Methodology for the design of climate responsive houses for improved thermal comfort in cold semi-arid climates

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ABSTRACT

A building must be energy-efficient and provide a comfortable indoor environment to the residents. Indoor thermal comfort can be improved using climate based passive design strategies. This study aims to improve indoor thermal comfort of residential buildings in cold semi-arid climates by providing informed decision support to architects at the early-stage design.

KEYWORDS

Thermal comfort, Decision support, Energy simulation, Passive design strategies, Sensitivity analysis, Materialization

PROBLEM

Pakistan is facing a severe energy crisis, and the housing sector is the largest consumer, using 45% of the total electricity [1]. There are diverse climatic zones in the country, ranging from very cold north to very hot in the south. The city of Quetta has a cold semi-arid climate with substantial temperature differences between summer and winter. The urban population of Quetta is more than 1 million, which increased to more than double in the last 20 years [2]. The houses are poorly designed, and the residents suffer due to uncomfortable indoor environment.

OBJECTIVES

- Characterization of the existing housing stock (inventory)
- Thermal comfort assessment of the common typology
- Benchmarking for parametric and comfort improvement
- Identification of influential passive design strategies and materials which can be used in such climate
- Development of a prescriptive guide to provide informed decision making, its testing and validation

AUDIENCE

Architects, designers, building/ construction engineers, contractors, researchers and resident builders

RESEARCH QUESTION(S)

- How to design climate responsive and thermally comfortable buildings in a structured way in the cold and semi-arid climates?

ORIGINALITY

- There is a wide knowledge gap on housing and thermal comfort in Pakistan
- The study provides informed design making to architects for the improvement of thermal comfort using passive deisgn
- Quetta has extreme weather conditions which requires context and climate-based design
- The study is based on monitoring, simulation and usability testing of the developed prescriptive guide.

METHODOLOGY

The methodology of this research is based on the following steps.

1. Housing characterization and benchmarking
2. Comfort and parametric analysis
3. Sensitivity analysis
4. Materialization
5. Decision support prescriptive guide

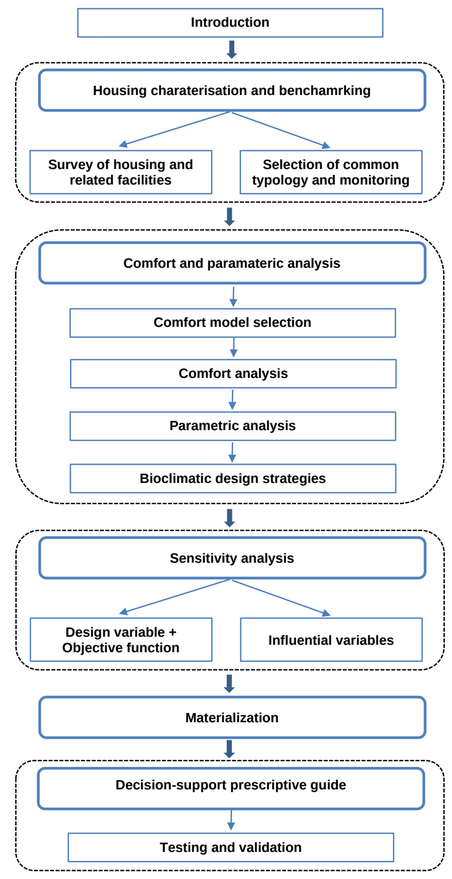

Fig. 1. Study conceptual framework

RESULTS

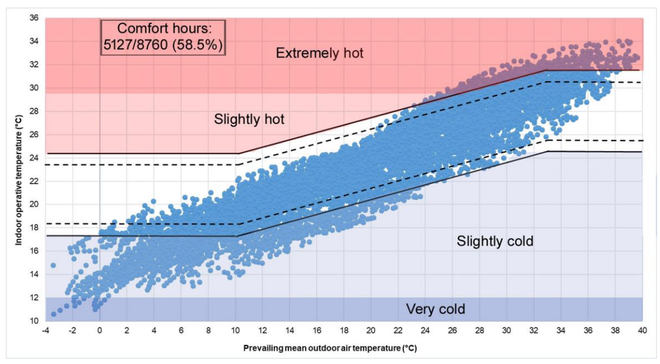

Fig. 2. Comfort improvement based on parametric analysis

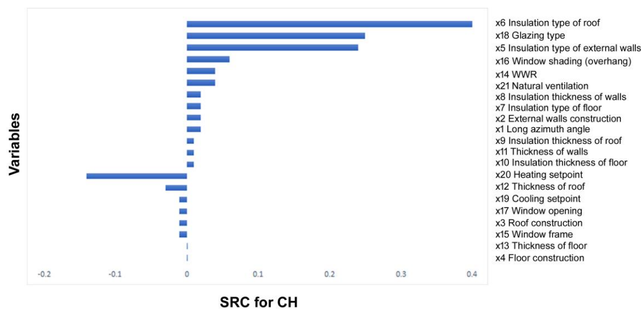

Fig. 4. Influential design variables based on a sensitivity analysis

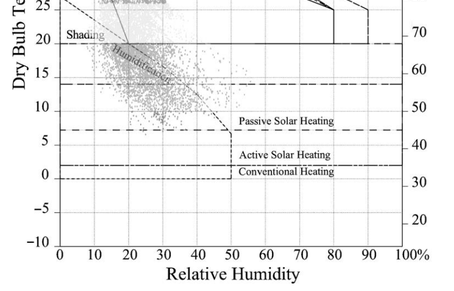

Fig. 3. Important passive design strategies

CONCLUSION

- Indoor thermal comfort can be improved up to 59% without using active systems [3].
- Thermal insulation, glazing, shading, natural ventilation, and orientation are influential variables for comfort improvement [4].
- The developed prescriptive guide provides better informed decision making for the design comfortable residential buildings in the cold and semi-arid climate of Quetta compared to the existing Building Code of Pakistan.

RESOURCES

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