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Study for New Cooling Technique in Tropical Climate

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Abstract: *In the modern world, it is quite difficult to achieve suitable indoor standards within a structure in tropical areas. This study investigates the development of indirect cooling techniques in residential construction as a means of preserving the environment by lowering cooling loads within the framework of interior design, using Navi Mumbai as a case study. This study presents conventional cooling techniques such radiant night cooling, radiant cooling with individual radiators, evaporate cooling, convective cooling, and rooftop pools. Over the past few years, Navi Mumbai's comfortable surroundings have been regulated by taking into account associations between the atmosphere, comfortable conditions, and framework cooling levels that specify how much cooling is required to accomplish those conditions. determining the right mixture that will produce.*

Keywords: Natural cooling methods, Housing Structures, Thermal comfort, Navi Mumbai, Computer model

I. INTRODUCTION

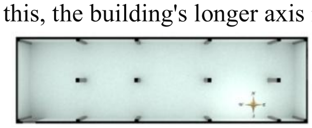
Mumbai, the capital of Maharashtra, has a metropolis called Navi Mumbai that has grown up around its eastern harbour. It is one of the largest planned communities in the world, with a tropical environment that is mild in many aspects and old-style buildings that have long supplied suitable living conditions for people with basic design and technology. This cycle recurs every few years as air conditioners and generators wear down and need to be replaced.
Politicians and scientists are harshly criticising this booming industry, the reliance on trade in technology, and the green house gas emissions produced by air facilities and machines from the comfort of their fully air-conditioned offices that are powered by standby generators, which generate 88.97 percent of their energy needs.

II. PASSIVE COOLING BY LESSING OF COOLING LOADS

For cooling and aeration of suburban buildings, passive cooling schemes are used. The main problem with this approach is to prevent cooling loads rather than just to cool the structure down. If extra heating can be minimized, the problem of efficient cooling would be half-solved. Sunlight from openings or on the outside of walls or roofs, hot air approaching the house or heat gain from the same are all examples of externally generated cooling loads.

2.1 Orientation of Structure

The precise location and orientation of the system is critical in a tropical environment. When the incident solar heat is extremely high, it plays a critical role. To do this, the building's longer axis is oriented East and West



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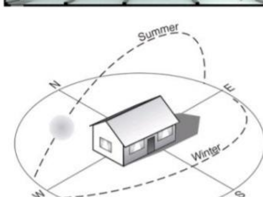


Figure 1: Orientation of building

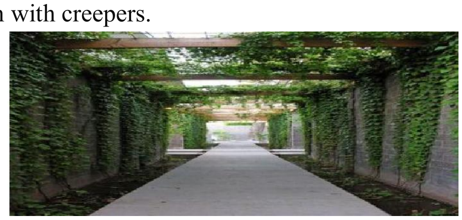
2.2 Appropriate Vegetation

The role of vegetation in reducing solar heat is critical. It has been shown that changing the surrounding atmosphere and decreasing irradiance achieved by vegetations is an efficient way of minimizing energy consumption for space cooling, and that approximately 25-80 percent savings on air conditioning can be achieved with correctly & escaping.

Figure 2: Surrounding vegetation to pre-cool winds & manage moisture percentage (2016)

2.3 Implementation & Selection of Appropriate Shading Devices

Proper shading system will help to minimize the amount of solar heat that enters the building. According to the findings of the survey, built shading devices will reduce the temperature by 8^0 degrees Celsius. Horizontal chajjas are unsuccessful at providing shade. As a result, vertical louvers must be designed at a specific angle to block solar heat while allowing plenty of light to reach the room. The environment of the courtyard can be regulated by selecting appropriate *chajja* and covering them with creepers.



2.4 Developing an Appropriate Building Enclosure

The building envelope can be made from a variety of material. Several raw materials captivate the heat in the morning and reduce it at night. "Thermal power & time lag" shows how materials behave in this way.

Sr No.	Wall types	No	U value (W/m².K)
1	Rat trap bond wall	1	1.673
2	Light Gauge framed steel structure with EPS	1	1.188
3	Light Gauge framed steel structure with PPGI Sheet	1	1.629
4	Reinforced EPS core Panel system	1	0.907
5	Glass fibre reinforced Gypsum Panel - Unfilled	1	1.559
6	Glass fibre reinforced Gypsum Panel - with RCC and non-structural filling	1	1.715
7	Glass fibre reinforced Gypsum Panel - with RCC filling	1	1.534
8	Brick Wall	1	1.670
9	Structural stay-in-place formwork system (Coffor) - Insulated panel	1	0.52
	Total	9	

Figure 3: Various material & it's u-value

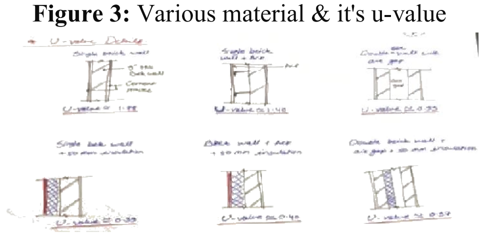


Figure 4: Brick wall & Insulation material combination & it's U-value

2.5. High Thermal Mass Implementation with Night Cooling

This is based on thermal mass's regular heat storage associated with night ventilation that cools the mass.

A. Attic Insulation, Ceiling & Roof

Insulation for the roof and horizontal surfaces is often associated with attic insulation. Sheet of "reflective foil laminate sarking or foil batts" is typically used as a reflective material beneath the roofs. The R-Value is the inverse of the U-

Value, and it is a measure of insulation's ability to resist heat transfer. In Roof pond water bags help to lower the temperature.

B. Reflective roofs and light wall colors are used

Reflective roof tops and coverings are a convenient and low-cost way to reduce roof heating, It contains items like "elastomeric white roof & acrylic coatings,""polyurethane foam coatings," and "bitumen," among other things. To reflect heat, light colors should be used on the walls.

Colors Absorption Coefficient	Percentage
Jet black	100 %
Normal black	85 %
Dark green, Dark grey	70 %
Light green, Light grey	40 %
White oil paint	20 %
New whitewash	12 %
White emulsion paint	12 – 20 %

III. REMOVAL OF EXCESS HEAT

Passive cooling mechanisms also known as natural cooling systems and active cooling systems are the two forms of solar cooling systems Natural chillers are solar cooling systems that rely solely on natural resources to keep buildings cool. Metallic plate radiators are used for long wave radiation in radiant cooling with advanced radiators. Evaporation from roof ponds lowers the temperature of the building structure.

3.1 Natural Ventilation

Ventilation is the method of exchanging used indoor air with outside air, and it serves three purposes: supply of fresh air, body cooling, and structural cooling. Wind, the buoyancy effect produced by temperature variations, or differences in humidity may all cause pressure differences. In hot, humid climates, ventilation system can be detrimental during periods when the temperature of the exterior air at night is far above the outdoor thermal threshold.

IV. PASSIVE COOLING SYSTEMS:

Buildings with efficient passive solar systems and energy conservation principles are difficult to design, and much depends on the architect's understanding of solar energy.

1. **Collection of Data:** This entails gathering and analyzing climatic data for a given location, such as outdoor air temperatures, humidity or vapor pressure, wind speed and direction, global radiation on a horizontal plane, daylight hours, cloudiness, and rainfall.
2. **Bioclimatic Analysis:** This includes using an acceptable thermal index to assess the thermal stress and comfort conditions. The most significant factor in the design of passive cooling systems is hot discomfort.
3. **Thermal Analysis:** This is a study of the building's thermal balance. To generate sketch design guides, the first study is done on the bases of climatic and site data.
4. **Choice of Passive Cooling System:** Many factors influence whether a passive solar or traditional cooling system is chosen, including customer demands, economic viability, fashion, culture, availability, and maintenance.

V. THE CLIMATE OF NAVI MUMBAI

At a height of 14 meters above sea level, Navi Mumbai is located on latitude $19^0$03' north of the Equator and longitude $73^0$02' east of the Equator. That's one of Maharashtra's large cities. The city of Navi Mumbai has equatorial rain forest vegetation. The rainfall data averages 1915 mm, with double peaks in June/July and September/October. And during the rainfall, there is normally more than 6 hours of daylight. Table 2 shows the results.

The thermal stress is measured using the temperature and relative humidity of the atmosphere. Shown in Table 3.

Comfort limits proposed by GRIHA. Source: GRIHA handbook

Relative humidity (%)	Day comfort limits (°C)	Night comfort limits (°C)
0 – 30	29.5 – 32.5	27.5 – 29.5
30 – 50	28.5 – 30.5	26.5 – 29
50 – 70	27.5 – 29.5	26 – 28.5
70 – 100	26 – 29	25.5 – 28

The comfortable situations (thermal stress) in Navi Mumbai were determined using these parameters.
The heat generation in Navi Mumbai was calculated using climatic data, IMD comfort limits, and this classification, as shown in table 5.

Human Comfort Conditions

Navi Mumbai (1983-2019)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Monthly Maximum Temperature (°C)	32.1	33.5	33.4	32.3	31.6	29.0	29.0	28.2	29.1	30.4	32.2	31.4
Mean Monthly Minimum Temperature (°C)	17.9	20.0	21.7	22.0	21.1	20.8	20.2	20.1	20.2	20.6	21.2	19.8
Mean Daily Maximum Relative Humidity (%)	66.3	65.1	75.9	78.4	79.6	83.2	86.6	85.8	84.6	79.2	75.2	70.7
Mean Daily Minimum Relative Humidity (%)	43.6	40.0	48.2	54.0	56.5	59.1	62.8	64.1	61.4	60.3	50.0	43.2
Day Thermal Stress	+	+	+	+	+	0	0	0	0	+	+	+
Night Thermal Stress	--	--	-	-	-	--	--	--	--	--	--	--

Hot dissatisfaction during the day is often accompanied by cold or very cold discomfort at night, allowing for the reduction of heat expansion by the use of high thermal power and long time lag building materials.

VI. COMPUTATION

The cooling load is the volume of cooling needed to maintain the interior spaces at a temperature that avoids hot discomfort, generally underneath the maximum comfort limit, irrespective of the outside temperature.
Heat gains that occur outside the building (or enclosure) are referred to as external cooling loads, and they include:

1. Heat gain from the sun by fenestration.
2. Heat gain via conduction by fenestration.
3. Heat gain through conduction via roofs and external walls
4. Conduction heat gain across floors, as well as interior partitions and ceilings in enclosures.

Inner cooling loads

1. Electric lighting generates heat.
2. Heat emitted by building or space inhabitants, both sensible and latent (usually human beings).
3. All heat-producing equipment and appliances gain heat.
4. Infiltration of heat and ventilation (both sensible & latent cooling loads). Infiltration load is a space cooling load caused by infiltrated air entering a conditioned room through cracks and openings due to a pressure differential around the building envelope.

The Cooling Degree Day (CDD) Technique

Multiplying the degree day figures by the cumulative energy heat gain per day yields the cooling load. The utilization of the degree day base temperature, which is often set arbitrarily, is a drawback of this process.

The Bin Method

Multiplying the modified degree day figures by the cumulative energy heat gain per day yields the cooling load.

The Los Alamos Solar Load Ratio (SLR) Method

Balcomband McFarland (1978) of the Los Alamos National Laboratory in Los Alamos, New Mexico, invented the solar load ratio system. The Solar Load Ratio (SLR) is a dimensionless correlation parameter that is defined as follows:

$$SLR = \frac{\text{Amount of solar enery absorbed on the southern façade wall surface in 30 days}}{\text{30 days building load (Counting the wall steady} - \text{state losses in the lack of solar gain)}}$$

The monthly building load is calculated by multiplying the monthly heating degree days by the building loss coefficient. The monthly SLR approach offers insight into the system's month-to-month activity, and the monthly values of solar energy

VII. ENVIRONMENTAL COOLING LOADS - Calculations

Degree days are a form of weather data measured from outdoor air temperature readings. Heating degree days, cooling degree days, and rising degree days are the three major forms of degree days. Cooling degree days (CDD) are a measure of how much (in degrees) and for how long (in days) the outside air temperature was above a certain amount. Heating degree days (HDD) are a measure of how much (in degrees) and for how long (in days) the outside air temperature was below a certain level. Growing degree days (GDD), also known as growing degree units (GDU), are a measurement of plant and insect growth and development during the growing season.
The amount of energy needed for cooling is been calculated by calculation and the distribution of this cooling load over the year.

Month	Cooling Degree Days	Error margin (%)
November 2018	191	0
December 2018	230	0
January 2019	212	0
February 2019	240	0
March 2019	260	0
April 2019	226	0
May 2019	216	0
June 2019	166	10
July 2019	146	0
August 2019	146	0
September 2019	148	3

VIII. OPTIMIZATION OF PASSIVE COOLING SYSTEMS

The aim of optimization is to maximize a system's effectiveness. Process optimization requires changing a process to maximize a number of parameters while remaining within a set of constraints. The microclimate, the building design (including materials, components, configuration, and fenestration), the location & positioning of the building, landscaping, the equipment installed, building use, and occupant behavior are all factors to consider when optimizing passive cooling systems. Computer modeling is the preferred method for resolving this form of problem.

IX. CONCLUSION

The construction of green structures in hot, humid conditions like those found along the coast of Maharashtra might benefit greatly from the optimization of passive cooling mechanisms for home developments in Navi Mumbai.
This, however, calls for a careful balancing of factors for microclimate control, including landscape, building design (materials, components, layout, & fenestration), building location & positioning, cooling equipment mounted, building use, & occupant efficiency.
Finding the right mix with the least amount of carbon footprint in the sense of Maharashtra's technical and socioeconomic circumstances would necessitate comprehensive and thorough computer modeling studies.
Grants and conferences are suggested as ways to promote research in this field. Climate data collection and analysis, as well as research on thermal stress trends, consumer habits and behavioral patterns, building materials properties and use, and building technologies, will all contribute significantly to this debate
Use of materials like Vermiculite, charcoal insulation will help in reduction in air moisture in the air.

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