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Opportunities for Energy Conservation in Residential Buildings of Bhopal: A Case-Study

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ABSTRACT Currently, about 40% of the world's energy consumption is used in buildings. In India, with the improvement of living standards and the improvement of living standards, the energy consumption of cooling/heating in buildings is also increasing. The document presents a study based on a survey conducted in residential buildings in Bhopal, Madhya Pradesh. This survey was conducted to evaluate the influence of various parameters such as orientation, window/wall ratio, open areas around buildings, window areas exposed to direct solar radiation, planting, shading, natural lighting, energy consumption in summer and winter. The results have been analyzed for thermal comfort conditions. Controlling this direct sunlight gain can be used as a measure to increase energy savings and thermal comfort. The method of controlling direct solar gain has been discussed in this document. Describes energy-saving opportunities and makes recommendations. From the perspective of optimally designing new residential buildings, this research is useful and can also reduce the energy consumption of existing buildings through some simple measures.

KEYWORDS: Energy audit, energy conservation, thermal comfort, solar, green buildings

I. INTRODUCTION

How buildings play an important role in the world economy. Environmental degradation, technological progress and the development of urban centers have greatly affected the energy consumption of buildings [1]. In the past ten years, developing countries have experienced a severe energy crisis, especially in summer, which is mainly due to the cooling load requirements of buildings. Energy consumption in buildings has greatly increased, and is expected to continue to increase due to population growth and improvement in living standards, as well as residents' demand for thermal comfort [2].

In India, the construction sector accounts for approximately 33% of the total electricity consumption, and the commercial sector accounts for approximately 8% and 25% respectively [3]. From this perspective, the thermal performance of the building envelope can greatly reduce the overall energy consumption of the building [4]. Therefore, remedial measures should be taken to reduce the carbon emissions of buildings by adopting good design/construction, operation and maintenance practices to achieve the sustainable development of buildings [3, 4]. If the design and planning of the building consider the microclimate, local topography and other external features, heating and cooling energy consumption can be reduced by 50-80% [5].

II. CLIMATE RESPONSIVE DESIGN

Climate design refers to the design of buildings, where climate is regarded as the foundation of the building, and its purpose is to minimize the use of mechanical cooling, thereby reducing the cooling of the building by using natural energy flow to provide thermal comfort to the building cost. [6].

The problems observed in the building depend on the design of the building, including the direction and shadow of the walls, doors and windows, colour, internal space, etc. And the building materials used for construction and weather conditions [7]. Therefore, by considering all these factors, it will be easy to draw construction problems, and it is possible to choose better solutions to minimize disadvantages, thereby moving towards sustainable development [8, 9].



III. THERMAL COMFORT

Thermal comfort is closely related to human satisfaction and the surrounding environment. Thermal comfort can be defined as the mental state or condition that expresses satisfaction after interacting with the surrounding environment [10, 11].

Thermal comfort is a key factor for the sustainability of a building, because it not only affects the comfort of the occupants, but also affects the energy consumption in the building [12,13]. Because the energy consumption in the indoor residential environment depends on human thermal comfort, and thermal comfort is largely affected by outdoor climate conditions [14, 15, 16].

IV. SURVEY & METHODOLOGY

A. Site Selection:

The survey covered three different areas of Bhopal, Madhya Pradesh, namely Kolar Road, Arera Colony and Maharana Pratap Nagar. These areas were chosen because they are areas with different populations. They are located in different parts of the city and have different environmental conditions. 155 people from these areas conducted personal interviews, of which 85 were from Kolar Road, 25 were from Arera Colony, and 45 were from Maharana Pratap Nagar.

B. Methodology:

The survey was conducted in December 2020 and is based on the results of interviews with residential buildings in different locations, door-to-door and telephone interviews. A questionnaire was developed that took into account the influence of various parameters such as orientation, building size, window/wall ratio, window area exposed to direct solar radiation, planting, shading, natural lighting, summer and winter Energy consumption and some basic issues. Information about solar energy and check the occupants' awareness of solar energy applications in their daily lives. Some questions were interviewed, some questions were visually analyzed, and some questions were measured using compass, inch tape, etc. The research aims to propose measures that can improve the thermal comfort of residents in residential buildings, and focuses on the acceptability of passive technology.

C. Mass Distribution:

A total of 155 residents participated in the survey. Housewives accounted for 59%, students accounted for 22%, professional professionals accounted for 12%, and retirees accounted for 07%. If all respondents are classified according to their age group, only 22% are between the ages of 16-25 and 56% of the total number are between 26-40. The age ratio Between 40 and 60 years old is 14%. Last but not least, only 08% of the elderly interviewed.

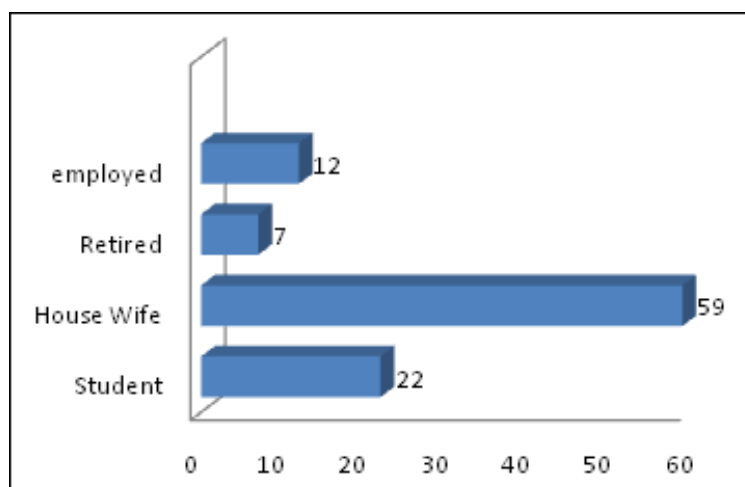
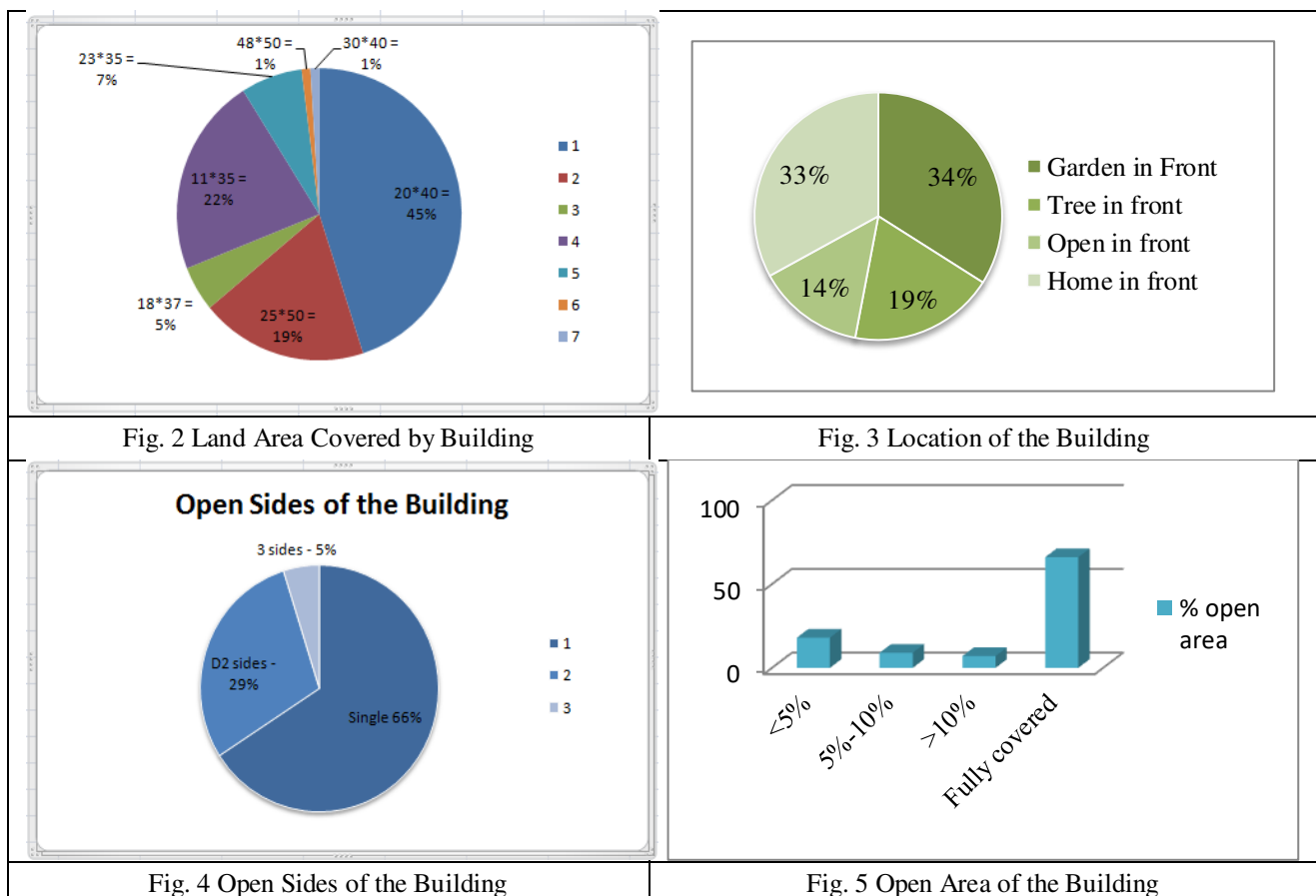


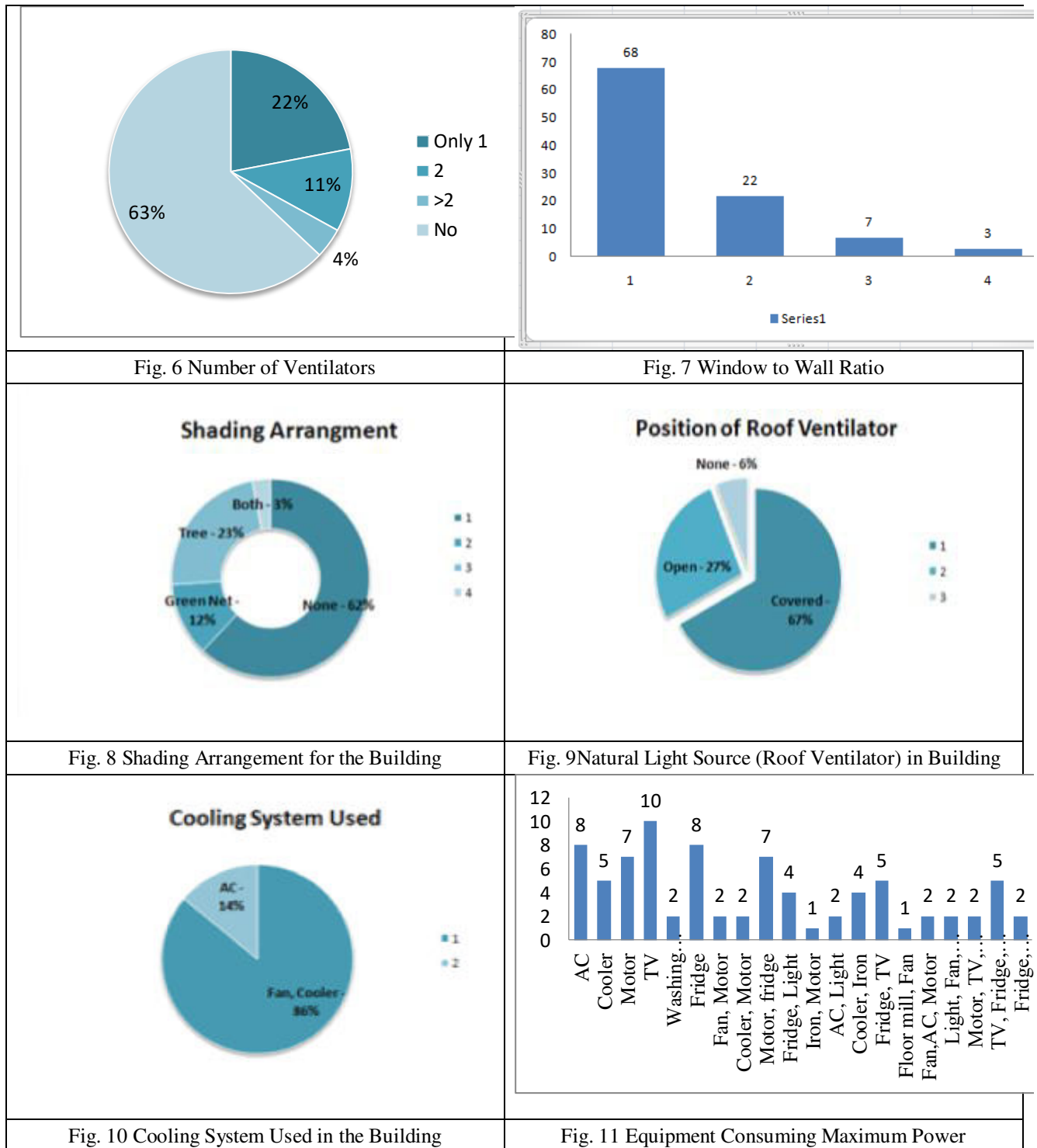
Fig. 1 Respondent's Profession

QUESTIONS OF QUESTIONNAIRE:

Q1	What is the total land area covered by your home/ building? (square feet)
Q2	Location / area of your building?
Q3	How much open sides around the built area? (1 side/2side/3 side/4 side)
Q4	Total area covered by the corridors or courtyard in the building? (in % of building area- <5%, 5% - 10%, >10%)
Q5	Total no of windows and ventilators in outer structure of the building? (in Numbers)
Q6	What is Window to Wall Ratio (WWR). (in % <= 25%, 25% - 50%, >=50%)
Q7	Have you done any arrangement for providing shading for wall, roof, or windows those are exposed to direct solar radiation? (Yes/No and type)
Q8	Is there any provision of natural light for the living space? (Y/N)
Q9	Types of cooling system used- AC, fans, coolers, ducts?
Q10	The biggest use of energy in your home is?
Q11	Can you believe that by changing our building structure we can reduce our heating or cooling load for building? (Y/N)
Q12	Can you believe that building structure affects the energy requirement for the building? (Y/N)
Q13	Can you believe that we can get cooling in our building by natural means without any electronic appliances?
Q14	Number, size and inclination of overhangs, if any?
Q 15	What type of special design used in building to allow maximum natural light inside the home? (Oriented along N-S/ windows along these space/ top lighting provision/ glazing material used)
Q 16	Do you believe that energy conservation is important in present era of civilization?

OUTCOMES OF SURVEY





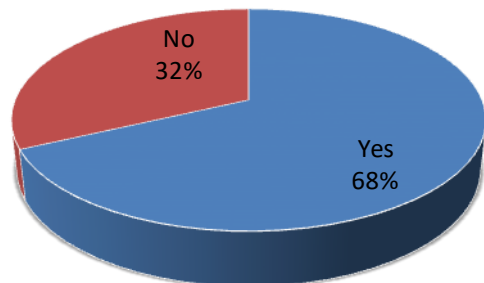


Fig. 12 Effect of Building Structure on Heating or Cooling Load for Building

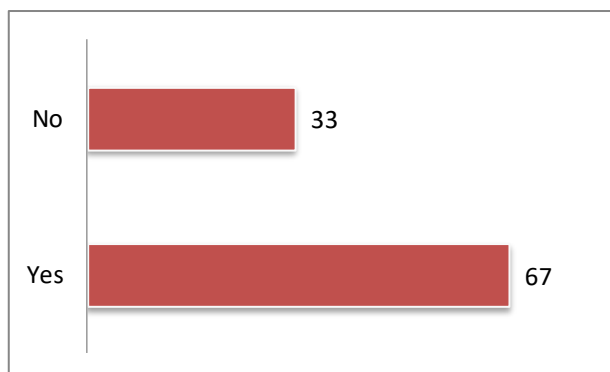


Fig. 13 Effect of Building Structure on Energy Requirement of the Building

V. RESULT AND OUTCOMES

The survey results show that few people are aware of the use of solar energy. Among the people surveyed, only 44% knew the application of solar energy in our daily lives, while the remaining 56% did not. Among all the houses, 66% of the houses have only one side exposed to the sun, so they can receive direct solar radiation. 29% and 3% of the houses were opened from the 2nd and 3rd sides respectively. Only 18% of houses have corridors or terraces covering less than 5% of the total floor area. 66% of the houses have been designed for complete coverage.

By calculating the ratio of windows to walls, it can be found that a large part of these houses have WWR less than 25%, while only 3% of houses have WWR greater than 50%.

During the research, we discovered that walls, ceilings or windows exposed to direct solar radiation provide different types of shadow arrangements. We divide this shadow arrangement into 3 categories: only trees, only green nets, and both. We analyzed that 23% of houses have trees in front of them, 12% of houses have green nets, and 3% of houses use shade. However, a large part of 62% of houses do not have special shading arrangements.

Here, the natural light source represents an open or partially covered area on the roof of a house, which transmits direct sunlight and heat from the sun to the house. 94% of the houses are equipped with ceiling fans to allow natural light in the house. It is observed that in 67% of the houses, ceiling fans are covered with transparent acrylic panels, domes, prisons, etc. Approximately 27% of houses have open ceiling fans, which means that the ceiling fans have no shade. 6% of houses are houses without ceiling fans.

Because the interviewees are mainly middle-class families. Therefore, most fans and refrigerators are used for refrigeration, which is why 86% of houses use fans and refrigerators, while only 14% of households use air conditioners to cool their houses. And mainly use distributed cooling system for cooling.

This shows that 68% of respondents believe that by changing the structure of the building, we can reduce the heating or cooling load of the building. 32% believe that the structure of the building will not affect the heating and cooling load. This 68% is a good ratio; it shows that people have an understanding of the passive design of the building.

67% of the respondents believe that the structure of the building will affect the energy demand of the building. Moreover, we can cool buildings in natural ways without any electronic equipment. 33% think they are wrong.

VI. CONCLUSION

The cantilever is the main part of the building and can be used to control the amount of sunlight entering the room. The main criterion for the cantilever is that the cantilever allows the maximum amount of sunlight to enter the building in winter and cuts off the solar radiation entering the room in the summer. The structure of the building should allow the building to have natural lighting and sufficient ventilation, thereby reducing the demand for electronic equipment for lighting and air conditioning. There should be enough shading devices in the building to minimize the heating capacity of the building in summer. Various passive technologies can be used in existing buildings, such as variable shading in summer and winter, insulation of ceilings and walls, plantations, paints and paints, etc. Using these technologies, the energy consumption of buildings can be reduced to a minimum.



VII. SCOPE OF FUTURE WORK

In the buildings of Bhopal, Madhya Pradesh, a lot of energy-saving work is needed because so far, little work has been done in this area. The use of solar energy and passive technology can help reduce energy consumption and improve thermal comfort to a large extent.

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