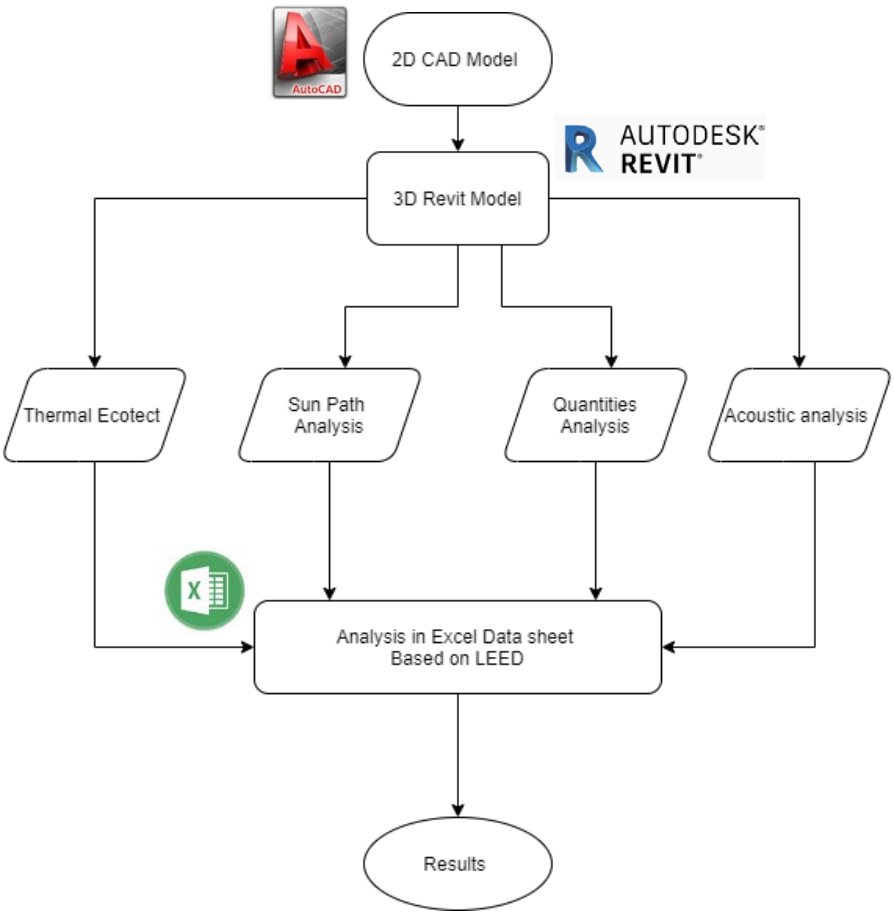
i) Design relevance to the ecosystem and cultural context.
ii) Environmental suitability.
iii) Use specialized technology suitable for functional need as energy conservation strategies and others.
iv) Use renewable building materials to the maximum extent possible.
v) Avoid using energy intensively because it ruins the environment and is wasteful.
vi) Flexible use of spaces and reduce the sources used.
vii) Create opportunities for the reuse and recycling of construction debris.
viii) future expansion and adaptation of use with minimal waste.

4) Methodology: Final indicators of sustainable design strategies

Thermal Strategies	1) Adoption of the principle of self-support of form by using the technique of self-systems (AI). 2) Multilayered building to invest in the realization of the principle of ceilings, walls, and thermal insulators. 3) Use smart glass (Skylight) on surfaces like Façade or building's roof. 4) Using the principle of high tech in building maintenance 5) Adopt the principle of crushers and moving shading systems to reduce heat gain. 6) Adoption of electrolysis to reduce environmental exposure and reduce materials used
Acoustic Strategies	1) Simulating the shape of the topography of the site and its impact on its shape and boundaries. 2) Use smart glass (Acoustic) on surfaces like Façade or building's roof. 3) Multilayered building to invest in the realization of the principle of ceilings, walls, and acoustic insulators.
Wind and ventilation strategies	1) Rationalizing the building's exposure to wind. 2) Depth ratios in the building and their windproof effect 3) Adoption of electrolysis to reduce environmental exposure and reduce materials used
Ecological and plantation strategies	1) Rationalizing the building's exposure to wind 2) Rationalizing the building's exposure to solar radiation. 3) Depth ratios in the building and their windproof effect and plant friendly environment 4) Adoption of electrolysis to reduce environmental exposure and reduce materials used

(Table 4) (Awadh 2017)

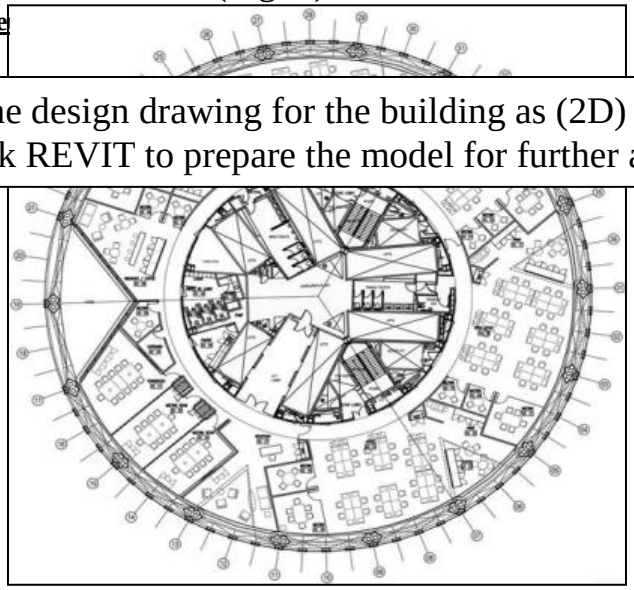
To get these data from buildings, each building must go into circulation of processes that judge each item against its value in the building and this gives the building certain mark, and this flow chart fig.2 shows this cycle.



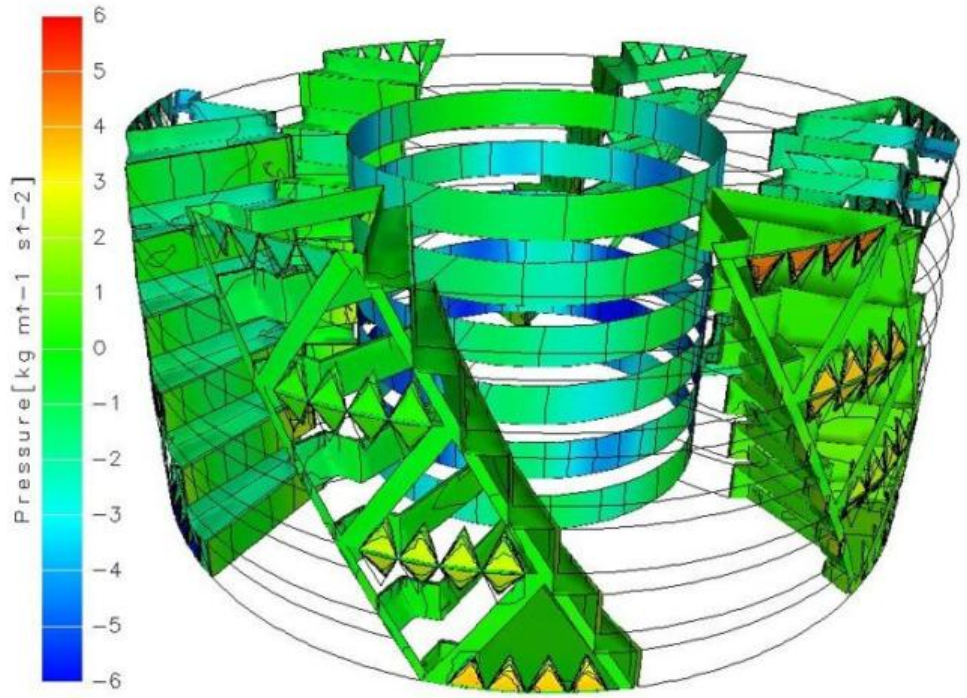
(Fig. 2)

5) The sustainability index de

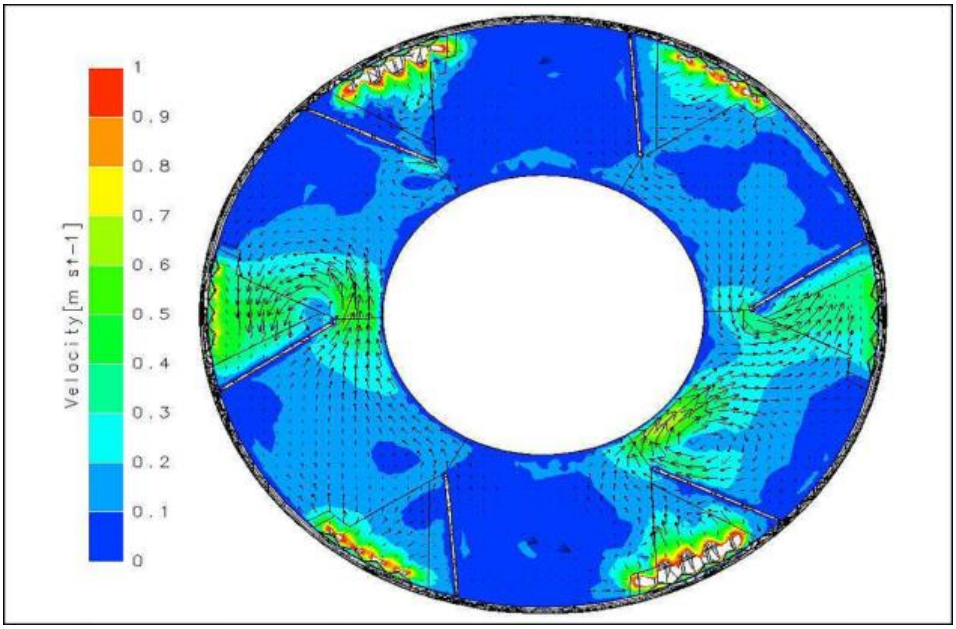
First step: is to get the design drawing for the building as (2D) for analysis and draw 3D model in Autodesk REVIT to prepare the model for further analysis.



Second step: make wind analysis using Autodesk green studio analysis software to calculate the wind velocity and circulation in the whole structure. Fig 4 &5



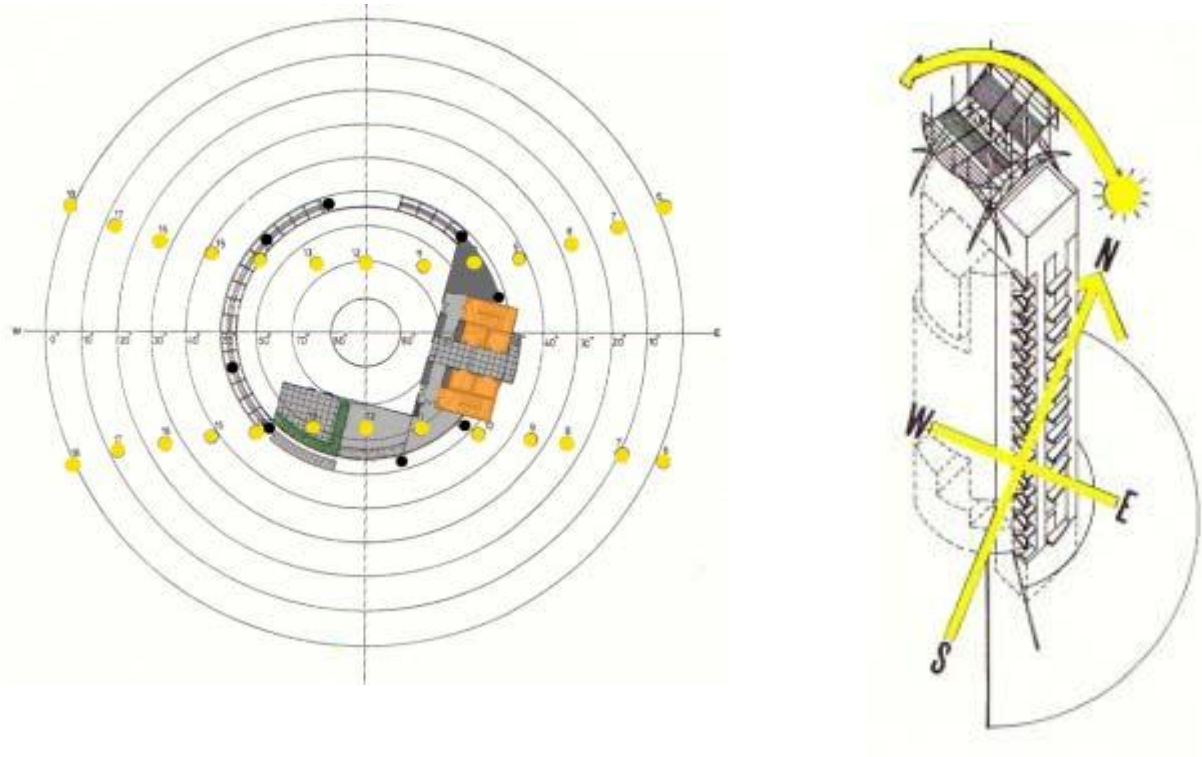
(Fig. 4) www.urbansystems.design/30-st-mary-axe-london-uk



(Fig. 5) www.urbansystems.design/30-st-mary-axe-london-uk

Third step: make the sun path analysis during the certain period to test how the building reacts toward the sun orientation during this period. Fig 6&7

(Fig. 6) (Walczak and Yeang 1992)



(Fig. 7) (Walczak and Yeang 1992)

8) Application

A sample of four architectural projects was selected that considered the differences between designers and the functional differences between

Projects, as the projects include recreational buildings and residential buildings, the four projects are:

i) Swiss building by Norman Foster in London.
ii) Conde Nast Building designed by Fox & fall architects.
iii) Menara Mesiniaga tower, Kuala Lumpur, 1992, designed by the architect (Ken Yeung)
iv) Freedom Tower which was built on the former site of the World Trade Center building in New York. Architects (Merrill and Studio Daniel, Skidmore, and Owings Libeskind)

i) Swiss building by Norman Foster

This tower is located on a street in the city of London and designed by the architect Norman Foster & co. Londoners refer to this architectural edifice as the newest addition to the skyline of their ancient city. this erect Tower as a fruit of choice consists of (41 floors), but what is remarkable about this building is not its beautiful architectural form but its high energy efficiency.(Munro 2004) its innovative and creative design achieves an expected energy saving of up to (50%) of the total energy consumed by a similar traditional building. The building's richness in energy-saving benefits is reflected in the use of natural lighting and ventilation wherever possible. The facade of the building consists of two layers of glass (the exterior of which is double glazing), both layers are surrounded by a ventilated cavity with computer-guided curtains, and the weather sensor system on the outside of the building monitors temperature, wind speed and the level of sunlight, closing the curtains and opening the window panels when needed. The Shape of the building is designed to increase the use of natural daylight, reduce the need for artificial lighting, and allow for natural outdoor views even for those who are inside the building.(Queheille, Taillandier, and Saiyouri 2019)

ii) Conde Nast Building designed by Fox & fall architects.

Built on forty-eight floors in Times Square, New York, designed by Fox & fall architects, it is one of the earliest examples of green sustainable architecture in a large urban building, and has used all imaginable energy-saving technologies. The building used a special quality of glass that allows natural sunlight to enter, keeps heat and ultraviolet radiation out of the building, and minimizes the loss of internal heat during winter. There are also two natural gas fuel cells that provide the building with four hundred kilowatts of power, which is enough to feed the building with all the electricity it needs at night, and 5% of the electricity it needs during the day. The hot water exhaust was produced by the fuel cells used to help heat the building and provide it with hot water. While the cooling and air conditioning systems on the roof are more of a gas generator than an

electric generator, this reduces the energy loss associated with the transmission of electric power, Photovoltaic panels on the outside provide the building with up to 15kW of additional power.(Inside the building, motion sensors control the fans and turn off lighting in low-occupancy areas such as stairs, and the exit signals are illuminated with light diodes that reduce energy consumption, the end result is that the building consumes 40-35% less energy than any similar conventional building.(Ali and Armstrong 2008)

iii) Menara Mesiniaga tower, Kuala Lumpur, 1992, designed by the architect (Ken Yeung)

The building is located in Subang Jaya, near Kuala Lumpur, Malaysia and is the headquarters of I.M.B designed by Ken Yeung, reflecting its principles and experience in bioclimatic architecture (green architecture), the building is considered as a model that applied the rules of traditional Malaysian architecture and modern rules in parallel, as well as an honorable model of environmentally friendly high-rise buildings, reflecting the strong relationship between the building and the climate and green spaces. The region has a hot tropical climate, in which the temperature of the night and the temperature of the day varies slightly, and the temperature and humidity are the same throughout the year. Building components: the building has a large entry yard for displaying products, classrooms, sitting rooms, prayer room, cafeteria, kitchen and administrative services, car garage below the building and basement. (Walczak and Yeang 1992) Technical data the height of the building 63m, consists of a ground floor+ 14 floors and is a circular Muscat the structure of the building is made of steel columns carrying concrete floor tiles installed on Camilo steel Nat total area of the floors 6503 square meters, the main idea of the building a roof garden to connect the building to the ground, upstairs, there are sash windows in the East and west facades with breakers. Aluminum sunshades and glass walls in the North and south facades, the main services were in the sun-exposed hot eastern facade to provide protection for the interior spaces from strong sunlight also allows natural lighting and ventilation of the stairs, elevators, toilets and corridors with the use of sun breakers in the side of the sun-exposed building external balconies and hanging patios and cooling, this project has distinguished With bold and thoughtful climate treatments in one of the high-rise buildings in an area with a tropical climate and in unconventional or stereotypical styles that evoke a high-end environmental awareness, making it a model of environmentally friendly high-rise buildings built in urban environments with a hot, humid climate.(Walczak and Yeang 1992)

iv) The Freedom Tower,2014

The Freedom Tower which is built on the former site of the World Trade Center building in New York, architects designed with the environmental design advantages program in all corners of the large building, and the main tower will contain (the foot of) solar panels as well as a wind power plant, the turbines are expected to generate about(1 megawatt)of power, which is enough to feed the tower 20% of its expected energy needs, and it will be based on natural lighting and ventilation, as well as energy-efficient lighting systems and elements.

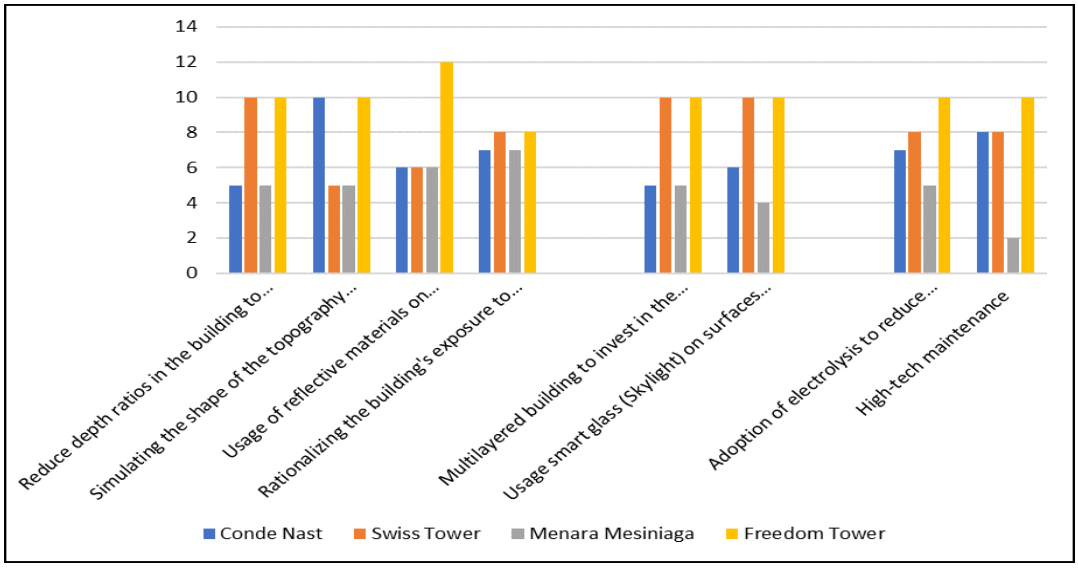
The towers are also designed in the form of framed tubular structures, giving tenants open floor plans, unhindered by columns or walls. The framed tube design was introduced by Bangladeshi American structural engineer Fazlur Rahman Khan in the 1960s. The design was also accomplished with several converging perimeter columns, providing much of the strength of the structure, while sharing the gravity load with the core columns. The elevator system,

which used sky lobbies and the system of rapid and local elevators, allowed a large floor area to be used for office purposes by making the structural core smaller. The structure's overall strength and stiffness were put to the test due to the tower's height and slenderness. To address those demands in a cost-effective manner, high-strength concrete with a compressive strength of up to 14,000 psi was used. Previously, New York City's maximum concrete compressive pressure was 12,000 psi. Quality management and close inspection of the mix elements, as well as the use of widely available local resources, are critical to achieving good and reliable performance in such challenging concrete mixes. Furthermore, the high-strength concrete used for the dense concrete walls, known as mass concrete, necessitated a specific concrete mix to fulfil the most exacting requirements. Supplementary cementitious materials, fly ash, granulated ground blast furnace slag cement, and silica fume were all included in all mixes, as needed. The use of these materials contributed significantly to the building's LEED Gold certification from the United States Building Council.(The Port Authority of New York & New Jersey 2014)

- Each building has given a score on their type of criteria and considering that the final scores are equal, in conclusion we produced the order of the buildings and according to preference as the best Freedom Tower comes next building) (Swiss Tower building) (Conde Nast, and finally Tower) (Menara Mesiniaga, details as in

Criteria	Conde Nast	Swiss Tower	Menara Mesiniaga	Freedom Tower
Reduce depth ratios in the building to deliver maximum natural light	5	10	5	10
Simulating the shape of the topography of the site and its impact on its shape and boundaries	10	5	5	10
Usage of reflective materials on morphological surfaces to minimize Heat gain and loss.	6	6	6	12
Rationalizing the building's exposure to wind and solar rays.	7	8	7	8
Multilayered building to invest in the realization of the principle of ceilings, walls, and thermal insulators.	5	10	5	10
Usage smart glass (Skylight) on surfaces like Façade or building's roof.	6	10	4	10
Adoption of electrolysis to reduce environmental exposure and reduce materials used	7	8	5	10
High-tech maintenance	8	8	2	10
Total	54	65	39	80

(Table 5)



9) Recommendations and conclusion:

The research reached a set of important recommendations aimed at achieving the sustainability of urbanization.

1. Design the building to be environmentally friendly.
2. Research recommends the adoption of ten sustainable design indicators to reduce environmental impacts.
3. Urge the designers to consider minimizing the use of new resources in the buildings they design and invite them to design buildings using resources were already used or waste materials.
4. Construction workers call for attention to the application of this principle with different and at the same time innovative methods and ideas, considering use of building materials and products that lead to global environmental destruction.
5. Develop an urgent plan to activate renewable energy sources) windmills-solar power plants (oblige all urban-based institutions to use local materials and follow up on this during implementation.
6. To initiate the recycling system for all waste from cities, whether gray water or building materials .... etc.

From this it is evident that this methodology, followed by the researcher, can be used at all levels of urbanisation, where strategies are applied at each urban level with tools that fit the urban dimensions, for example but not limited to cost-saving or economical strategies, that are developed at the regional level in various forms and styles than at any other level. This rising interest in the implementation of sustainable principles is the most proof that urban expansion on the world has not happened This is no longer isolated from the urgent environmental problems which in recent years have begun to harm the planet and progress.

In addition, building creates huge amounts of pollution and solid waste, sectors are the most draining sources of natural resources, such as soil, materials, water and energy.

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