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THE IMPACT OF CLIMATE CHANGE ON ARCHITECTURE

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Abstract: Climatic change an extreme global malaise and intractable phenomenon has great impact on buildings and the built environment thus must attract the significance attention from the design and construction experts. Building designs rely on climatic data and other geographic indices, however the unprecedented effects of global warming have dwarfed in significance most historic climatic data which can no longer accurately represent future conditions over the life of a building. In this paper, the investigations of the effect of climate change to the design and safety of high-rise building will be in sharp focus. Climatic factors such as temperature, rainfall, humidity, among others will be examined with regards to their effects on high-rise buildings. It is also concluded that the climatic data used in the designs of building should urgently be reviewed as it may be leading designers to adopt solutions which will be inappropriate for future uses and infrastructural developments within the built environment.

Keywords: *Climate Change, Greenhouse Gas Emission. High-rise Buildings, Temperature, Rainfall, Humidity, Architecture.*

INTRODUCTION

Many scientists believe that what appears to be a gradual warming of the earth's surface and atmosphere may be the result of human activity and increasing urbanization around the globe. Many also believe this warming trend has the potential to destabilize weather patterns and increase the frequency and intensity of severe weather related events*. (*For example 2005 was the warmest year on record and coincided with the most active hurricane season since record keeping began. 2005 was also the costliest year ever for the insurance industry when it came to building failures and claims for damages.) Climate provides man with the enabling environment in the context of its suitability for us to live. It contains several features such as air temperature, rainfall and wind and many other environmental attributes. Over the last 150 years, the Co_2 concentration has increased by 30% and the Ch4. Concentration has increased by 150%

globally including some man-made contributions coupled with the changes brought about by the atmosphere causing irreversible changes in global climate (Figure 1 and Figure 2). Researchers are already concerned about the implications of a warming climate in terms of flood, wind loads, soil moisture, demand of energy and water supply system and other factors concerning the designs and construction of buildings with the intent to checkmate climate induced disaster and instituting a close monitoring regime of the situation.

AIMS AND OBJECTIVES

This paper looks into the effects of the climate and its overall impact on buildings and how to safely design urban structures (high-rise) given the notable effect of climate change and the safety of these structures.

This work also focuses on literature review of work done in some countries as well as climate change mitigation and adaptation measures in order to strengthen the parameters of ideal high-rises design and construction by architects, engineers and other construction professionals so that these buildings are more sustainable.

METHODOLOGY

It is a statement of fact that updates of historic designs and construction data especially as it affects green Architecture and returning to basic of organic principles is a sure way to counteract the effect of climate change on the built environment. This research has to a very large extent utilized facts from other literature, experts and other professional stakeholders in this field of study.

The use of the internet has been employed as well as journals and other research works related to this topic.

Definition of Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) defines it as a change of climate that is attributed directly or indirectly to human activity altering the composition of the global atmosphere. Some of these activities are pollutions from industry, use of fossil fuels, landfills and industrials wastes and other sources that produce green house gases. Carbon dioxide has the ability to create a buffer of infrared light thus contributes to the warming of the atmosphere through a process known as the greenhouse effect apart from Carbon dioxide gas having the ability to remain in the atmosphere for tens or hundreds of years making it harmful and an existential threat to humanity and the planet.

Climatic Factors and Environmental Consideration

There are different climate factors that must be considered in civil operations, building constructions and building designs. The most significant climatic factors are as follows: sunshine, weather, temperature, relative humidity, wind speed and rainfall (Figure 3-
Figure 5).

Sunshine: The rate of receiving sunshine is a function of several factors which include: latitude (angle of sunshine), the amount of cloud, and sunshine hours. The less the latitude, the less the angle of the stretch of sunshine with the vertical line to horizon and the more the receiving of sunshine. In areas where the rate of receiving sunshine by the earth surface is high, temperature is high. If the goal is to reduce the amount of sunshine entering the earth surface strategy is one of hypothetically introducing reflexive mirrors as orchestrated by climate scientist and earth engineers. However, this is theoretical at the moment as it will have massive budget and paraphernalia.
Weather Temperature: Perhaps weather temperature is the most important climate factor affecting climate designing. Temperature and precipitation may lead to considerable effects on structural elements of building and affects the serviceability as well as the safety of the structure.
The intended dimensions in designing various points of a building and also the material in use are determined by the maximum and the minimum temperature of the region. Therefore, the materials, quantity and quality for constructing a building are variable depending on the region: tropical, cold or moderate.

Glacial region would require taking special decisions on the choice of materials. In order to prevent energy dissipation in tropical and cold regions in summer and winter time, body insulation of the buildings must be considered whereas this issue might not be of priority in moderate regions.

Temperature: As the Global temperature so does the soil temperature. Soil temperature and its changes are of importance over the year. The soil surface experiences the most Changeable temperature during the year which is caused by proximity with air and other variable indices. The more we go to the depth of the soil, the less changes of temperature we have so that in a specific depth called depth or attenuation depth temperature, annual changes of soil temperature is observed. Given the fact that building foundation lies in the soil, knowing about soil temperature, especially glacial soil and its depth, is of high significance in the selection of the materials and determining the foundation of a building. Moreover, knowing about the depth of glacial soil can be effective in the installation of gas, water… pipes. The depth of glacial soil is a point where the soil does not freeze in the coldest time of the year. It is clear that in cold regions the depth of installing such equipment must be lower than the depth of glacial soil so that they become immune of any frozen state. In order to know about the depth of glacial soil in any region, one shall refer to long-term climate data provided by meteorological stations.

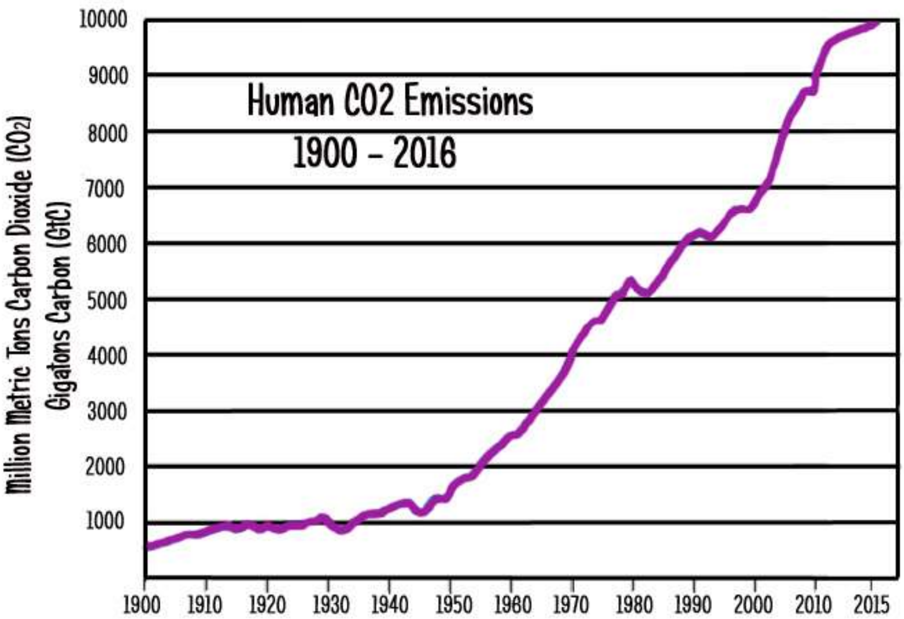

Figure 1: Human CO2 Emissions

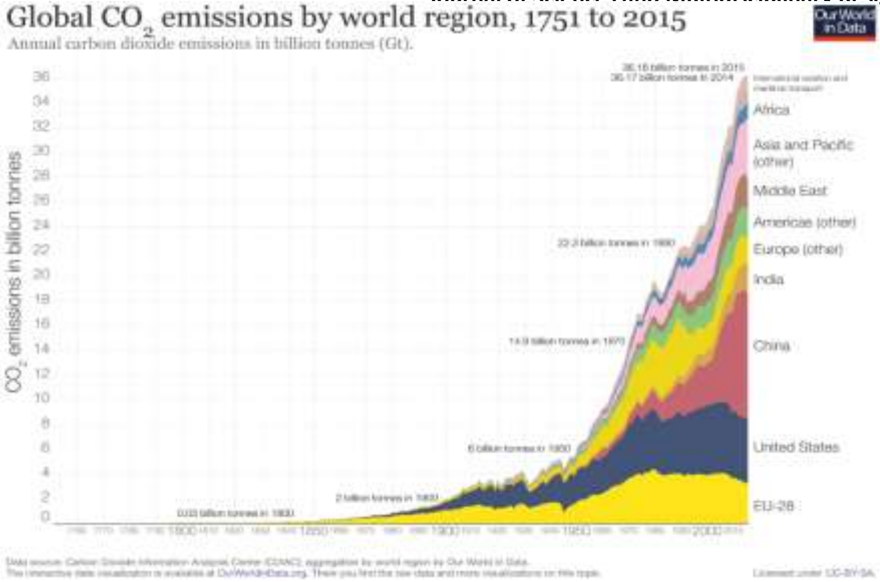

Figure 2: Global CO2 Emissions by world Regions

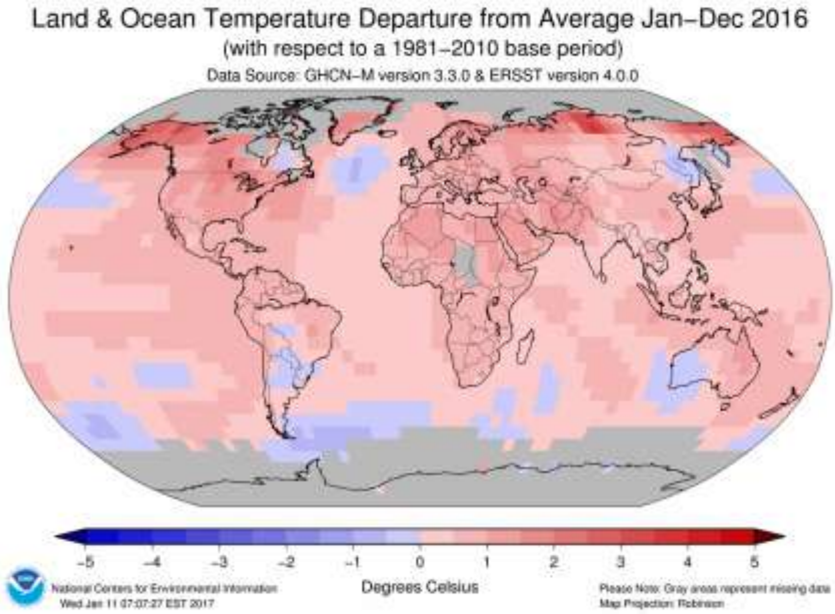

Figure 3: Land and ocean temperature departure from average

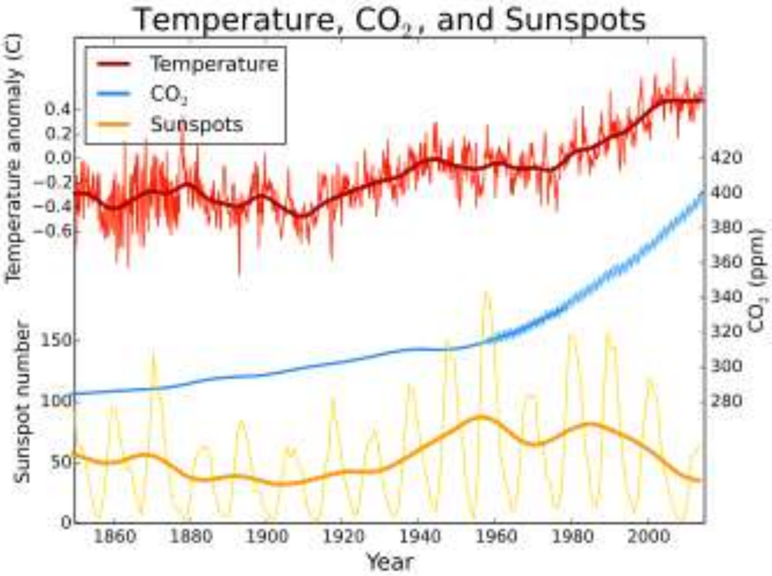

Figure 4: Temperature, CO2, and Sunspots

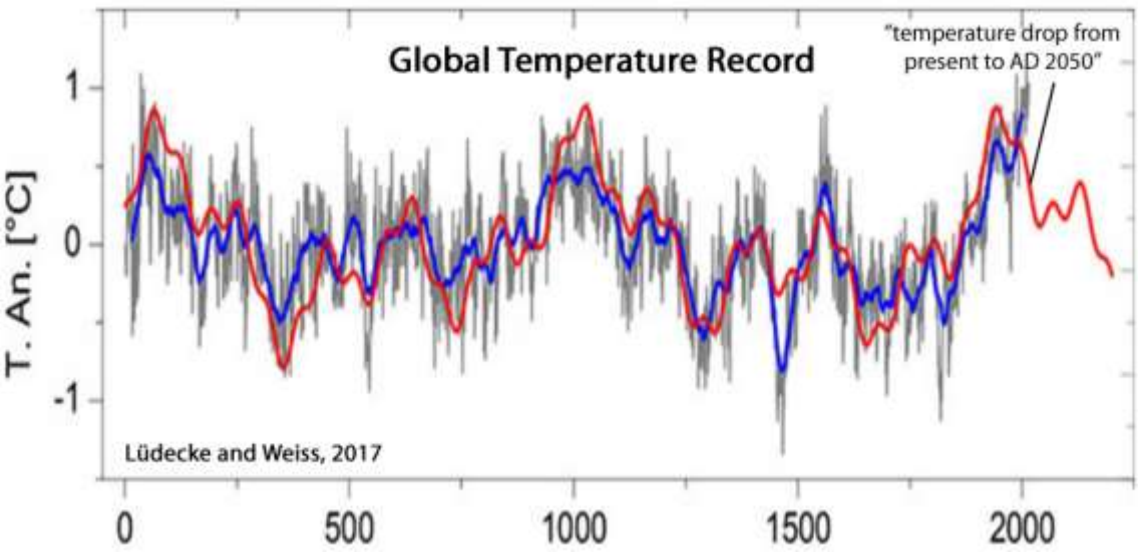

Figure 5: Global temperature Record

By definition, relative humidity refers to the proportion of the existing amount of humidity in the air to the maximum amount of acceptable humidity in terms of percent. The more the rate of relative humidity, the more the possibility for the formation of water drops on physical objects on the earth surface (including buildings and other infrastructural facilities as bridges, pavilions, etc.). This means the acceleration of the effect of humidity on equipment and their rust chemically (corrosion of metals, oxidation of metals, etc.) and physically (freezing water and cracks in buildings. In the regions where there is high relative humidity as in coastal

areas and islands, designing and construction of the buildings take place with the adverse effects of water in mind during the design analysis. They must be designed and constructed in a way that physical and chemical adversity in terms of moisture is minimized or reduced to zero.
This need is met through the selection of water and corrosion-resist materials and equipments.

Materials swell and shrink as they take on and lose water. Humidity therefore affects the dimensions and weight of materials. Wood, leather, paper, cloth, carpet, and rugs all contain water in quantities that vary with the surrounding humidity. For example, at 60 percent RH, a cubic foot of dry wood weighs 30 pounds and holds 3 pints of water. If the RH were lowered to 10 percent, the wood would hold only 1 pint of water and would be lighter. The effects of this constantly changing moisture content can shrink joists and studs, crack plaster, separate wood paneling, and dry out furniture, art, and books. Air inside a building tends to be dry during cold weather because the RH drops as the air is heated. Static electricity, which is caused by friction, increases proportionally with the speed. Because machinery runs at high speeds, dry air causes problems. Without sufficient humidity to stop static electricity, high-speed machinery will not be able to function efficiently. In the printing industry, static electricity must be kept down to a level that prevents paper from jamming the high-speed presses. Sparks caused by static electricity are dangerous in areas containing flammable materials.

Wind Direction and Speed

What is Wind? Wind means the motion of air in the atmosphere. The response of structures to wind depends on the characteristics of the wind.
According to Scott Eicheberger, James MCCAA and some other researchers, studied increase in annual mean near-surface wind speed values up to 2050 using the A2 emission scenario(Figure 6).
Causes of Wind-Wind is by air flowing from high pressure to low pressure. Since the Earth is rotating, however, the air does not flow directly from high to low pressure, but it is deflected to the right (in the Northern Hemisphere; to the left in the Southern Hemisphere), so that the wind flows mostly around the high and low pressure areas.

Variation of Wind Velocity; with Height-Near the earth's surface, the motion is opposed, and the wind speed reduced, by the surface friction. At the surface, the wind speed reduces to zero and then begins to increase with height, and at some height, known as the gradient height, the motion may be considered to be free of the earth's frictional influence and will attain its 'gradient velocity'. Gradient Height 300 m for flat ground and 550 m for very rough terrain. Wind force governance for tall structure; With increase height of building Construction cost per unit area decrease increasing lightness in weight per unit area and more danger against high velocity of wind force at high level. Effect of wind load on tall structure and wind effects on Structures; Wind effects on structures can be classified as'Static' and 'Dynamic'. Static-Static wind effect primarily causes elastic bending and twisting of structure. Dynamics for tall, long span and slender structures, a 'dynamic analysis' of the structure is essential. Wind gusts cause fluctuating forces on the structure which induce large dynamic motions, including oscillations. Wind direction is a way from which it is blowing. Knowing about the wind direction of each region, bearing the most frequency from that direction (prevailing wind), is an important factor in setting the direction of building construction aerodynamically so that in the state of heavy winds, light buildings wouldn't be hit.

In ancient times, in order to design the direction of wind wards especially in tropical regions (Yazd and Kerman), the length of wind ward vents was built in the direction of prevailing wind so that wind could be used in the best way possible to cool the building. Wind speed is also important because in the case of high speed winds, there is the possibility for the detachment and physical damage to different parts of building especially light ones. Knowing about the mean of wind speed at the project site and seasonal and annual distribution of wind speed are important factors for strengthening against wind power. The more the mean of wind speed in the region, the more powerful the building must be. In projects where there are several choices in terms of region, it is a good idea to pick up the one in which wind speed is lower than other regions. These regions are identified through wind pattern plans and measuring wind speed at different points of a region. If the goal is to use wind power such as establishing wind power plants, the place of the construction shall be chosen in a way that there is high-speed wind around. It is clear that, in this case, permanent high-speed wind for most of the year or even all the year is an upward.

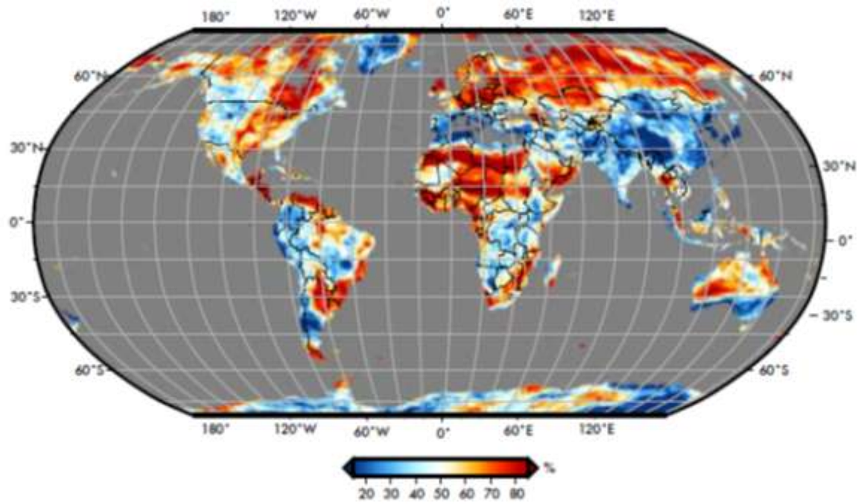

Figure: 6 Percentage-of-Global-Climate-Models-Showing-Increased-Annual-Mean-Wind-Speed -Values-In-2050.pngUCT
Source: Zareaian and Zadeh

Rain fall: The amount of rainfall is one of the most determining factors that shall be considered in building design. There are clear differences of building requirements in the tropics and in the temperate regions of the world. Knowing about the rate of rainfall, especially for designing structures like dams (estimation of the Maximum probable rainfall) is necessary so we can determine spill away dimension. Moreover, in order to design surface water disposal systems across cities when it rains, knowing about the maximum urban flood relevant to return period is essential(Figure 7).

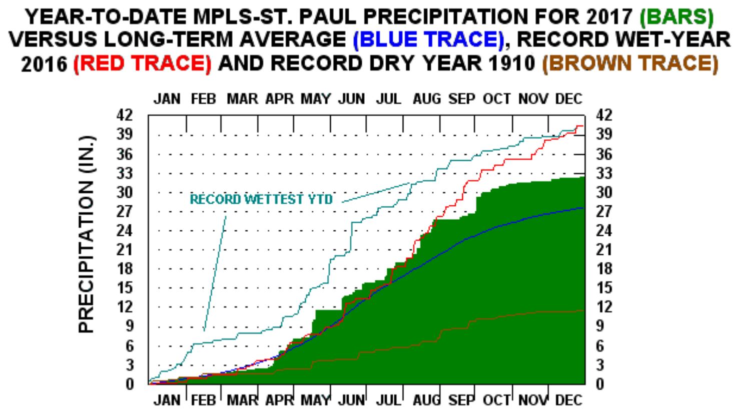

Figure 7: Year –to date Precipitation

DISCUSSION

Global warming comes with precipitous arrays of inclement climatic consequences that affects the only know habitable planet in the universe especially the built environment. Throughout this research efforts have been made to examine how this had impacted or have the capability of creating problems for buildings of all shades through the weather elements. As the study had seen how climate change can affect the final reliability analysis, with respect to extreme wind speed, precipitation and the temperature within the built environment. The investigation is analyzed through a simple linear regression model. The Pearson correlation coefficient for the wind speed and precipitation is only 0.378 with a value of 0.226. Obviously, this shows that the correlation is not so severe between the wind speed and the precipitation. But the mean temperature cannot be ignored. Of the linear model between the wind speed and the mean temperature is 0.801. It means the mean temperature is strongly correlated with mean wind speed. Thus, in the prediction of future extreme wind speed, we will consider simple linear regression model between wind speed and mean temperature. Possible solution is that impact climatic data used for building design calculations should be regularly reviewed and updated otherwise its use may result in buildings not suitable for the next millennium. In buildings the major plank will be good cross ventilation and this requires that the wind approaches the building from the most favorable direction. Solar radiation control through shading devices such as horizontal screening/roof overhangs could be very effective against overhead sun especially on north and south facades and then east and west for tropical climate. Horizontal screening must allow vertical air flow. Shading with trees and plants can also be helpful as long as it does not stop cross ventilation and improves humidity problems.

CONCLUSION

The solution to climate change problem is not entirely dependent on Architects alone to solve, but Architects can set a very good example to reverse the effect as about 50 percent of the GHG emission is generated form infrastructure and building related components and manufacturing. Methods to reduce energy consumption in buildings can take many forms from mundane to state of the arts. In New York City for example, there are plans on the way to reduce energy use for heating, cooling and lighting among other things, encourage updates on exterior lighting and improve ventilation system and these will reduce green house gas emissions by 2.7

million metric tons by 2050, the equivalent of taking 560,000 cars off the road, according to press release. Also for design purpose, historic climatic data ought to be reviewed due to climate change in order not to lead designers to adopt solutions which will be inappropriate for future use.

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