DEVELOPMENT OF OTTV BASED APPROACH FOR THREE TROPICAL CLIMATES AS AN ALTERNATIVE TO THE PRESCRIPTIVE APPROACH IN BUILDING ENERGY CODES

by

SEEMA DEVGAN

(2004CEZ8158)

Department of Civil Engineering

Submitted

in fulfillment of the requirements of the degree of

DOCTOR OF PHILOSOPHY

to the

INDIAN INSTITUTE OF TECHNOLOGY DELHI

AUGUST 2009

CERTIFICATE

This is to certify that the thesis entitled "**Development of OTTV based approach for three tropical climates as an alternative to the prescriptive approach in building energy codes**", being submitted by **Ms. Seema Devgan** to the Indian Institute of Technology Delhi, India, for the award of the degree of "**DOCTOR OF PHILOSOPHY** in Civil Engineering", is a record of original bonafide research work carried out by her under our guidance and supervision. To the best of our knowledge, the thesis has reached the requisite standard. The material contained in this thesis has not been submitted, in part or full to any other University or Institute for the award of any degree or diploma.

(Prof. A. K. Jain)

Professor
Deptt. of Civil Engineering
Indian Institute of Technology Delhi
Hauz Khas, New Delhi-110016 India

(Prof. B. Bhattacharjee)

Professor
Deptt. of Civil Engineering
Indian Institute of Technology Delhi
Hauz Khas, New Delhi-110016 India

ACKNOWLEDGEMENT

It gives me great pleasure in expressing my regards and profound sense of gratitude to **Prof. B. Bhattacharjee and Prof. A. K. Jain,** Department of Civil Engineering, Indian Institute of Technology Delhi, India for their invaluable guidance and constant encouragement throughout the period of doctoral programme.

I also extend a special word of thanks to my teachers Prof. Shashi Mathur and Dr. Alok Madan of Civil Engineering Department, Indian Institute of Technology Delhi and Prof. S. C. Kaushik of Centre of Energy Studies, Indian Institute of Technology Delhi for their valuable comments and suggestions at important milestones in this work.

I would like to thank the management of Unitech Ltd., especially Dr. P. K. Magu, Head, Architecture, Unitech Ltd. for giving me details of the buildings which were very crucial as case studies in this study. I would also like to thank Lt. Col. Ashutosh K. Beri, Managing Director, Property & Asset Management, West Asia, Jones Lang Lasalle Meghraj, for his support during the entire period of this study. As a very special mention I would like thank Mr. Marlin Addison of U.S. Department of Energy, for stimulating discussions and path breaking inputs to the simulation methods used in this study.

I am also thankful to my research scholar colleagues B. Kondraivendhan and Sairam for their cooperation during the study at IIT Delhi and Kamal Kant Jain for helping in the writing of the Visual Basic Program needed in this study.

Last but not the least; I am greatly indebted to my family members many of whom have played important key roles in bringing this thesis in its final form. My children, Harsh and Esha, have coped with my work very well and always motivated me for completing this work. My husband Ashutosh has given me all the freedom to plan my activities for this thesis work right from the very outset. His support has given me stress free work time. My father Dr. K.K. Gupta has been a huge pillar of strength and I am greatly indebted to him for stimulating discussions. My father-in-law, Prof. O. P. Sharma has also given me a lot of motivation and guided me to bring this thesis in its final form. My mother-in-law, Mrs. Savitri Sharma has been a support at home while I have been busy with the thesis work. I lost my mother July 2008 after her brief illness. However, she has been with me throughout in my thoughts and she has been my greatest inspiration in all times. Many others, family and otherwise, whom I have not named, have helped me directly and indirectly, I express my heartfelt gratitude.

Seema Devgan

August 2009 **Seema Devgan**

ABSTRACT

This thesis attempts to formulate OTTV coefficients for *Composite, Hot- Dry and Warm- Humid climates*, the three main tropical climates in India. Case studies of four existing air-conditioned office buildings- two mid-rise and two high- rise were modeled using eQuest v.3.6, which is a DOE2.2, based simulation engine. Based on the building envelope, loads, operation and HVAC system characteristics of these representative buildings, a hypothetical high rise office building of octagonal plan and 16 storey was created for parametric studies. 98 types of opaque exterior wall constructions and 93 types of glass constructions were varied sequentially in parametric runs to obtain results for hourly wall conduction, glass conduction and glass radiation heat flow in eight orientations for each of the climate type. The selection of the time period of the year for summing the hourly 'gains' was crucial and dependent on the characteristic of the climate type. Regression analysis was used to obtain coefficients TD_{eq}, DT and SF for the three climates. A new OTTV equation is obtained as both the wall conduction heat flow intensity and glass conduction heat flow intensity are found to have non- linear second order polynomial correlation with wall solar transmittance (U_w*α) and glass transmittance (U_f) respectively.

The set of coefficients obtained were validated by calculating the OTTV for the four case study buildings, again by varying exterior wall and glass constructions in parametric runs. The computed OTTV for the four case study buildings had linear correlation with the annual space cooling plus heating energy use in all three climates. Thus the obtained coefficients can be used for calculating the OTTV value for similar operation air-conditioned office buildings situated in places with similar tropical climates.

TABLE OF CONTENTS