PASSIVE GROUND COOLING
AN APPROACH FOR ENHANCING THERMAL PERFORMANCE OF RURAL DESERT HOUSES IN EGYPT

By

Lubna ElSayed Amer

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
In
Architectural Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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GIZA, EGYPT
2019

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Lubna ElSayed Amer Date:

Signature:

Dedication

May Allah accept this work and bless it
To my father, my mother, my husband and my lovely children

Acknowledgments

"The journey is the reward."

Chinese Proverb

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Abstract

This thesis presents a proposal for designing rural desert dwellings that accommodate the hot dry climate in Egypt and reduce the demand for air-conditioning in Egypt's houses that affects the country escalating energy consumption where most consuming sector is the residential. So energy efficient rural houses are targeted.

The proposal using passive ground cooling techniques - where the ground used as a heat sink to produce cooler air [***Earth sheltered buildings*** + ***Earth to air heat exchangers (EAHE)***] - and local building materials can be a higher chance to reach Egypt's Energy Strategy's Goal to achieve energy savings up to 18% of the total consumption in **2035**.

The National Project for Desert Hinterlands (NPDH) is targeting rehabilitation of the poor in alternative villages in the near desert to stop urban sprawl over agricultural land and decrease congestion in the old habitats. The thesis proposal starts off the project's vision then Generates eight design prototypes of sunken courtyard rural houses incorporating an (EAHE) System. Furthermore, whole building simulation experiment is executed using **Design Builder V.5** Program to test and evaluate these prototypes in terms of Energy Efficiency and Thermal Comfort. First: Annual patterns of soil temperature variations were calculated as a function of the depth and time due to their significant effect on underground heat transfer, Second: The eight proposed house prototypes (R1, R2…R8) were tested each for four proposed arrangements [Above or Underground / with or without EAHE system] and four different climate regions in Egypt (Aswan, Ismailia, Dabaa, and kharga) and four orientations.

Calculated underground temperatures showed a sinusoidal behavior and the cyclical temperature wave that becomes more flat with the increases in depth, indicating the potential of energy conservation due to underground stable temperatures and time lags. Simulation results substantiate the thesis proposal and assured the potential of Earth cooling in providing residential low energy cooling in Egypt while providing thermal comfort, and that an underground constructed house with a sunken courtyard built using stabilized earth blocks as building material and incorporating an Earth to Air Heat Exchanger System (EAHE) can reduce between 43 to 81% of energy consumption used to achieve thermal comfort compared to contemporary desert housing projects' prototypes.

CHAPTER 1: INTRODUCTION