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Energy Efficient Building Morphology for Indian Climatic Zones

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Abstract – Abstract— Certain energy related building standards make use of simple numeric indicators to describe a building's geometric compactness. Typically, such indicators make use of its surface area. the indicators are than used along with information on. the thermal transmittance of the building enclosure element to relevant thermal insulation criteria .Using extensive parametric thermal simulations ,this paper examines the reliability of such simple compactness indicators for energy-related evaluative assessments given that building with the same compactness attribute could differ in enclosure transparency ,orientation, morphology and shading in Indian five climatic zones i.e . Hot and Dry, Warm and Humid ; Temperate; Cold Composite.

Keywords: More Than Four Key Words Must Be Given.

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I. INTRODUCTION

Since the last half century energy crisis has become a major issue. Buildings, industries, transportation are major factors in energy consumption. Buildings are already responsible for almost 48 % of the total energy consumption and this figure is expected to grow. Energy is mostly needed for heating (26.1%), lighting (14.7%) and cooling (9.3%).Building heating and cooling loads are affected by internal as well as external sources. Internal sources like electrical lighting, building equipment, people etc. And external sources like solar radiation, air temperature, wind etc. Global warming and climate change are also among the major external sources affecting energy demand nowadays.

Prescriptive building energy codes often set minimum requirements concerning thermal properties of building components. To account for the geometry of building in a simple manner, some energy related building standards make use of simple numeric indicators that focus on building's geometric compactness in five Indian climatic zones. Typically, such indicators are derived based on the relationship between the volume of a built and the surface area of its enclosure. The indicators are then used along with information on the thermal transmittance of the building enclosure elements to evaluate the degree to which a building design meets the relevant minimum thermal requirements. However, the usage of geometric compactness for such evaluative purpose could be criticized on multiple grounds. First, compactness does not capture the specific morphology (or the unique three-dimensional formal articulation and massing) of a building's shape, even though it could influence the thermal performance in five climatic zones. (e.g. via self-shading). Second, compactness does not capture the amount and distribution of the transparent components of the enclosure. Thus, corresponding radiative gains and losses are not accounted for. Third, changing the orientation of a building (e.g., south orientation versus west orientation) does not change its compactness, but may affect thermal performance given changes in insolation and shading conditions in five Indian climatic zones

II. METHODOLOGY

A. Overview

The research design for the present study involves the following steps: I) A sample of different building shapes is Selected, providing morphological variance ins Indian climatic zones; II) Different glazing scenarios are generated through variance in glazing area, orientation and shading; iii) The resulting set is thermally analyzed via Autodesk Ecotect; iv) The simulation results (energy load, overheating index) are discussed in the context of the sample's variance in morphology and transparence in five Indian climatic zones.

B. Shape

A modular geometry system was derived based on an elementary cube (3X3XBm). To generate different building shapes, 27 such elements were used (see Figure 1). These elements were aggregated in different ways to create 70 morphological variations. Figure 2 illustrates this set according to their compactness. Cooling energy demand may rise to 25% when radiation hits the building. The ratio of volume and outer surface of building facade should be small as possible.

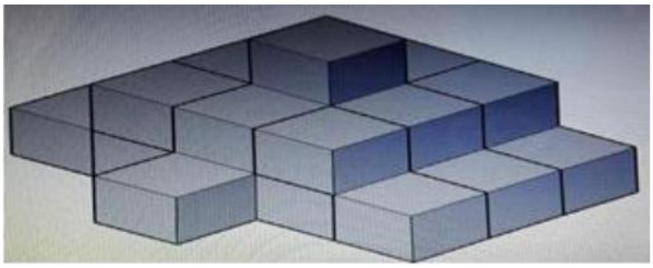
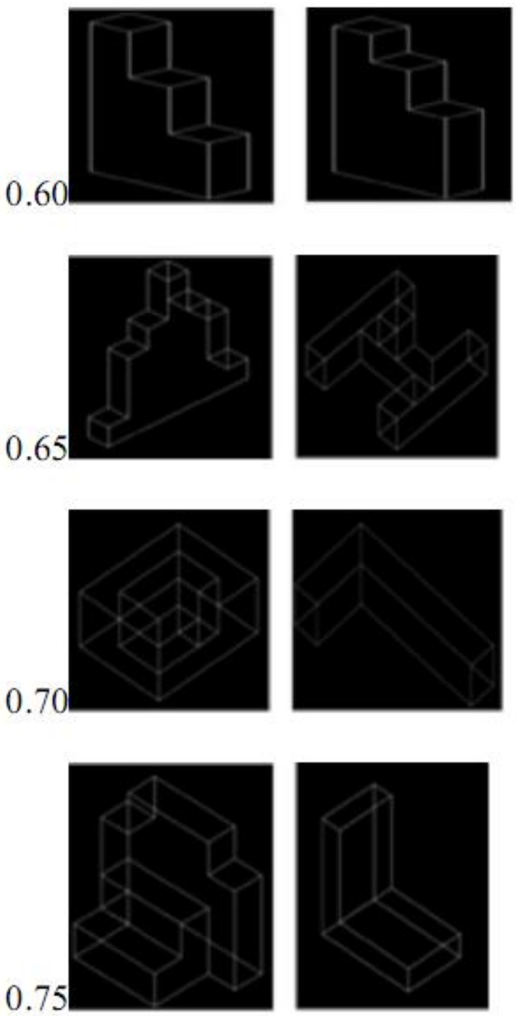


Figure 1 – Generation of shape on 27 cubical elements



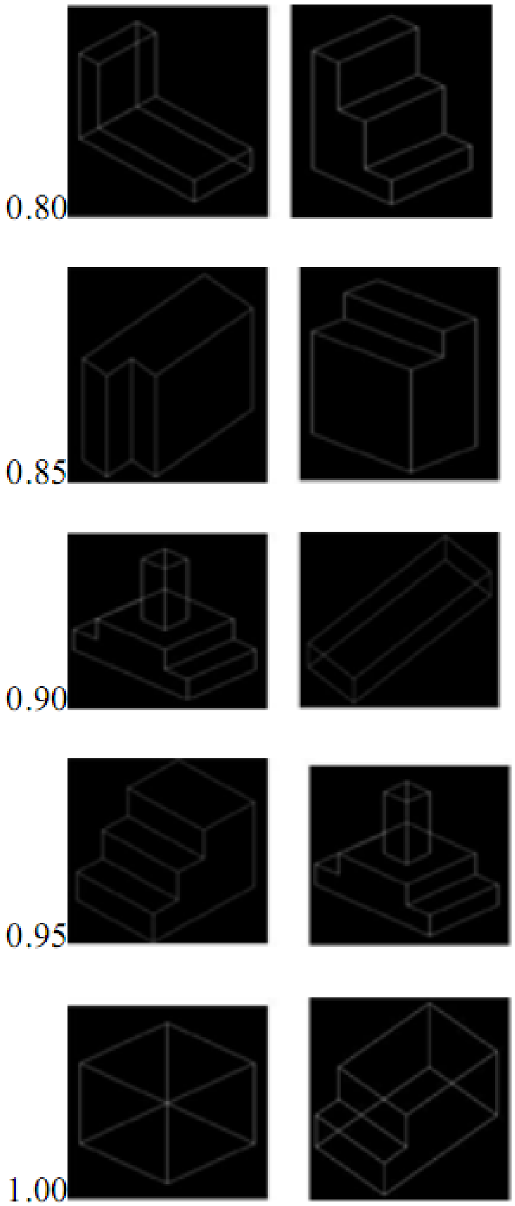
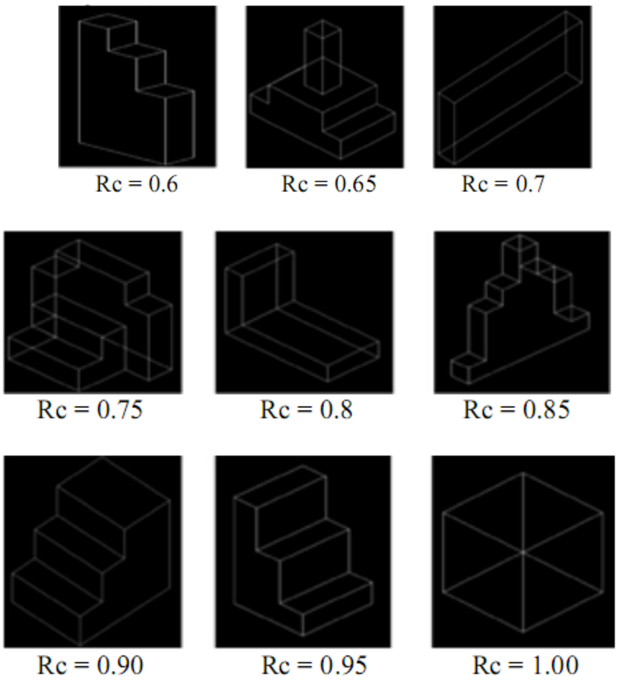


Figure 2 – All generated shapes

C. Relative Compactness

To specify compactness, we used the "Relative Compactness"(RC) indicator (Mahdavi u. Gurtekin 2002a). The RC of a shape is derived in that its volume to surface nation is compared to that of the most compact shape with the same volume.

From the sample shown in Figure 2 a subset of 12 shapes with distinct RC values was selected for the simulations (figure 3.).



D. Orientation

Orientation is the most important parameter involving in energy efficient building design. The level of direct solar radiation design depends on the azimuth in wall and orientation angle of the building. It also influences other parameters such as shading and solar envelope performance. The building with longer side exposed to southern side is generally considered optimal for all climates. Every model is simulated with all four directions of five climatic zones.

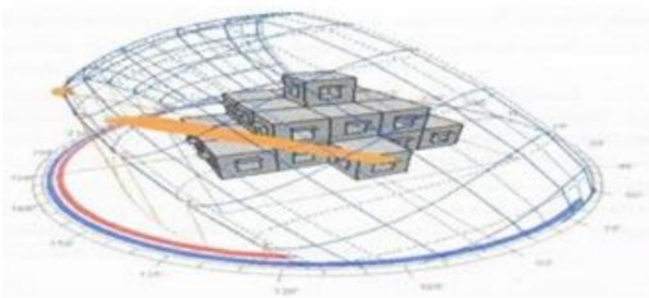


Figure 4 – Sun Diagram

E. Window to wall ratio

Almost 10-20% of all the heat loss occurs through the window. In window design it is necessary to consider performance in terms of heat transfer, thermal comfort, light transmission and appearance. There should be a design solution which provides effective thermal comfort and day lighting. To achieve variation in enclosure transparence, the amount of glazing and its distribution across the enclosure walls was changed. Concerning glazing area, three levels were considered, namely 20%, 30%, and 40% all sides glazing, expressed as fraction of the gross floor area of each model.

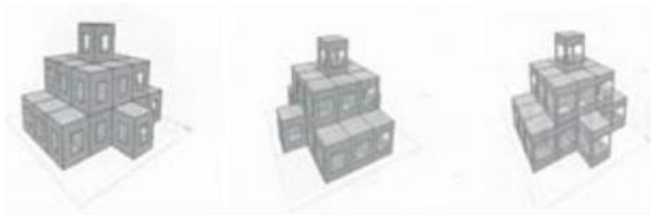


Figure 5 - illustration of the variation of the glazing percentage

F. Shading

Shading on building facade elements control the amount of solar radiation received by building. it provides positive results when action are performed on the building facade In hot climate there are greater energy benefits with a high shading coefficient. Control of shading is necessary in order to assure thermal and visual comfort inside the building. Every model is simulated with chajja and without chajja of five climatic zones.

Windows without chajja

Windows with chajja

Figure 6 – Shading illustration

G. Assumptions

A number of parameters were kept constant in five Indian climate zones i.e . Hot and Dry, Warm and Humid; Temperate; Cold Composite throughout the Autodesk Ecotect. A sample of different building shapes is selected, with morphological variance. All buildings are oriented 90 degrees and 180 degrees with the north.

H. Autodesk Ecotect analysis

Autodesk's Ecotect energy simulation package will be used for the thermal analysis. It is popular program used by architects. It is easy to manipulate properties of models. Its procedure starts with creating a three dimensional shell. It can be done either by (1) drawing plans and then forming a 3D model or (2) import model as gbXML file from a different SD modeling program such as Rivet or AutoCAD.

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