CHAPTER ONE:

INTRODUCTION
1.1 Preface

Man's activities on the earth have inevitably adversely affected the quality of the environment in many ways and have resulted in devastating crises of atmospheric ozone depletion, the greenhouse effect, the global spread of pollution and the deterioration of ambient air quality. The prevailing circumstances of the world witnessing crises in the quality of the environment have principally resulted from the increasing consumption of energy resources. People concerned with areas related to the environment need to review their activities and seek for alternative methods to resolve these unintentionally caused problems by impeding this progressive devastation or at least working to limit the disaster. Since buildings basically depends on energy to provide shelter and comfort for human beings, it is one field that influences the environment and its quality. Reducing the working and running costs of buildings without harming the environment is one of the main objectives of current work. To provide alternative solutions, efforts have been made to develop the use of passive low energy sources. Natural light is one of the passive sources that is required to be efficiently and effectively controlled in houses. Architecture throughout history has demonstrated a deliberate manipulation and control of natural light and other passive energy sources in buildings. In addition, the traditional buildings in most of the urban settlements in tropical and non-tropical areas of the world reflect different methods and tools of natural light control. Architects and designers should take natural light control in buildings into account during the design process in order to conserve energy, save the environment, reduce the working and running costs, and also to maintain visual comfort.
1.2 Importance of Natural light

Robbins has given some reasons which justify the Architect considering natural light as a light source in architecture. These reasons, which may apply more to one building category than another, are as follows:

1. Quality of the light
2. Importance of natural light as a design element
3. View (natural light apertures are visual communication channels to the outside)
4. Use of daylighting apertures as fire exits in emergencies
5. Energy conservation resulting from the use of natural light.
6. Energy consumption and peak demand cost savings resulting from the use of natural light
7. No cost change in construction
8. Opportunity to develop integrated structural and mechanical systems.
9. Psychological and physiological benefits not obtainable with electric lighting or windowless buildings
10. The genuine desire to have natural light and sunlight in a room or space.

Maintaining an optimum level of visual comfort (healthy-delightful environment) requires control of levels of brightness and shade to avoid discomfiting glare. This requires suitable strategies for natural light control in houses. In addition, integration of daylight provision in a building and other architectural and environmental considerations is essential:

Window's design, siting, and size is influenced directly or indirectly by thermal insulating standards, degree of natural light, degree of natural air, and adequate degree of sound insulation.
Lam² has given five categories of design strategies for natural light which a good
design using sunlighting can achieve. The five strategies are as follows:

1. To provide user comfort and delight in the interior environment.
2. To satisfy the programmatic needs of the users.
3. To minimise the building energy cost.
4. To optimise the public architectural image; and
5. To minimise the initial building construction cost.

He added that each of these strategies could be explained and maintained individually
in a fairly easily way, but it is difficult to achieve all these strategies simultaneously
in a building without very excessive pre-design analysis and consideration.

The common goals for planning by natural light as proposed by Robbins⁴ aim at
ensuring that natural light is available around and within buildings as needed. Natural
light planning goals are as follows:

Goal 1: To ensure that natural light is present on and between the facades of groups
of buildings, in order to provide good interior and exterior lighting
conditions.

Goal 2: To ensure that natural light can be had specifically where it is wanted, either
in particular rooms of buildings or at particular exterior locations around
buildings.

1.3 Research Justification

In addition to the importance of natural light in buildings, there are some points
which could justify this work. As this work concentrates on studying natural light
control in Hedjazi houses of Saudi Arabia and particularly on investigating the
performance of the *Rowshan*, the following points demonstrate the particular relevance of this research:

1. The vernacular Hedjazi houses were basically passive and low-cost architecture. The investigation of how such designs had utilised natural light could give the researchers of the fields of passive and energy-conservative architecture some directions and guidelines.

2. The use of the *Rowshan* was and still an important element in Hedjaz in the traditional forms and even in new buildings. The application of the *Rowshan* in Hedjazi houses is for the purposes of privacy and other environmental considerations. One of these is the provision and control of natural light. This specific purpose has not yet been evaluated by a scientific investigation.

3. It is really astonishing to have an architectural element which occupies this amount of space in the literature of Hedjazi architecture, so it is very clear that this element has possible aesthetic, climatic and architectural functions. These functions are required to be interpreted and scientifically investigated in order to evaluate their architectural applications in this environmentally conscious age.

### 1.4 Goals and Objectives

The overall aim of the work described in this thesis is to study the methods of natural light control that have been employed in vernacular Hedjazi houses. This involves analyses of the vernacular Hedjazi house, its different internal design elements, the functions of these elements, the environmental problems of spatial design and floors, the environmental considerations, and the resulting methods of controlling natural light.

The research objectives can be divided into a number of areas as follows:
A) The House:

In order to investigate a house in Hedjaz, the following points should be covered:

1. The prevailing climatic conditions and therefore availability of natural light.
2. The requirements of visual comfort.
3. The architectural elements which affect the natural light control and provision.

B) The Rowshan

After accomplishing the above, the impact of the Rowshan on natural light control, can be investigated with reference to factors such as:

1. Analysis of the Rowshan elements (frames, slats, etc.)
2. Individual parameters that influence the Rowshan performance such as slat geometry, slat thickness, slat declination angle, number of slats, etc.
3. Internal room design parameters which influence the Rowshan window such as the room dimensions and internal surfaces finishes.

C) The Investigation Tool

The above objectives of the investigation of the Rowshan and its applications can not be accomplished without a suitable investigation tool; so, within this context, certain objectives can be added such as:

1. Performing some physical experiments to investigate the performance of the Rowshan in relation to as many variables and parameters as can be physically simulated.
2. Since the Rowshan structure is complex and its performance can not be sufficiently understood via physical experiments a validated computer program should be developed to complete the required investigations.
3. Before achieving the above two objectives a prior survey of the previous studies concerned with elements similar to the Rowshan must be carried out. Previous experimental works and prediction techniques which are relevant should be reviewed.

D) Design Guidelines and Recommendations

The last objectives of this research focus on achieving a meaningful contribution to architectural science, specifically in relation to the Rowshan and its application in architecture. The objectives in this context are as follows:

1. Further analysis of all previous contributions on the Rowshan and its applications in the tropics and then setting up a standardisation of the Rowshan structural elements and its luminous environment.

2. Completing the investigations of the Rowshan performance by computer simulation according to selected cases and variables.

3. To draw up conclusions which set up architectural design guidelines and recommendations for further studies.

1.5 Scope and Limitations

Natural light data, used in this work are extracted from CIBSE records of radiation for 20° Latitude which is similar to the latitudes of the Hedjazi cites of Jeddah, Makkah and Taif. By employing what is known as the luminous efficacy, the radiation data is converted to illuminance data. Another important factor is that natural light from sun or sky is not constant. This work, therefore, will consider the average values between the two cases of maximum and minimum, in as much as the sky in Hedjaz is clear.
Natural light control in Hedjazi houses is achieved by several elements in the house with construction such as Rowshans, stairwells, lightwells, cours, etc. The Rowshan is the most important element as it is a technique manipulated in the windows which are the basic natural light source of lighting for the internal spaces of the house. The Rowshan is not used only to provide natural light. It also provides privacy, air penetration (ventilation) and maintains the shade over the plain window.

The Rowshan characteristics discussed by Hariri M (1991) are considered as the standard characteristics for this study. Other sources of information regarding the Rowshan and its applications in the Hedjazi house are as follows:

1) The study conducted by Fadan Y (1980) of the traditional houses of Makkah.

2) The study of Jeddah old houses that has been accomplished by Khan S (1986).

3) The book entitled Patterns from Old Makkah Buildings which has been published in 1993 by the Hajj Research Centre, Umm Al-Quara University, Makkah.

4) The study of traditional houses of Suakin. Suakin houses are considered as typical of Jeddah houses as they were built by merchants who had come from Jeddah.

5) Several Master and Ph.D. thesis that are concerned with the Hedjazi architecture and different issues related to it.

The most important limitation that should be taken into account is that the Rowshan casement has many different forms and designs. This study is restricted to the one designed with multiple sashes of horizontal slats which is the most common in the Hedjazi region of Saudi Arabia and other tropical and non-tropical areas of the world.

### 1.6 Research Methodology

The techniques used by the author for achieving this research would be as follows:
1. Visiting the traditional and vernacular sites preserved in the Hedjaz area of Saudi Arabia.

2. Collecting literature concerned with Hedjazi architecture and natural light control, as well as the literature related to the techniques for the investigation of natural light.

3. Performing experiments in the lighting laboratory to obtain an initial understanding of the performance of the Rowshan and the effect of the different variables of the Rowshan.

4. Developing a computer simulation program using the FORTRAN language, capable of modelling the action of natural light on the Rowshan. The program is then validated against experimental measurements.

5. Completing the investigations, analysing the results and drawing up conclusions and recommendations.

1.7 Logic Sequence of the Research Approach

The approach employed in this research is based on synthesising a number of stages which are considered as the basis for the titles of the chapters of the thesis. After this introductory chapter, Hedjazi architecture which is the subject of these investigations will be analysed in chapter 2. Secondly, natural light in architecture will be discussed in chapter 3. From these two chapters the different characteristics of the Hedjazi architecture, its different environmental treatments, the principles of natural light in architecture, the luminous environment and finally the Hedjazi house in the context of natural light are understood. The conclusion of these two chapters led to chapter 4 which identifies the Rowshan as the most effective environmental control technique used in the Hedjazi house.
Chapter 4 analyses the Rowshan from different perspectives: its importance in the house, typology and dimensions, functions and characteristics, and an assessment of new applications in modern houses in Saudi Arabia. The conclusion of this chapter confirms that the Rowshan is very complex in its elements and functions and identifies the importance of investigating this device from the point of natural light control.

In chapter 5 a review of the available experimental techniques and previous experiments related to the Rowshan and its form as a type of shading devices is presented. In addition this chapter gives an extensive description of a set of experiments performed to the highest accuracy possible using the available instruments and materials. The conclusion related is that although this gives an initial understanding of the most important parameters of the Rowshan, a more advance investigation tool is required.

Chapter 6 reviews the common prediction techniques and identifies the possibility of simulating the effect of the Rowshan on natural light. There is no available prediction tool that can be employed in the case of the Rowshan. From the principles and considerations reviewed in the work, various techniques and methods can be exploited as the basis for developing a computer program specifically for the Rowshan. All principles, programming considerations as well as an analysis of the Rowshan elements and variables are included in this chapter as a foundation for the computer program.

Chapter 7 describes the various stages and procedures of the mathematical model used in the computer program. Then, an attempt is made to validate the program against some experimental measurements.
Chapter 8 analyses the *Rowskan* within its luminous environment. This chapter standardises the *Rowskan* parameters with reference to the common applications and their design alternatives. The luminous environment is analysed according to the availability of the illuminance data for a *Rowskan* constructed in an elevation of a building. This chapter is very important for the selection of the parameters and cases to be simulated via the computer program as will be required by chapter 9.

This chapter describes and analyses the parametric investigations that are conducted to identify the effect of the various parameters on the performance of the *Rowskan*. Appendices of tables, figures and contouring maps are provided to illustrate the performance of the *Rowskan* in relation to various parameters and luminous conditions. At the end of this chapter a guidelines for architectural design for natural light control by *Rowshans* were recommended.

The last chapter summarises the researcher’s experience, results and the recommendations that can be concluded from this research.
1.8 References


4 Robbins C, *op. cit.* p. 130

5 An island, was a port on the Sudan coast of the Red Sea, nearly opposite to Jeddah.
