

Chapter One

General

1.1. General

Cities face many environmental problems. Generally, these problems are manifested in the lack of natural ventilation due to low wind speed within residential areas.

The study, therefore, aims to study wind patterns that induce satisfactory cross ventilation in urban residential areas especially the third class districts. More specifically, the study tends to investigate the behavior of the wind around a cluster of buildings.

The research also deals with wind pattern around and within building in term of layouts, geometrical characteristics, heights of buildings, distance between each other and orientation that have negative effects on future performance and quality of the third class urban areas as a number of them are located on wind shadow. This phenomenon has many impacts such as poor ventilation because some buildings are placed on wind shadow. The study focuses on hot-dry climate in central Sudan.

1.2. The Statement of the Problem

- a. Lack of wind studies and its effects on natural cross ventilation in urban residential areas in Sudan especially in the third class areas.
- b. Physical planning laws and building regulations are issued with no regard to wind studies and its effects on urban residential areas of the third class areas.
- c. Residential areas, especially the third class, are not planned according to scientific methods or studies on wind or air movement that brings about proper natural ventilation.
- d. The distance between building and the boundary wall between the neighbours specified in the law is 2.5 m or, $\frac{1}{3}$ of the height, but these distances not determined in the building regulations according to the wind studies, the air movement, and the wind pattern a round buildings.

Although, these distances are very important to ensure wind flow and access to any residential building.

1.3. Significance of the Research

1. This research is tended to be a reference literature for urban planners, so as put into account cross ventilation whenever residential areas are planned.
2. No similar study has been carried out in Sudan yet.
3. This research will contribute to the development of the scientific basis for the planning of cities and residential areas in particular, in terms of providing natural ventilation.
4. This research will come up with good recommendations in support of physical planning laws related to residential areas planning.

1.4. Aims and objectives of the research

The aim of this research is to study the appropriate wind patterns that induce satisfactory cross ventilation in third class residential areas of hot-dry climate of central Sudan.

The objectives of this research are as following:

1. To study forms and patterns of wind movement around and within urban residential buildings in the current situation of the study area and the possibility of providing natural ventilation in this situation.
2. To study the general planning of sites which include a series of buildings and studying the pattern of wind movement through these buildings to provide natural ventilation.
3. To study the wind movement around the buildings assuming that all buildings in the study area consist of 4 floors at a height of 13 m according to the Buildings regulations of the third class.
4. To study the wind movement around the buildings assuming that the southern part of the study area contains buildings with a height of 13 m

(4 floors), and the northern part contains buildings with a height of one floor, the direction of wind from north to south.

5. To study the wind pattern around buildings for the same situation mentioned in the 4 above, but the wind direction here from the south to the north.

6. To determine the distance between buildings that leads to natural ventilation for each house.

7. To determine the height of the buildings and width of the streets and open spaces which ensure natural ventilation.

8. To study the effect of open spaces and streets on the movement of wind around buildings

1.5. Research Limitation

1. The existing situation of the study area contains buildings with a height of one floor. Less than 10% of the buildings contain two or three floors.

2. Study area consists of houses with same height (four stories) according to the building regulations in third class areas.

3. The southern part of the study area consists of four-storey buildings, while the northern part draws one-storey houses, and the wind blows from south to north.

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1.6. Methodology

Different methods are employed in this research depending on the nature of each stage of analysis. This includes analytical method and analytical-practical approach which represents field measurement data and computational fluid dynamics (CFD) simulations.

The analytical theoretical method consists of the following:

1.6.1. Library research and data and information collection from the various sources including books, journals and references.

1.6.2. Previous studies on the same topic

1.6.3. Theses and dissertations

1.6.4. Technical publications

1.6.5. Conference Papers

1.6.6. Websites

The analytical practical method involves analysis of wind pattern around residential buildings and configurations which are analyzed on CFD. This software will be elaborated later in the study.

The research will be carried out at the urban scale of built forms only, so analysis will be at this scale with simulations models to have the results.

The following equipment is needed for this research:

- a. Architectural science lab, wind tunnel and computer software simulation programs must be required.
- b. Advanced Laptop or desktop computer connected to internet for simulation and modeling.
- c. Short courses in computer programs (CFD, Eco-Tect, and Energy Plus)
- d. Printer and scanner
- e. Digital camera

1.7. Expected results, achievements and assumptions

According to the aims and objectives of the study, the following results are expected after analysis of the wind pattern around built forms:

1. To find out wind and air patterns which verify the effective natural ventilation.
2. To find out appropriate distance suitable for effective natural ventilation between buildings.

3. Critical review of techniques used in wind analysis at the urban scale including the efficient computer simulation programs which used for analysis of wind movement and wind pattern around buildings

1.8. Organization

The research is composed of eight chapters:

1-Chapter one consist of general introduction, statement of objectives and significance of the study, methodology and research organization.

2-Chapter Two contains theoretical background and literature review including climatology which is concerned with environmental phenomena free of human intervention in their formation or emergence.

This chapter also investigates characteristics of regional climate and variations in global climate. Atmospheric boundary layer (ABL), the mean wind speed profile in the ABL have been explained and defined along with six main types of wind which surround the globe.

3-Wind movement and the physical elements affect wind movement are defined and discussed in chapter three.

4-In Chapter Four, tools of wind studies are evaluated in order to choose the suitable one in terms of precision, accuracy, easy application and cost. Wind tunnel is defined as the oldest tool used in wind studies. CFD which is defined as a modern wind analysis tool is chosen for the analysis.

5- Chapter Five focuses on applications of CFD for the analysis of wind pattern around buildings in urban areas. The case studies have been analyzed and the CFD techniques are defined and specified.

6- Chapter Six discusses and defines the study area, population, social and economic situations and the climate of the area.

7- Chapter Seven is devoted to analysis and simulation by CFD software.

8- Chapter Eight is designated to discussion and recommendations of the research.

1.9. Conclusion

The current situation resulting from the impact of wind pattern around residential areas, especially in the third class neighborhoods, has motivated the researcher to conduct this study.

The aim of this research is to study the appropriate wind patterns that induce satisfactory cross ventilation in third class residential areas of hot-dry climate of central Sudan.

Also it aims to define and specify impact of wind pattern around buildings, and handle the effects on built forms at urban scale.

There are many methods used in planning of residential areas as explained above. These methods aim at achieving different requirements including providing natural ventilation. A real example of residential area is studied to determine the behavior of wind and availability of natural ventilation. The different wind analysis methods will be reviewed to choose and employ the most suitable ones for this study.