# SOLAR THERMAL MODELLING OF BUILDINGS AND SPACE CONDITIONING SYSTEMS

*by*

**SUBHASH CHANDRA**

Thesis Submitted to the
Indian Institute of Technology, Delhi
for the award of the degree of
DOCTOR OF PHILOSOPHY

CENTRE OF ENERGY STUDIES
*Indian Institute of Technology, Delhi*

March 1982

TO MY

Late Grand Mother

# ACKNOWLEDGEMENTS

I feel honoured to express my deep sense of gratitude to Professor M.S. Sodha, Deputy Director, I.I.T. Delhi for his overall guidance, endearing gaurdianship, enlightening inspiration and stimulating discussions at all levels of this research work. I owe my indebtedness to Drs. S.C. Kaushik and N.D. Kaushik for their invaluable guidance, dynamic supervision and unflagging encouragement during the tenure of this exposition as a consequence of which my reveries reached fruition.

I wish to express my sincere thanks to Professor S.S. Mathur, Head, CES who encouraged me by providing all the facilities to carry out the research work reported in the present thesis. Grateful thanks are also due to Professors H.P. Garg, B.C. Raychoudhari and S.P. Sabberwal, and Dr. R.P. Sharma for their keen interest and cooperation.

Varily and virtually, I have no befitting words to give vent to my feelings towards my colleagues Dr. Pradeep Bansal, Mr. S.K. Rao and Mr. C.P.S. Tomar for their timely encouragement, benign attitude and unlimited cooperation.

The completion of this work has left me indebted to a galaxy of kith and kin whose good wishes served as becons amidst vicissitude. I acknowledge the help received from Drs. Ashvini Kumar, T.C. Kandpal, Ashok Sharma, Ms. Usha, Dhiman, Yojana; Messers M.S. Reddy, Sanjay Prakash, Shiv Singh, Santram, Pradeep, P.S. Nagar, Avinash Singhal, S.N. Sukla and Bapeshwara Rao.

I must also appreciate and thank Mr. Kirpal Singh for the fast tracing of figures, Mr. D.R. Joshi for elegant typing and other non-teaching staff of CES for their timely help.

Last but not the least, I wish to express my deep sentiments to my friends Messers Jaiveer, Narendra and Mukesh who occasionally lent their concern with the progress of this work.

(SUBHASH CHANDRA)

## SUMMARY

This thesis presents some investigations on solar thermal modelling of buildings and space conditioning systems. Some passive concepts for solar energy utilization in buildings have been proposed and analysed from the point of view of reducing their thermal load to minimum. A self consistent periodic heat transfer model has been developed for predicting the thermal performance of a non-airconditioned building incorporating the effects of presence of window, furnishings, heat conduction to the basement ground and heat transfer due to air ventilation or infiltration. The control of various water evaporative roof cooling and ventilation control systems on the indoor air temperature of a non-airconditioned building exposed to harsh summer climate has been investigated. It is seen that the maximum cooling is achieved by water spray over the roof and that the effectiveness of the evaporative cooling can be improved by judicious choice of the rate and duration of ventilation for the temperature control in a building. A theoretical model for a phase changing component material (PCCM) thermal storage Trombe wall in an airconditioned building has been developed using the concept of effective thermal properties of the PCCM. The study shows that PCCM thermal storage wall with low melting temperature

and high latent heat of fusion is desirable from both points of view of efficient thermal storage and excellent thermal comfort in an airconditioned building. However, for feasible range of melting temperature of PCCM, it is more incentive to develop a PCCM wall with high storage mass rather than high latent heat of fusion. The optimum distribution of insulation thickness inside and outside an insulated thermal storage water wall for thermal load levelling has also been determined.

Thermal modelling of an aqua-ammonia absorption cycle, based on steady state thermodynamic analysis has been carried out. Three modes of operation of the cycle are considered viz. (i) refrigeration mode; (ii) cooling mode; and (iii) heating mode. A comparative study of the system performance at low/high heat supply and sink temperature shows that unlike the case of low generator temperature behaviour, the coefficient of performance for each mode is reduced at higher generator temperatures. However, the results are more pronounced for refrigeration mode than the heat pump mode and least effective for airconditioning mode.

A simple periodic heat transfer analysis for the temperature distribution in sunlit moist ground has also been developed to evaluate the moisture evaporation.

# TABLE OF CONTENTS

CHAPTER - 3



CHAPTER - 4