APPRAISING A RELATIONSHIP BETWEEN MORPHOLOGY AND ENERGY INDEX OF OFFICE BUILDINGS IN TROPICS: A CASE OF URBAN BUILDING STOCK IN COLOMBO MUNICIPAL COUNCIL

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Thesis/Dissertation submitted in partial fulfillment of the requirements for the degree Master of Philosophy in Architecture

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Declaration page of the candidate & supervisor

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ABSTRACT

In the last few years, together with the surge in new construction, the energy demand from buildings has also been influenced by current practice on energy demanding mechanically controlled buildings with artificially lit interiors. Present urban development strategy of implementing Mega polis development plan for city of Colombo expands its boundaries of the urban building stock. Thus, it's vital to explore the end use energy demand of national building stock and comprehend a relationship between building morphology and energy consumption. A walkthrough field investigation was performed in 46 Wards in Colombo Municipal Council region. The structure of the survey was organized in relation to geographical information system (GIS) data and land use maps of the CMC region. Data was collated to formulate a comprehensive database on morphology of office building stock comprising major physical parameters and energy indices. Results revealed the office building stock is primarily composed of Air-conditioned office spaces and of which 78% contains naturally ventilated common spaces. In this stock 53% and 13% of the office buildings have an annual average building energy index above 200KWhm^{-2} and 300KWhm^{-2} respectively. Linear shape dominates the plan form representing 70.2% of the stock. Other basic shapes such as square, circular and composites corresponds to 19.5%, 2.3% and 8% respectively.

. 54.55% of the office buildings have an average BEI of 150-250 kWhm-^{2}. Out of which 37.03% of the office buildings are EW oriented. Nexus between building façade configuration and building energy index were further analyzed using multiple and simple linear regression analysis. The analysis was conducted for buildings in the identified energy index categories by considering all four orientations. EW and NS oriented buildings were considered for further investigation to evaluate the effect of aspect ratio on energy index. It is evident that aspect ratio of 0.70 (1:1.43) in 100-150 kWh-^{2} energy index range was within the optimal range. The optimal aspect ratio for buildings along east west axis is within the range of 1.27:1 to 1.5:1. Further increase of aspect ratio beyond this range result in increase of energy consumption in buildings. The average aspect ratio for NS oriented buildings in 100-150 kWh-^{2} energy index range was 1.49 (1.49:1), which was within the optimal range. Nonetheless, the average aspect ratio for NS oriented buildings in Average Range is 3.22 (3.22:1), which is beyond the optimal range.

Further onsite thermal investigations in the selected representative buildings with deep and shallow plan forms revealed a clear indoor temperature difference during air conditioned and non-air-conditioned period. It is evident that deep plan form has a greater potential to control external heat gain and reduce end use energy demand. In contrary, shallow plan forms are more susceptible for external heat gain and higher temperature variation is evident periphery and core. Moreover, overheating building periphery in both shallow and deep plan forms are susceptible for overheating condition. Thus the findings of this study represent the criticality of building morphology based on plan shape, orientation and interior planning which demonstrate a significant impact on end use energy demand due to external heat loads.

Key words: Morphology, building stock, urban offices, Building energy intensity

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List of Abbreviations

Abbreviation	Description
ASHARE	American Society of Heating, Refrigerating & Air conditioning Engineering
BEI	Building Energy Index
BEND	Building ENergy Demand
BREEAM	Building Research Establishment Environmental Assessment Method
CBECS	Commercial Energy Consumption Survey
CBSL	Central Bank of Sri Lanka
CMC	Colombo Municipal Council
CO2	Carbon Dioxide
DS	Divisional Secretary's Division
ECCABS	Energy Carbon and Cost Assessment for Building Stocks
EEBC	Energy Efficient Building Code
EPBD	European Directives on the Energy Performance of Buildings
EUI	Energy Use Index
EW	East West
GEA	Global Energy Assessment
GDP	Gross Domestic Product
GHG	Green House Gas
GIS	Geographic Information System
GGBP	Greener Greater Building Plan
GN Division	Grama Niladari Division
HVAC	Heating, ventilation, and air conditioning
IEA	International Energy Agency
IPEEC	International Partnership for Energy Efficiency Cooperation
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design
NE-SW	North East-South West
NS	North South
NW-SE	North West-South East
SLSEA	Sri Lanka Sustainable Energy Authority

UN DESA	United Nations Department of Economic and Social Affairs
WWR	Window to Wall Ratio

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