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ASSESSING THE IMPACT OF SITE BOUNDARY CONDITIONS ON THE THERMAL PERFORMANCE, SOLAR ACCESS AND VENTILATION OF A BUILDING

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Abstract: *A sustainable building is designed to reduce its energy footprint and carbon emission. The thermal performance, solar access and ventilation of a building not only depend upon the ecological microclimate of the building but also on the behaviour of immediate site surrounding conditions. There are different parameters of sustainable performance which are affected by the boundary condition differently. This study tries to establish the need to study the immediate site surrounding in detail before starting the designing process and not just rely on climatic/microclimatic data of the site. Since the site surrounding conditions cannot be controlled, the building should be designed keeping in mind possible variations around the site and their ultimate effect on building performance. In this study, the performance parameters of the building will be evaluated concerning the boundary condition with the help of a literature study and CFD simulation of the case study. This study also reviews the existing methods and techniques to predict thermal behaviour, solar access and wind movement on a site neighbourhood-scale which will be helpful for calculating the performance parameters of the building.*

Index Terms **- Universal Design, Interior Design, Design for all, Inclusive design**

I. INTRODUCTION

Architects and urban planners have concentrated on the relationship between building performance and neighbourhood form since the 19th century (Linlin Guo, 2018). The interaction of buildings with their surroundings is a multidisciplinary problem. Earlier, researchers were interested in the effect of urbanization on climate change and vice versa, urban planners studied the impact of urban morphology on thermal comfort in buildings and urban environments and the architects considered energy and comfort mostly on the building site scale (Csilla V. Gál; 2012). However, it is now realised that focusing exclusively on individual structures or the urban scale is insufficient and it is necessary to examine the area between these two criteria. The site boundary condition characterizes all the factors around the site that will affect the performance of a building. It is an area smaller than the microclimate, focused around the building and beyond the building site (Csilla V. Gál; 2012). Various research and simulation exercises have proved that the wind movement, solar access and thermal behaviour of buildings are altered when the immediate site boundary condition changes. Surrounding building geometry, their Orientation and neighbourhood patterns affects the amount of solar radiation on the building envelope and also the wind flow pattern around buildings (Dimitra Tsirigoti and Katerina Tsikaloudaki, 2018). The indoor and outdoor environments of a building are influenced by the position and orientation of nearby buildings, as well as their form. Also, the building placement and land-use patterns have a significant impact on the external air and temperature of the microclimate generated by the boundary conditions. From the literature review, it is evident that there is a lack of scientific research on the quantification of the impact of local boundary conditions on building performance. The purpose of the present work is to investigate the variability in the performance due to different site boundaries situations. The study aims to establish the local condition differences and their effect on building behaviour based on a literature review and simulation study of the selected case study.

II. AIM

To identify and analyse the effect of site boundary conditions on the thermal performance, solar access and ventilation of a building and to validate the same using CFD simulation.

III. OBJECTIVE

1. To identify all the site boundary condition factors that will affect the thermal performance, solar access and ventilation of the building.
2. To evaluate the effects of boundary condition factors on the performance of buildings based on the identified parameters and validate them through CFD simulation.
3. To review existing methods and techniques to predict the impact on performance parameters because of site boundary conditions.

IV. LITERATURE REVIEW

This study systematically reviews no. of research done on the effect of building block form on thermal performance, wind movement and solar access of a building independently. The interrelationship between surrounding structure and microclimates has been the subject of many papers. Most publications focused on the relationship between building microclimate and performance parameters and reviewed the impact of the site surrounding on thermal performance, solar access and wind movement. According to one study, it is difficult to evaluate the impact of the neighbourhood on a building's thermal behaviour since it is challenging to quantify all of the important indicators at the same time. As per the studies, the majority of the work is focused on air ventilation because it is the most essential parameter that controls the building's performance. According to one study, the site coverage, density of the structure, and arrangement of building masses are the main parameters governing the urban microclimate at uniform building height. The effect of architectural form is more significant than the effect of orientation, according to this study, especially in configurations with high site coverage and evenly dispersed buildings. According to one study, the presence of a built form has a significant impact on the building's microclimate, both within the built-up region and in the environment above and beyond its bounds. It is concluded that a single architectural element can influence the climate on a micro-scale, and the form of the surroundings can radically change the effect. Finally, the research shows that urban shape, building density, height, size, direction, and layout all have a major impact on the local wind pattern and cause wind speed fluctuation near structures.

V. SITE BOUNDARY CONDITION

The region around the building site's periphery, which may contain other structures, roads, vegetation, and so on, is known as the site boundary. In this paper, boundary conditions include all the factors around the vicinity of the site which will affect the performance of the building. Based on literature studies and site analysis, the following list of boundary condition factors is identified which could be analysed for all building types. The performance will change based on variation in one or a combination of factors. Special conditions may be available around the which may have a major effect on the performance is not listed here as that would be not be applied to all sites in general.

1. Site Surrounding Structures	1. Form of Surrounding Buildings
	2. Distance Between the Buildings
	3. Building Orientation
	4. Building Height
	5. Building Façade Material
	6. Density of Buildings Around the Site
	7. Zoning
2. Circulation around the Site	1. Width of Roads
	2. Circulation Area Around the Building Site
3. Site Surrounding Landscape	1. Vegetation Around the Site
	2. Natural / Artificial Water Body Around the Site

Table: Site Boundary Conditions Identification

VI. THERMAL PERFORMANCE, SOLAR ACCESS AND VENTILATION

a.) Thermal Performance: The process of modelling the transfer of energy between one building and its environment is referred to as a building's thermal performance. The thermal characteristics of buildings aid in the calculation of a building's cooling load. Field research data could be used to evaluate a building's thermal performance based on specific parameters including, Air temperature, Radiant temperature, Air velocity, and Relative humidity. These are measured both inside and outside the structure.

b.) Solar Access: Solar access refers to a structure's capacity to receive sunlight without being hindered by another's property across property lines (buildings, foliage or any other impediment). A sun path diagram can be used to conduct a preliminary analysis of solar access. The term "solar access" refers to the amount of sunshine available to a solar array at a given location. It's also known as Solar Access Value or Solar Access Percentage. The available solar energy is expressed as a percentage of what would be available in ideal (i.e., shade-free) conditions. Solar access is determined by dividing the actual solar energy present at the site, given shading, by the amount of solar energy present if there were no shadows.

c.) Wind Flow: Winds are categorized according to their spatial scale, speed, types of conditions that drive them, the regions in which they occur, and their impact. When the wind reaches a building's exterior, the flow splits as it passes along the surface of the structure. The wind stream separates above and around the sides of the building at the windward surface, where the wind first impacts the structure**.** Following are the wind effect on a building: Street canyon effect, Venturi effect, Windchill factor, The downdraught factors, Wind shadow, Special condition: tall building.

VII. CASE STUDY ANALYSIS

For the Case Study, a Residential society of Central Noida was taken as a project. Since the building taken for this case study is 64 storeys high and all other surrounding buildings were less than 20 storeys, the wind flow condition was extreme which also hindered the flow of the surrounding building. This excessive wind flow created uncomfortable conditions for the residential unit. Out of all three parameters, a CFD simulation was conducted for wind flow. From the data collected by the simulation of the case study, it is evident that the intensity and movement created around a building with clear site surroundings and with buildings of varying height are very different and the downdraught effect and wind tunnel effect are higher in the case building with dense site surrounding

VIII. CONCLUSION

After the CFD Simulation and literature study, it can be concluded that the impact of the surrounding condition on the thermal, solar wind flow behaviour of a building cannot be calculated accurately because it is hard to apply all relevant indicators simultaneously. There are limitations in the methods and techniques that describe all the parameters concerning their surrounding structure simultaneously. Most of them work on microclimatic data independently. The prioritization of the performance parameters needs to be done depending on the building design and microclimate. This particular case study indicated that the wind flow was the most impacted parameter as per site boundary conditions. Before designing the site, a specific study shall be done by analysing all the boundary conditions and their possible effect on building performance. Simulation exercises need to be performed before the construction of the building to evaluate the building behaviour concerning site performance. The change in the performance shall be evaluated concerning the change in site surroundings. Also, the form, structure and orientation shall be based on the findings of the analysis.

IX. TOOLS AND TECHNIQUES TO REVIEW THE EFFECT /OF PARAMETERS

Through literature study, it is evident that there are various software and techniques to review the effect on parameters of solar access, wind, and thermal performance. For thermal Performance, Energy plus, energy pro, Envi-Met, DEM can be used, For Wind flow performance, Field measurement, CFD, Eco-Tech, Envi-Met may be used. For solar access daylight factor, shadow maps, solar envelope, sky view factor, and eco-tech may be used.

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