# HEAT GAINS TO BUILDING INTERIORS THROUGH ROOFS: A STUDY BASED ON SELECTED CONFIGURATIONS IN SRI LANKA

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The above candidate has carried out research for the Masters under my supervision.

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Professor R.A.Attalage Date

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Professor K.K.C.K. Perera Date

## DEDICATION

To

My project supervisors and

The Department of Mechanical Engineering, University of Moratuwa.

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## ABSTRACT

Roofs of residential buildings play a crucial role in the context of building heat gains and thermal comfort, since they are exposed to a significant portion of insolation during the day. Therefore, it is important to develop a generalized model to evaluate thermal performance of roof structures under local conditions. This modeling becomes complex due to the dynamic nature of the parameters and various configurations, orientations of the roof surfaces in 3-D space. To address this issue a numerical approach was used to determine view factors of roof surfaces of a generic configuration. Consequently, a thermal model was developed to represent roof structures with four roof surfaces and a ceiling. Model is capable of incorporating insolation on roof surfaces, environmental conditions, roof configuration and materials and obtaining thermal responses of roof surfaces. A computational tool was finally developed based on the model. In order to validate the computational tool, an experimental setup was build and readings were recorded for several days. Same system was simulated using the computational tool and the results were compared. Furthermore, a commercial software and the developed computational tool were used to simulate a selected case and the results were compared with each other.



Keywords: Roof heat gain, View factor, Attic temperature, Solar irradiance, Thermal response

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## List of Symbols

| | |
|---|---|
| A | Surface area |
| a | Thermal diffusivity |
| $E_b$ | Black body emissive power |
| $E_q$ | Equation of time |
| $F_{ii}$ | View factor between $i^{th}$ and $i^{th}$ surfaces while energy leaves $i^{th}$ surface |
| $F_{ij}$ | View factor between $i^{th}$ and $j^{th}$ surfaces while energy leaves $i^{th}$ surface |
| $F_{ji}$ | View factor between $i^{th}$ and $j^{th}$ surfaces while energy leaves $j^{th}$ surface |
| G | Irradiance |
| h | Convection coefficient |
| I | Radiation intensity |
| $I_{\lambda,e+r}$ | Spectral intensity of emitted and reflected radiation |
| J | Radiosity |
| $L_{loc}$ | Longitude of the location |
| $L_{st}$ | Local meridian for the standard time zone |
| n | Day number over the year |
| q | Heat exchange |
| $q_{i\rightarrow j}$ | Radiation leaving $i^{th}$ surface intercepted by $j^{th}$ surface |
| T | Absolute temperature |
| $t_{so}$ | Solar time |
| $t_{st}$ | Standard time |
| $\alpha$ | Total hemispherical absorptivity |
| $\beta$ | Slope angle |
| $\gamma$ | Surface azimuth angle |
| $\delta$ | Declination angle |
| □ | Emissivity |
| $\theta$ | Incident angle |
| $\theta_z$ | Zenith angle |
| $\rho$ | Total hemispherical reflectivity |
| $\sigma$ | Stefan- Boltzmann constant |
| $\tau$ | Total hemispherical transmitivity |
| $\varphi$ | Latitude angle |
| $\omega$ | Hour angle |
| $\Omega$ | Solid angle |

**Subscripts**

| | |
|---|---|
| abs | Absorbed by a surface |
| be | Beam |
| bh | beam horizontal |
| bi | $i^{th}$ surface of a black body |
| bn | beam normal |
| d | Diffuse |
| e | Emitted radiation |
| e+r | Emitted and reflected radiation |
| en | Environmental |
| i | $i^{th}$ surface |
| in | Inside |
| ir | Radiation of inner surface |
| j | $j^{th}$ surface |
| on | Extraterrestrial normal |
| or | Radiation of outer surface |
| r | Reflected radiation |
| ref | Reflected by a surface |
| s | Solar |
| T | Indication of a tilted surface |
| th | total horizontal |
| tr | Transmitted by a surface |
| λ | Spectral(Wavelength depended ) |

# LIST OF APPENDICES