VIVA-Tech International Journal for Research and Innovation *Volume 1, Issue 5 (2022)*
ISSN(Online): 2581-7280
VIVA Institute of Technology
10th National Conference on Role of Engineers in Nation Building – 2022 (NCRENB-2022)

VIVA-TECH INTERNATIONAL JOURNAL FOR RESEARCH AND INNOVATION
ANNUAL RESEARCH JOURNAL
ISSN(ONLINE): 2581-7280

Design & Analysis Of Self-Cooling Building

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Abstract : *There has been a drastic increase in the use of air conditioning system for cooling the buildings all around the world. The last two decade has witnessed a severe energy crisis in developing countries especially during summer season primarily due to cooling load requirements of buildings. Increasing consumption of energy has led to environmental pollution resulting in global warming and ozone layer depletion. Passive cooling systems use non-mechanical methods to maintain a comfortable indoor temperature and are a key factor in mitigating the impact of buildings on the environment. Passive cooling techniques can reduce the peak cooling load in buildings, thus reducing the size of the air conditioning equipment and the period for which it is generally required. This paper reviews and critically analyzes various passive cooling techniques and their role in providing thermal comfort and its significance in energy conservation. The implementation of passive cooling into office buildings are becoming increasingly common due to a wide range of factors including the damage caused by an office buildings energy consumption, operation on the environment, increasing electricity prices, change in the climate conditions, worsening of heat islands, increase in greenhouse effect and so on. Passive cooling involves the incorporation of techniques with the intention to treating the internal environment of an office building in a natural means without the use of mechanical means, to improve the buildings performance globally.*

Keywords - *Natural Cooling, Passive Cooling Techniques, Climatic Design, Energy Conservation*

I. INTRODUCTION

The Sustainable design is a leading practice in today's society for services, consumer goods and more in response to the overwhelming evidence that suggests global climate change. The built environment is at the forefront of the discussion on how to reduce the environmental impact on the earth and its inhabitants. In an attempt to reduce the impact of the built environment there is a significant effort being made to change the way it is designed and constructed. This effort ranges from designing to maximize efficiency, using choice materials to changing construction practices in order to reduce the impact on the environment. There are several approaches being made in the design aspect, by designers, material manufacturers, building product suppliers and other members of the building industry, to help reduce this impact and be more sustainable. There are technology-based solutions to maximize building efficiency and there are passive solutions to minimize the expense and impact of technologies by using more natural approaches of allowing nature to do the work. There is also the approach of using innovative natural methods that mimic the environment itself so as to minimize negative environmental impacts. We can find these approaches under a broad definition of ecological architecture, which is designing with the environment in mind by incorporating it into the design as well as preventing harm to the environment through alternative design and energy strategies. However, each of these approaches can be very different and could be a type of architecture of their own. Nature and the environment can provide the optimal solutions to the way the built environment is designed; it has had 3.8 billion years to evolve and learn what works as well as to optimize its performance. The people involved in the built environment need to focus more on the past successes that can be found in nature and the environment to identify design solutions that will reduce the impacts upon it

II. LITERATURE REVIEW

2.1 General

A literature review is a summary of studies related to a particular area of research. It identifies and summarizes all the relevant research conducted on a particular topic. It is important that your literature review is focused. Therefore, you should choose a limited number of studies that are central to your topic rather than trying to collect a wide range of studies that might not be closely connected.

Literature reviews help you accomplish the following:

- Evaluate past research
- Identify expert
- Identify key questions
- Determine methodologies used in past studies

This chapter contains 2 research papers on Self-cooling Building and their case studies carried out on how to maintain sustainable energy. All research paper shows the satisfactory result in designing and analyzing of self-cooling methods.

2.2Literature Review on designing and analysis of Self Cooling Building

1. An Overview of Passive Cooling Techniques in Buildings: Design Concepts and Architectural Interventions, September 2012 (02)

Mohammad Arif Kamal

In this paper several passive cooling techniques were reviewed and discussed with reference to their design implications and architectural interventions. The continuing increase of energy consumption of air conditioning suggests a more profound examination of the urban environment and the impact on buildings as well as to an extended application of passive cooling techniques and also in this research paper they review and discuss in detail various passive cooling techniques with a special focus on solar shading techniques, as they are most economical and thus most suitable for houses in developing countries.

2. Case Study - EAST GATE HARARE ZIMBABWE, November 2016 (05)

Shiva Shankar

From this research paper it is found that it helps with this last, the windows have adjustable blinds, but Pearce also used deep overhangs to keep direct sun off windows and walls. Deep eaves are a traditional solution in Africa, shading the walls completely from the high summer sun, while allowing the lower winter sun to warm the building in the morning.

III. METHODOLOGY

3.1 METHODOLOGY AND SELF-COOLING BUILDING PHILOSOPHY

To proceed any sorts work, various methods or steps are adopted from its initial stage to final stage. Following are some of the methods been adopted during the analysis and design of one-storey commercial self-cooling building.

3.1.1 Selection of building and data collection

After having proper concept about the project, the building was selected then the data required for the analysis and designing of the building were collected.

3.1.2 Study of Architectural Drawing

Architectural drawings of the building were properly studied. Rooms within this commercial and office building were allocated to various purposes such as staff room, administration, store room, retail shop, restaurant etc.

3.1.3 Preliminary design

Estimation of various structural elements such as beam and slab were designed and checks were done with the help of deflection criteria and moment criteria. For the column, vertical axial capacity was taken for the design and percentage of steel was checked.

3.1.4 Load calculation

After the study of architectural drawing and preliminary design, load calculations were done using the IS 875:1987 as reference. The exact value of unit weights of the materials from the code was used in the calculation. The thickness of materials was taken as per design requirement.

3.2 Gravity load calculation

There are three types of loads for which are considered in this analysis.

1. Dead load
2. Live load
3. Lateral load

3.2.1 Dead load

Dead load consists of the self-weight of the column, beam, slab and wall. Dimensions of column, beam, and slab were taken from preliminary design. For wall load, thickness of wall was taken from plan, deduction of opening was done according to the average size of opening in the outer and inner walls and deduction was not made in solid wall. In the case of the partition wall in the middle of slab, the total weight of the wall was calculated as uniformly distributed load and assign over the nearest beam.

3.2.2 Live load

Live load was determined by using code for design loads (IS 875:2000 part 2) for various types and purposes of rooms.

3.2.3 Lateral load

Lateral load acting in the building is earthquake/seismic load and wind load. Earthquake load is determined by calculating lumped mass at floor level and horizontal base shear (IS 1893). It was done by Seismic Coefficient Method. Wind load (IS 875 Part 3) is obtained by design wind speed and design wind pressure. Earthquake load being the pre-dominant one between the two lateral loads, hence its effect was only considered. For the analysis of earthquake load, following methods is generally carried out:

1. Seismic Coefficient method (Static)
2. Response Spectrum method (Dynamic)

3.3 Loading pattern

The loading is applied to the slab elements directly. The load on slab is taken as per the requirement stated in IS875:1987(Part I & II).

The uniformly distributed dead and live load acting on the slab are transferred to the beams holding the slab. The slab load is distributed on the floor beams as shown in figure below. The smaller beam holds the triangular load and the longer beams hold the trapezoidal load as shown in figure. The beam element also resists the self-weight and the wall load including all the finish loads on wall such as external and internal plaster.

3.3.1 Load Cases

Load cases are independent loading for which the structure is explicitly analyzed. Earthquake forces occur in random fashion in all directions. For building whose lateral load resisting elements are oriented in two principal directions. It is usually sufficient to analyze in these two principal directions (X and Y direction) separately one at a time.

Thus, the load cases adopted are as follows.

1. Dead load (DL)
2. Live load (LL)
3. Earthquake load in X direction (EQX)
4. Earthquake load in Y direction (EQY)

Following load combination are adopted for design

a) 1.5(DL±LL)
b) 1.5(DL+LL±EQX)
c) 1.5(DL+LL±EQY)
d) 1.2(DL+LL±EQX)
e) 1.2(DL+LL±EQY)
f) 0.9(DL±EQX)
g) 0.9(DL±EQY)

3.4 Practical considerations

Besides all the fundamentals of planning discussed, following practical points should be additionally considered:

1) The elements of the building should be strong and capable to withstand the likely adverse effects of natural agencies.
2) Strength, stability, convenience and comfort of the occupants should be the first consideration in planning.

3) Elevation should be simple but attractive. The number of doors and windows provided should be less for a commercial building.
4) The provisions of built-in furniture at proper places are useful from the point of view of utility.
5) Since the plan is for a commercial building, the car parking must be secured with required space than usual.

3.4.1Planning considerations

The plan and detailing were drawn using Auto CAD. shape of the building is rectangular in plan. The building consists of G+1. The parking space is provided around the building. The floor height of the building is 3 m. The height of the parapet wall is 1m. The staircase is provided including lift with enough safe.

3.5 Self-cooling Building Philosophy

There has been a drastic increase in the use of air conditioning system for cooling the buildings all around the world. The last two decade has witnessed a severe energy crisis in developing countries especially during summer season primarily due to cooling load requirements of buildings. Increasing consumption of energy has led to environmental pollution resulting in global warming and ozone layer depletion. Passive cooling systems use non-mechanical methods to maintain a comfortable indoor temperature and are a key factor in mitigating the impact of buildings on the environment. Passive cooling techniques can reduce the peak cooling load in buildings, thus reducing the size of the air conditioning equipment and the period for which it is generally required. This paper reviews and critically analyzes various passive cooling techniques and their role in providing thermal comfort and its significance in energy conservation.

3.6 Passive cooling of buildings

A 'passive' solar design involves the use of natural processes for heating or cooling to achieve balanced interior conditions. The flow of energy in passive design is by natural means: radiation, conduction, or convection without using any electrical device. Maintaining a comfortable environment within a building in a hot climate relies on reducing the rate of heat gains into the building and encouraging the removal of excess heat from the building. To prevent heat from entering into the building or to remove once it has entered is the underlying principle for accomplishing cooling in passive cooling concepts. This depends on two conditions: the availability of a heat sink which is at a lower temperature than indoor air, and the promotion of heat transfer towards the sink. Environmental heat sinks are:

- Outdoor air (heat transfer mainly by convection through openings)
- Water (heat transfer by evaporation inside and / or outside the building envelope)
- The (night) sky (heat transfer by long wave radiation through the roof and/or other surface adjacent to a building
- Ground (heat transfer by conduction through the building envelope)

3.6.1 Solar shading

Among all other solar passive cooling techniques solar shading is relevant to thermal cooling of buildings especially in a developing country owing to their cost effectiveness and easy to implement. Rural India and developing countries in Middle-east region has witnessed a steep rise masonry house with RCC roofs. However, the availability of electric power in the village's especially during summer is limited. These RCC roofs tend to make the indoor temperature very high around 41°C. This is due to high roof top temperature of around 65°C in arid regions. Solar shading with locally available materials like terracotta tiles, hay, inverted earthen pots, date palm branches etc. can reduce this temperature significantly. Shading with tree reduces ambient temperature near outer wall by 2°C to 2.5°C. On an average a depression of six degree centigrade in room temperature has been observed when solar shading techniques are adopted. Kumar, Garg and Kaushik evaluated the performance of solar passive cooling techniques such as solar shading, insulation of building components and air exchange rate. In their study they found that a decrease in the indoor temperature by about 2.5°C to 4.5°C is noticed for solar shading. Results modified with insulation and controlled air exchange rate showed a further decrease of 4.4°C to 6.8°C in room temperature. The analysis suggested that solar shading is quite useful to development.

3.6.2 Shading by overhangs, louvers and awnings etc.

Well-designed sun control and shading devices, either as parts of a building or separately placed from a building facade, can dramatically reduce building peak heat gain and cooling requirements and improve the natural lighting quality of building interiors. The design of effective shading devices will depend on the solar orientation of a particular building facade. For example, simple fixed overhangs are very effective at shading south-facing windows in the summer when sun angles are high

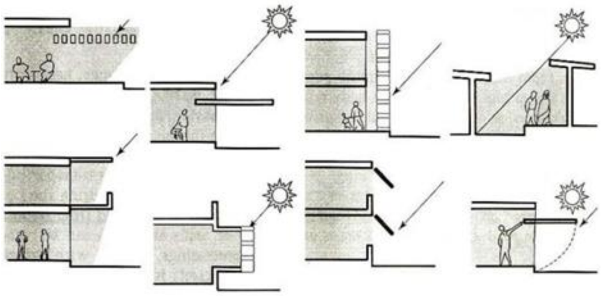

Fig 3.1. Different types of shading devices.

However, the same horizontal device is ineffective at blocking low afternoon sun from entering west-facing windows during peak heat gain periods in the summer. Fig. 3.6 shows the different types of shading devices.

3.6.3 Shading of roof

Shading the roof is a very important method of reducing heat gain. Roofs can be shaded by providing roof cover of concrete or plants or canvas or earthen pots etc. Shading provided by external means should not interfere with night-time cooling. A cover over the roof, made of concrete or galvanized iron sheets, provides protection from direct radiation. Disadvantage of this system is that it does not permit escaping of heat to the sky at night-time (Fig. 3.7).

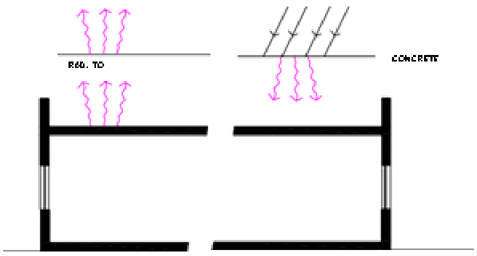

Fig 3.2. Roof shading by solid cover.

3.6.4 Shading by trees and vegetation

Proper Landscaping can be one of the important factors for energy conservation in buildings. Vegetation and trees in particular, very effectively shade and reduce heat gain. Trees can be used with advantage to shade roof, walls and windows. Shading and evapotranspiration (the process by which a plant actively releases water vapor) from trees can reduce surrounding air temperatures as much as 5°C. Different types of plants (trees, shrubs, vines) can be selected on the basis of their growth habit (tall, low, dense, light permeable) to provide the desired degree of shading for various window orientations and situations. The following points should be considered for summer shading.

1. Deciduous trees and shrubs provide summer shade yet allow winter access. The best locations for deciduous trees are on the south and southwest side of the building. When these trees drop their leaves in the winter, sunlight can reach inside to heat the interiors.
2. Trees with heavy foliage are very effective in obstructing the sun's rays and casting a dense shadow. Dense shade is cooler than filtered sunlight. High branching canopy trees can be used to shade the roof, walls and windows.
3. Evergreen trees on the south and west sides afford the best protection from the setting summer sun and cold winter winds.
4. Vertical shading is best for east and west walls and windows in summer, to protect from intense sun at low angles, e.g., screening by dense shrubs, trees, deciduous vines supported on a frame, shrubs used in combination with trees.
5. Shading and insulation for walls can be provided by plants that adhere to the wall, such as English ivy, or by plants supported by the wall, such as jasmine.
6. Horizontal shading is best for south-facing windows, e.g., deciduous vines (which lose foliage in the winter) such as ornamental grape or wisteria can be grown over a pergola for summer shading.

IV. CONCLUSION

The main objective of this project is to analyze various self-cooling techniques that can be used in the building instead of using artificial techniques. Going through a lot of research papers we came to the conclusion that using self-cooling techniques the use of energy consumption gets reduced and it is also economical. Implementing passive cooling systems in building design has many advantages over using the fossil fuel-based cooling systems, as they produce no environmental impacts and GHG emissions. Theoretical studies have shown that the application of all the above techniques in buildings may decrease their cooling load up to 50% - 70%.

Acknowledgements

We are using this opportunity to express our gratitude to everyone who has supported us throughout the completion of this project. We are thankful for their guidance, constructive criticism and friendly advice, during the project work. We express our gratitude to Prof. Vishal Urade for giving us an opportunity to carry out project on Design & Analysis of Self-cooling Building. We would also like to thank Prof. Lissy Jose, Head of Civil Department and Dr. Arun Kumar, the Principal for their whole hearted support.

Lastly, we express our gratitude towards all those who directly or indirectly helped us in the completion of our studies.

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