DESIGNING ENERGY EFFICIENT BUILDINGS

Pratyodhaya P, Tejaswini Deshpande, Aryan Prajapati, Himanshu Bansal, Mahir Neema

Supervisors: Dr. Navaneeth K.M. and Dr. Ramjee Repaka

CP301
Course
Evaluation

ABSTRACT

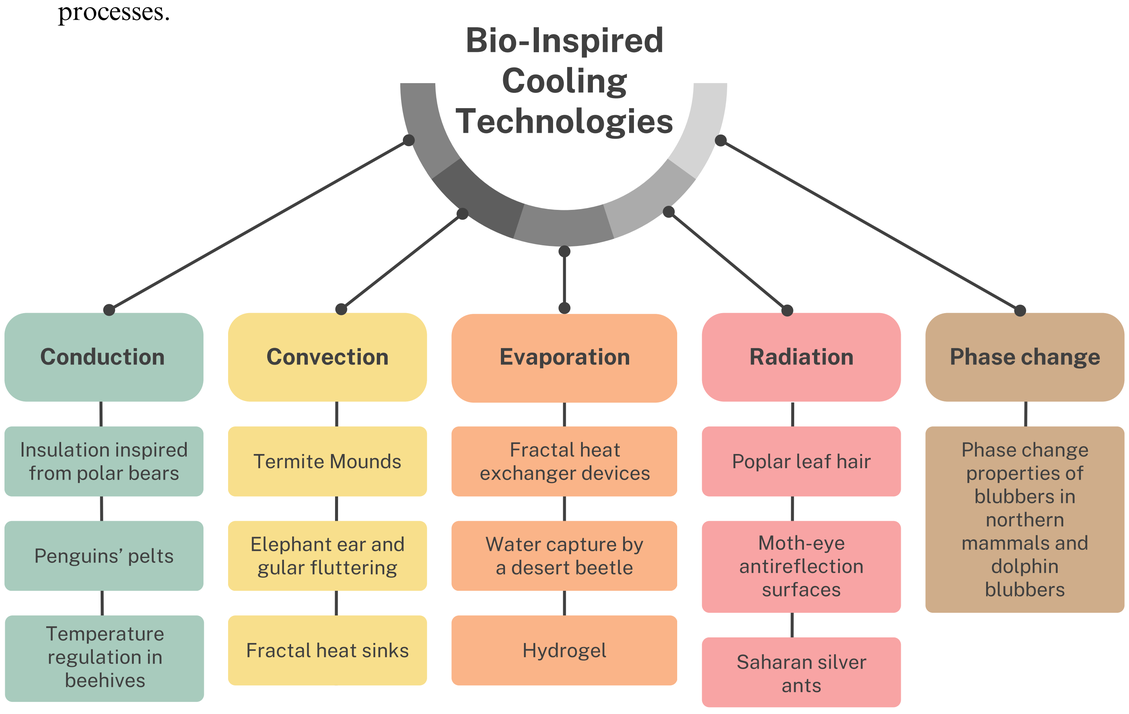
- Buildings have a significant impact on the environment due to energy consumption, and there is a need for green building practices to promote sustainability.
- The project aims to reduce cooling load in the Punjab region by using different materials and modifications.
- EnergyPlus, an open-source software for building energy modeling developed by the U.S. Department of Energy, was used to simulate a room structure.
- The simulations were based on weather files of the cities Chandigarh and Amritsar.
- Thermochromic windows was the most effective method for reducing energy consumption in Punjab's climatic conditions.

ACKNOWLEDGEMENTS

- Open-source software EnergyPlus and OpenStudio were used with a plug-in of the 3D design software named SketchUp.

BIO-INSPIRED ENERGY EFFICIENT TECHNIQUES

- Energy-efficient buildings offer a multitude of benefits, such as reducing energy consumption and associated environmental impacts, cutting energy costs, improving indoor comfort and air quality, and increasing building resilience to climate change.
- Innovative bio-inspired design modifications and technologies can be adopted to create more energy-efficient buildings, including heating and cooling techniques inspired by nature's processes.

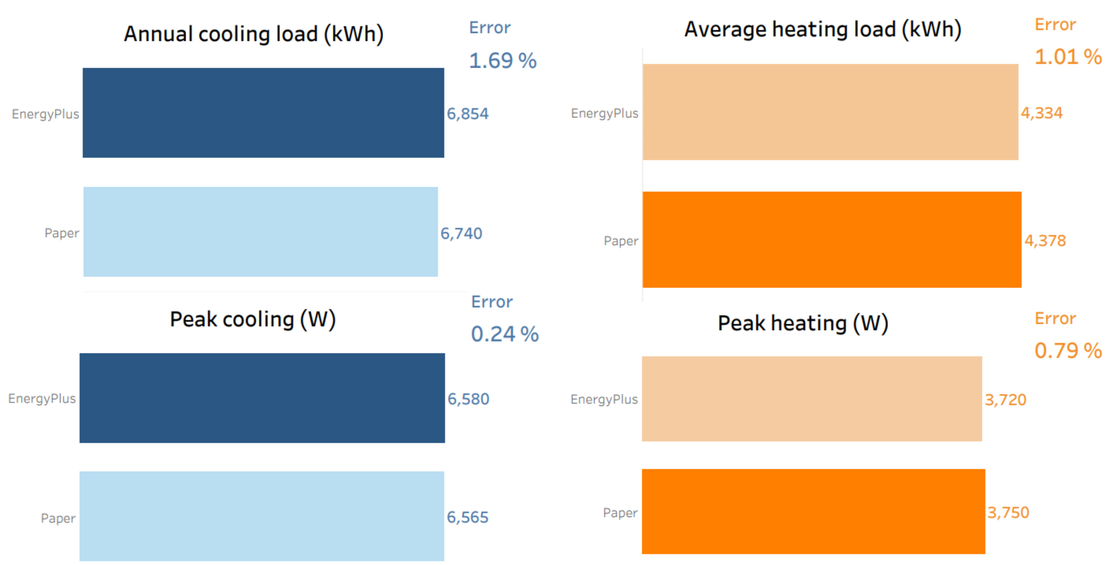


OBJECTIVES

- The primary aim of the project was to explore nature-inspired cooling and heating technologies and assess their practical feasibility for real-world applications.
- The project involved identifying factors that influence savings associated with these technologies by conducting energy simulations using Energy Plus software.
- Calculations of cooling loads for different bio-inspired technologies and building designs in various locations across Punjab were to be conducted to determine a suitable method.

VALIDATION

- Simulations were validated with comparative tests provided by EnergyPlus using the standard weather data file provided by ASHRAE for energy simulations
- For a standard 140 test case 600 building envelope a cooling load of 3446.15 kWh was stated by A.P Melo et.al for weather conditions of Porto Allegre, and we attained a cooling load of 3411.94 kWh hence validating our simulations.



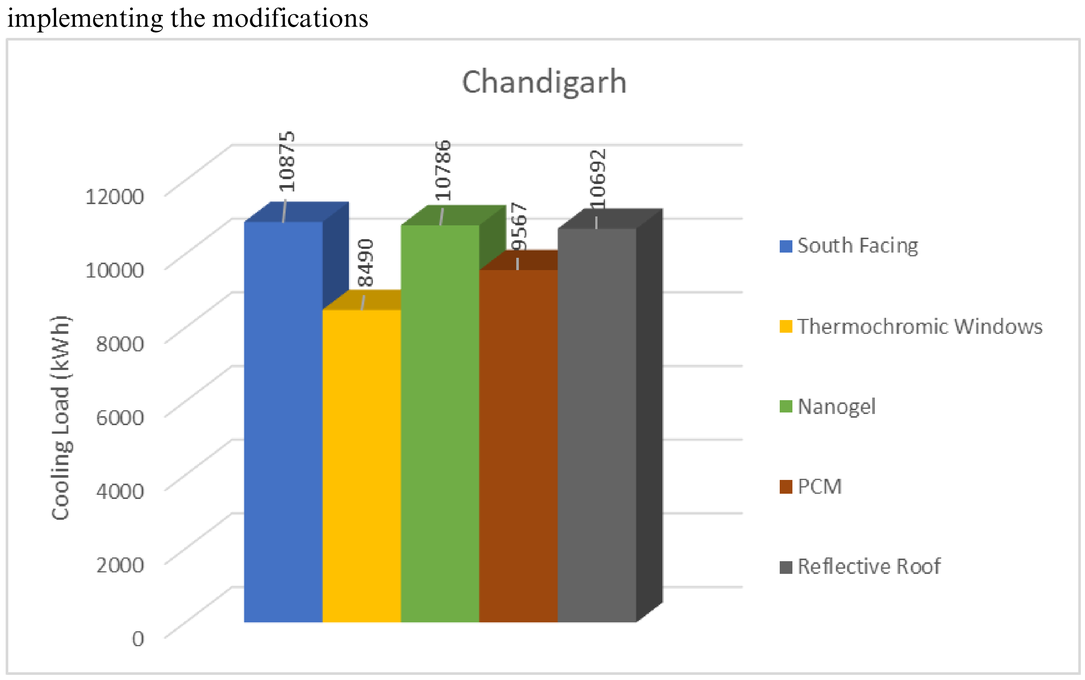
Reference file-Assessing the accuracy of a simplified building energy simulation model using BESTEST: The case study of Brazilian regulation
A.P Melo et.al

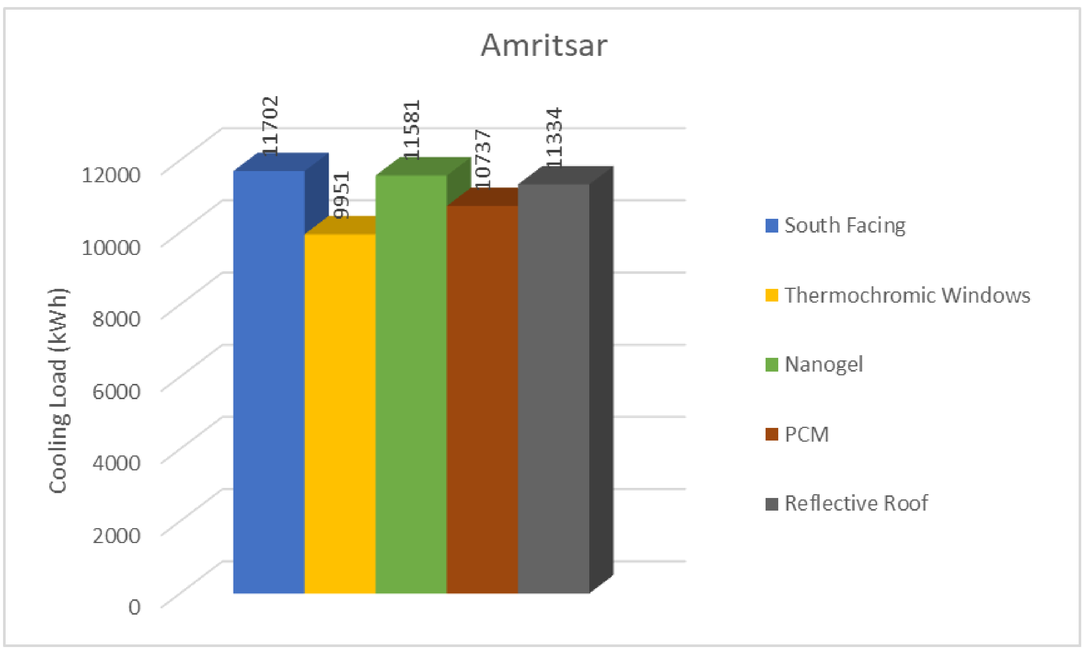
MODELLING DETAILS

- ASHRAE stated standard test case 600 is taken as a reference and then modified to provide a reduction in cooling load. The test case 600 room is rectangular, measuring 8m x 6m with a height of 2.7m with two double pane windows, each measuring 3m x 2m, on the south-facing wall.
- These modifications include the arrangement of windows, use of PCM or nanogel as building material also the use of thermochromic windows and reflective roofs.
- These modifications were made one by one, and a few combinations of geometrical modifications and building materials were also observed.
- Simulations were conducted on EnergyPlus using weather files of Chandigarh and Amritsar to analyze the reduction in cooling loads for standard test case 600 and its modified files.
- The modifications can be listed as follows:
  a. East & West Facing Windows
  b. East & South Facing Windows
  c. Thermochromic Windows
  d. Thermochromic Windows - East West Facing
  e. Nanogel
  f. PCM - East West Facing
  g. PCM
  h. Reflective Roof

RESULTS

- Annual cooling loads for Chandigarh and Amritsar were obtained through simulations after implementing the modifications





CONCLUSION

- Various techniques were used to investigate the impact of reducing the cooling load in Punjab.
- Geometric modifications by placing windows with east-west and east-south spacing resulted in a reduction ranging from 7% to 16%.
- Combining this geometric approach with changes in building materials resulted in a reduction of less than 1% and 8-20% using nanogel and phase change materials, respectively.
- Reflective roofs also showed a reduction of about 3% in cooling load.
- Thermochromic windows showed the most promising results with a reduction of 14-34% in cooling load.

FUTURE WORK

- The project aimed to select an efficient cooling technique for Punjab and can be extended to explore other bio-inspired technologies and geometric designs to find an affordable and appropriate technique.
- The project can be further extended to test techniques in different locations and suggest suitable ones.
- Several other parameters can be optimized and based on simulation results, there can be a significant development in energy efficient buildings.