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ANALYSIS OF MICROCLIMATE AND ENERGY LOADS IN BUILDING DESIGN

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POLITECNICO
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A MINI PROJECT REPORT

ON

Analysis of Microclimate and Energy Loads In Building
Design

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ABSTRACT

Architectural condition related to the presence and effects of urban heat island are studied here. The area of study is Karachi, Pakistan. The specific study is on informal settlement in Karachi named Hazara Colony. It is a study of microclimate in a building present in the settlement. The analysis has been carried out with a building energy simulation programme named CASANOVA, which is educational software for heating and cooling demand of a building as well as free floating temperatures. Based on the information provided by the program, the possible thermal effects of retrofit intervention regarding building envelope, energy systems and comfort conditions.

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Analysis Of Microclimate In Building Design

Abstract

Architectural condition related to the presence and effects of urban heat island are studied here. The area of study is Karachi, Pakistan. The specific study is on informal settlement in Karachi named Hazara Colony. It is a study of microclimate in a building present in the settlement. The analysis has been carried out with a building energy simulation programme named CASANOVA, which is educational software for heating and cooling demand of a building as well as free floating temperatures. Based on the information provided by the program, the possible thermal effects of retrofit intervention regarding building envelope, energy systems and comfort conditions.

INTRODUCTION

Climate has a huge impact on human lives. Global climate changes are observed to be everywhere. Many warmer cities around the world have become very hot because of effects of climate change. The area under study is a metropolitan city Karachi, Pakistan. Karachi is between the Gulf and the rest of Asia. It acts as a South Asia busiest seaport. Pakistan is a home of 180 million of population and about 40% of population is in urban areas. The population in Karachi started to increase after independence from India in 1947. Majority of population in this city are migrants bringing diverse cultures and traditions. According to survey in 1955, Karachi city was spread over 104.26 km² that reached to 785.45 km² in 2006 with an increase of 63% in 5 decades. City

was planned and developed in 1960 by the construction of roads, educational institutes and gardens. Nowadays, Karachi is densely populated and is full of high rise buildings. It is mostly occupied by informal settlements. The city is growing unplanned day by day. Number of new buildings and population growth leads to heat energy to be concentrated at one place, this makes temperature of that specific area to be greater than surroundings. The city is an urban heat island that can reach temperatures up to 15 °C warmer than its surrounding rural areas. Demand of water and energy is also influenced. The areas often have low air quality because of presence of more pollutants. Health problems and water borne diseases are also very common. Recently in June 2015, Karachi also suffered from severe heat wave which result in death of 2000 people by heat stroke and dehydration. The temperature recorded during that time was 49°C.

Urban growth also influences the climate. Sometimes it also creates microclimate that can cause comfort and discomfort. Karachi has a mild climate and is at the coast of Arabian sea. Sea breezes are the reason for high rise buildings here. Urban planning helps to use it and improve quality of life. But if urban growth is unplanned, it can result in severe result as in the case of heat wave. Local climate of an urban area is affected by physical structures, green spaces and water bodies in it. The configuration of buildings, their orientations, and their geometry creates a specific microclimate for each site. The use of materials, surface textures and colour of exposed surfaces also contributes in the changes in microclimate. Human interacts with urban microclimate through exchange of energy.

My work is focussed on microclimate and thermal discomfort inside the buildings and energy consumption by the energy systems to minimise it. By studying microclimate in an informal settlement, we will be able to find cheap

solutions for an individual to cope in extreme weather conditions. Main steps that I followed to study specific climate are

1. Observing the level of human discomfort during extreme temperatures especially during summers in May and June.
2. Some interventions in building envelope to reduce conduction and heat loss.
3. Extent to which environment could be developed for green space.
4. Energy demand by the systems and effects of intervention.

Location

The specific location where this research is done is in the South of Karachi. It is near to main road which connects north and south of Karachi named as Shahrae Faisal. It is an informal settlement and is very near to railway lines. There are three informal settlement named Railway colony, MES colony and Hazara Colony. My work is in Hazara colony which is spread over an area of 100km².

I worked on building which is located outside the colony and is in front of main road. The present construction of a building is improved by passive cooling methods and the area can also developed for green space. These minor things will help to create a human comfort zone with less energy consumption. Air quality is also bad because it is facing the main road. Ventilation inside the building is not satisfactory. Surrounding are also buildings with almost height. Basement of the buildings mostly are shops.



Location of Hazara Colony

METHODOLOGY

Method to obtain a favourable indoor microclimate in a building is done by using software which is a building energy simulation programme CASANOVA. The programme is especially designed to study heating and cooling demand in a building and temperature changes in a specific area. By analysing the information provided by the programme we can follow the following steps to reduce energy consumption in a building. . Main steps that I followed to study specifically are

1. Observing the level of human discomfort during extreme temperatures especially during summers in May and June.
2. Some interventions in building envelope to reduce conduction and heat loss.
3. Extent to which environment could be developed for green space.
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1. HUMAN COMFORT

By taking into account the local climate and the site context, specific cooling strategies can be selected to prevent overheating. Human discomfort is observed If ceiling is the contrasting surface and the ceiling temperature is greater than 9° F (5° C) warmer or 25° F (14° C) colder than other surface temperatures in the room. In case of Karachi where summers are extremely hot and humid during the month of May, June and July. The temperature range is analysed by CASANOVA, that can be described as below.

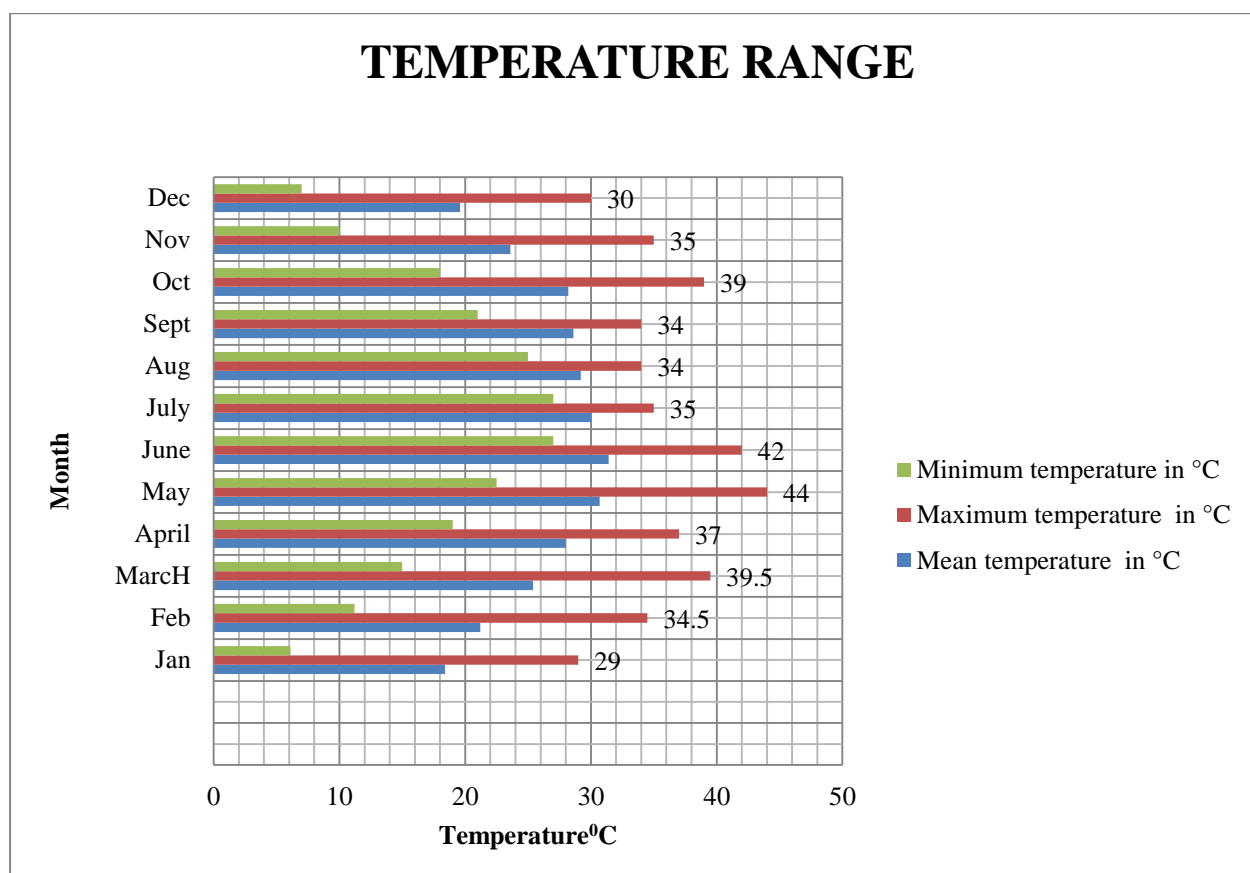
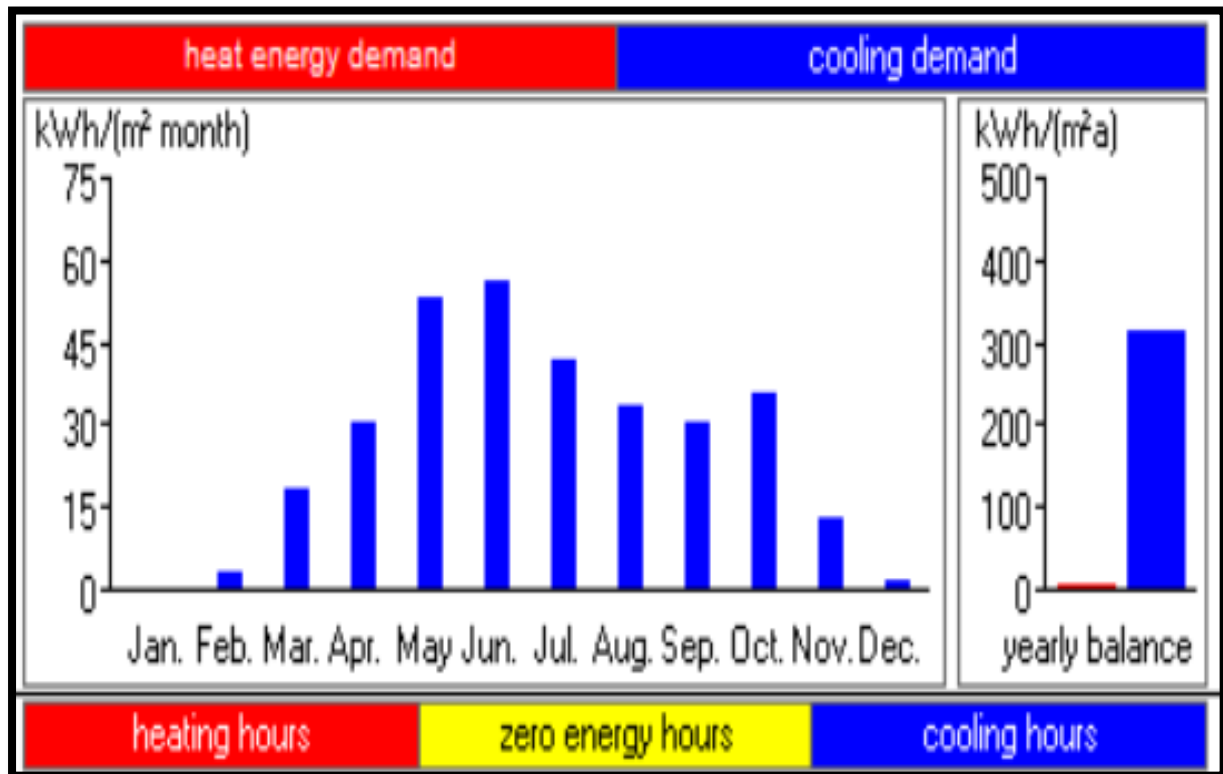


FIGURE: temperature variation in a year

We can see that air temperature in summers can reach as high as 44°C. It is observed to be high during month of March till November. To maintain an inside temperature of 18°C minimum, there is need of energy demand. Energy demand in present situation is



Energy demand by the Systems

There is cooling energy demand in ten months of a year, which is an extreme demand for energy systems. Yearly balance as shown above for cooling energy demand is approximately 320 kWh per m²a.

2. BUILDING ENVELOPE

A building envelope is the physical separator between the conditioned and unconditioned environment of a building including the resistance to air, water, heat, light, and noise transfer. Building envelopes in the climate in question may be better accompanied by building mass and ventilation.

Present construction conditions:



Building under observation

The building which is here specifically studied consist of concrete blocks covered with flat metal roof and has unglazed windows. The building has reinforced concrete structure. Ground floor of the building is used as a shop while the rest are being used for residential purpose. The u value of respective used materials is described below.

Used materials

MATERIAL	DESCRIPTION	U-VALUE
CONCRETE	12” THICK consist of building wall	0.75
STEEL	Consist of windows and open area	5
METAL	Sheet covering roof	7

TABLE; Used Material

Improvement in materials:

MATERIAL	DESCRIPTION	U VALUE
DOOR	Wood	0.64
Ventilated steel roof	Ventilated double layer of corrugated galvanised steel sheets ,6 cm thick	2.1
White paint	Whole building	30 %Reduction in heat gain

TABLE; Improvement in used material

3. ENVIRONMENTAL HAZARD

Human comfort is also influenced by presence of green area and water body in a specified area. The area is also facing environmental problems that can be improved easily and can help to create a healthy microclimate.

- Waste management can be solution to many problems. If waste is timely collected and recycled . Use of proper waste bin and knowledge of reuse , recycling and sustainability can help because it will involve the local people to control the collection of waste .
- Planting trees will also be favourable because they can help in conduction of heat energy.
- Because the colony have narrow streets, if there is limited access to vehicles it can help to avoid pollutants accumulation that are also causing health problems.



Images of narrow streets and vehicles in colony



Improper waste disposal

4. Results And Discussion

By improving the used materials we can achieve 30% decrease in usage of energy systems. Colour of wall also effects on absorbing heat radiation from outside, thus light colours with low thermal absorptivity like white which is 0.2 absorbtivity or stone grey which is 0.6. The effect on energy systems especially for cooling demand on summers is mentioned below.

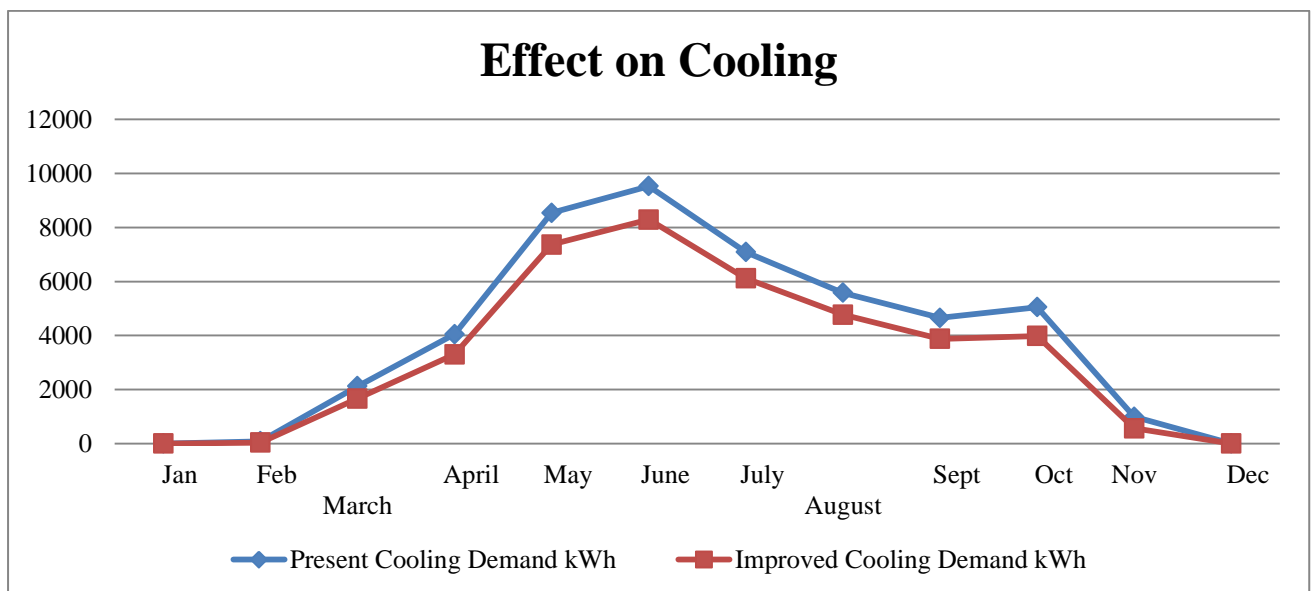


Figure: Shows change in cooling demand before and after improvements.

Similarly, Energy demand by the systems could be controlled. By improving the building material and using passive methods to cool the building, we can achieve the result which could be less energy consumption. More energy-efficient lighting and electronic equipment tend to release less energy thus contributing to less internal heat loads inside the space. The energy demand by the building in this context in a complete year is shown below.

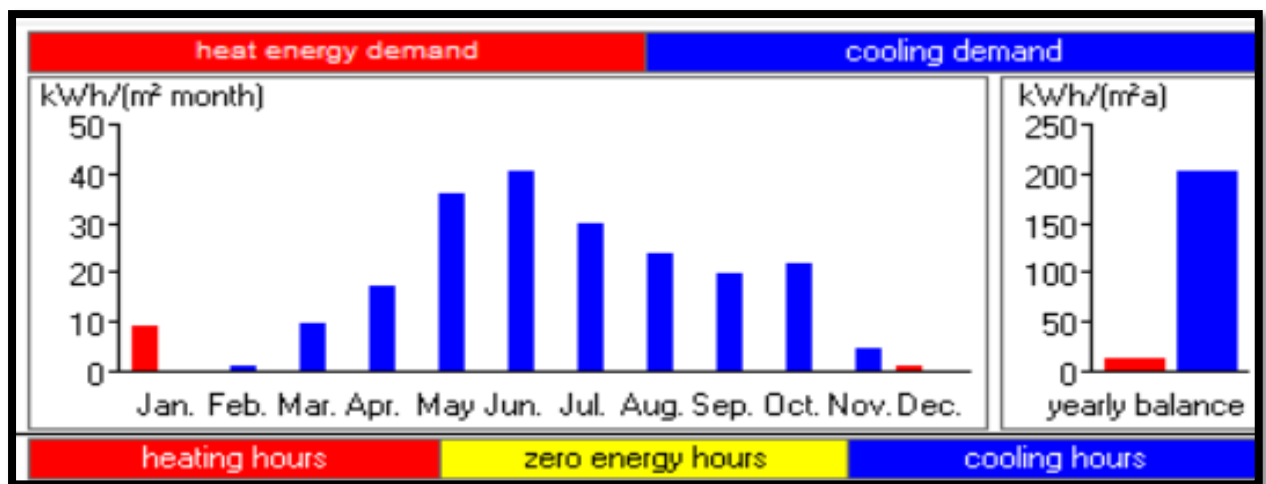


Figure: heating and cooling energy demand kWh/m²

CONCLUSION

I worked on an indoor microclimate in an existing building in an informal settlement. By analysing the problem of occupants I worked on reducing cooling energy demand by using simple and passive methods. By improvement in materials that are locally available and analysing the heat gain by outdoor climate, we can reduce the energy demand. I worked with an energy simulation programme and if we change some materials or some positions of materials with in a building envelope then we can achieve 30 % reduction in energy demand. Natural ventilation can greatly affect energy demand and thermal comfort. By some intervention like introducing shades and possible improvement in materials can help to reduce energy requirements and increase thermal comfort. Some improvements for this reason could be adding thermal mass (through dense materials) when lacking and changing colour of surface. Wall and ceiling temperature could be controlled. Making green environment could help the community to grow better and healthily.

REFERENCE

1. <http://www.lonelyplanet.com/pakistan/sindh/karachi/introduction#ixzz4I9aKeJED>.
2. https://en.wikipedia.org/wiki/Passive_cooling
3. <http://nationalgeographic.org/encyclopedia/urban-heat-island/>
4. Kazmi SJH, Mehdi R, Arsalan MH. Karachi: Environmental challenges of a mega city. In: Misra RP (Ed.) South Asian cities. Cambridge University Press, New Delhi, India. 2008; pp. 23-36.
5. <https://lh3.googleusercontent.com/hhVSXOrZGX39xapvxKmOUhID6pKhzYULzG-16k2GvpACQKSNp4GwTuII6wcBap1bJw=h900>
6. <http://climate.nasa.gov/news/2479/nasa-analysis-finds-july-2016-is-warmest-on-record/>
7. <https://germanwatch.org/en/download/8551.pdf>
8. GISTEMP Team, 2016: *GISS Surface Temperature Analysis (GISTEMP)*. NASA Goddard Institute for Space Studies. Dataset accessed 20YY-MM-DD at <http://data.giss.nasa.gov/gistemp/>.
9. https://en.wikipedia.org/wiki/Demographics_of_Karachi#cite_note-The_Express_Tribune-6
10. https://soa.utexas.edu/sites/default/disk/preliminary/preliminary/1-Boduch_Fincher-Standards_of_Human_Comfort.pdf
11. <http://archive.unu.edu/unupress/unupbooks/80a01e/80A01E06.html>
12. <http://www.ndma.gov.pk/site/files/heatwave.pdf>
13. https://en.wikipedia.org/wiki/2015_Pakistan_heat_wave

