ROOM AIRFLOW CHARACTERISTICS WITH REFERENCE TOTHE ROWSHAN (WINDOW BAY) CONFIGURATIONS: CFD STUDY.

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1. Abstract

Hijazz Is one of the historical regions of Saudia Arabia. The Traditional Architecture of this region as, all Islamic architectures, is very prosperous in details. Many of these details are functional response to climatic factors. Rowshan (window bay) is the local version that is predominant in that region. Several types of Rowshan are defined in the region. Rowshans are essential to provide indoors with the desired level of ventilation and daylight whilst preserving occupant's privacy.

This paper investigates Rowshan types and their design parameters. Louvers Angle, Position and depth are among these parameters. The impact of these parameters on the airflow within internal spaces were investigated using computational fluid dynamics modeling (CFD) technique. FLUENT software was found useful to predict room air flow at early design stages.

The paper concluded with a group of design charts that could help designer to predict airflow within the internal space in certain directions and certain levels within the room.

Keywords: Ventilation, CFD, Rowshan, Traditional Architecture

2. Rowshan as an Environmental Response Element:

Traditional Architecture has responded to environmental and climatic pressure in several ways. Covering outside openings with Rowshan window type is one of these responses. Rowshan, traditionally known as Mashrabia, could be described as a wooden screen with different opening sizes. It plays a major role in natural ventilation within rooms. It acts as a modulator to the airflow pattern, to its velocity and to the flow rate of passing air. This could be achieved through tilting the moving louvers of the Rowshan. Moreover, it can direct the airflow to the body level of the space. (Maghrabi, 2000), (Al-Lyaly, 1990), (Sharma and Sharafat, 1986)and (Oliveira and Bittencourt, 1998).

Ventilating the space is not useful only for reducing the temperature of the internal space but also for reducing the humidity. It works also as a solar shading device and a tool for providing a visual privacy for occupants. Figure (1) Illustrates a traditional buildings with different types of Rowshan. (Maghrabi 2000),

Figure : 1 Traditional buildings with different types of Rowshan

2.1. Rowshan Types

Rowshan is the type of Mashraia that is used in the western region of K.S.A. Rowshan is classified into two main types the vertical long Rowshan (types 1, 2 ,3) and the split Rowshan (types 4, 5, 6). Each type has different details Figure (1) illustrates these different types. (Hariri 1992)

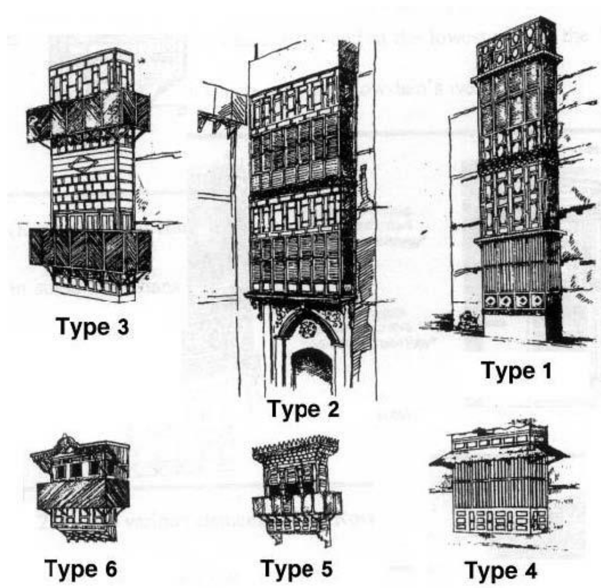

Figure : 2 Various types of Rowshan found in Jeddah (Khan, 1986).

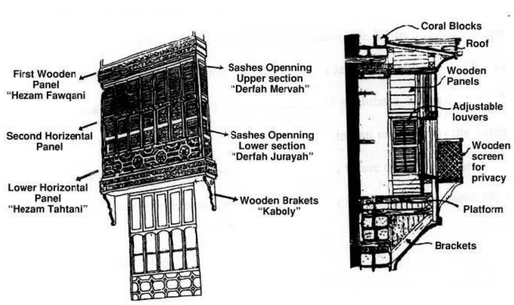

Figure : 3 Perspective and section of Rowshan

2.2. Rowshan Construction

Rowshan is a wooden structure. It's body composed of three main parts (Crown, upper belt, Sashes, Lower belt and Brackets) Figure (3) illustrates the structure elements of the Rowshan**.**

2.3. Parameters Affecting Airflow Within Internal Space:

Airflow is affected by several factors besides the Rowshan design parameters. Among these factors:

. Wind speed outside building
. Opening size and directions
. Space form and dimensions

. Inlet-outlet relationship in terms of size, position and direction This paper will limit its scope to the Rowshan design parameters as the inlet and their impact on the airflow within the internal space.

2.4. Rowshan Design Parameters:

As mentioned before Rowshan known in several forms and design details. These details affect the airflow through the internal space. The paper scope is limited to study the following factors impact on the airflow and natural ventilation:

. . Louvers Depth. d Louvers tilting angle. θ.

. . Opening between louvers height. L Rowshan height in relation to space height. Rowshan projection.

. Rowshan sitting height.

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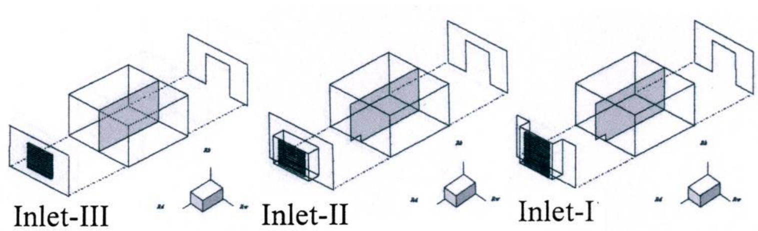


Figure : 4 Selected Rowshan Configurations for Test

3. Modle Simulation:

3.1. Tools: The simulation in this paper covers the patterns of airflow within a room based on louvers. Several packages are available for such simulation. Among these packages PHOENICS, FLINT, STARCD, FLOVENT and FLUENT.

FLUENT is a numerical simulation software that has been used to predict airflow within internal spaces through the last three decades. The CFD modeling technique is well established to represent velocity, directions and pattern of airflow across a room. This technique is widely implemented to predict indoor airflow characteristics within and around buildings After decades of implementation, FLUENT is found valid alternative along with other modeling techniques such as wind tunnel or smoke testing techniques in case of full-scale measurements (Kindangen et al. 1997), (Awbi, 1989), (Maghrabi,2000). The present work required facilities for single-phase flow and two-dimensional modeling. A number of papemters are described before running the case including detailedspecifications of flow mechanism and its boundaries in addition to modeling turbulence equations. The model built in this case using Cartesian Grid system instead of body fitted grid system as found more appropriate.

3.2. Turbulence Modeling: There are different approaches in dealing with turbulent flows. Turbulence is measured in this paper depending on the Reynolds number, Navierstokes, k-6 model equations and others. The equations governing the model are described in the author's work (Maghrabi, 2000) for future reference. The equations are transformed into a set of algebraic equations that can be solved iteratively. This transformation, also called discretisation, involves the following.

. The domain is divided into cells or control volumes.

. The governing equations are integrated over each cell.

. The algebraic equations so obtained are solved by iteration.

3.3. Boundaries Modeling: The following describes the boundaries' specifications

. **Inlet:** At which conditions of flow components are identified such as velocity, turbulence and composition of the flow.

. **Outlet**: Normal velocities are adjusted at outlet boundary to satisfy an overall mass balance and no velocity gradients are exists.

. **Wall**: Including walls, floor and ceiling. At these boundaries, the normal velocity component vanishes.

1 **Inlet Modeling:** The decision was made to evaluate the effectiveness of MLW (Modulated Louvered Windows) to produce patterns of airflow indoors. These were traced with the influence of three different combinations shown in Figure (4). The number of louvers in each combination varied accordingly. While they were either plain or projected Rowshan covering part or whole wall, they varied in louver numbers, wall configurations and dimensions. The outlet were considered a typical door located in the middle of opposite wall.

4. Simulation Process:

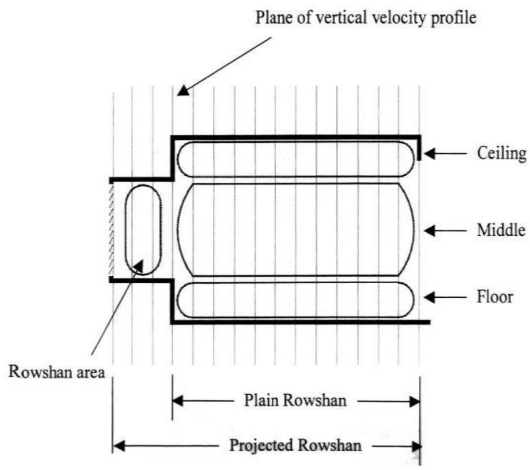
. The evaluation process of the flow patterns was made into three levels within the room. They included ceiling, middleand ground zones. Rowshansitting zone were added whenthe projected Rowshans were examined as seen in figure(5).

. Outlet considered to be door 1* 2 m ($2m^2$) in the middle of the space

. Both middle and floor zonesare considered the occupants' living zones (AI-Lyaly, 1990).

. Louvers' inclinations of θ= 0°, 30° and 60° were examined.

. A two-dimensional physical domain was made and setting up the model and physical domain were followed.

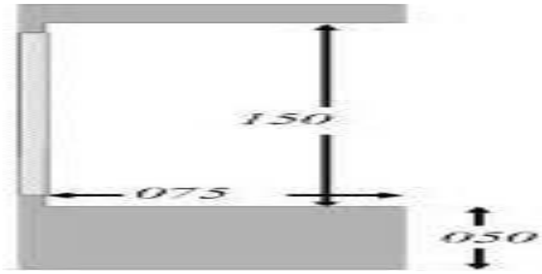


5. Results:

Table (1) presents the results of simulating three cases of a room with inlet as Rowshan type I and 2m height door as outlet. Different louvers angle was selected for each case. The following table shows the airflow velocity, direction, contours and pattern at the middle section of the room.

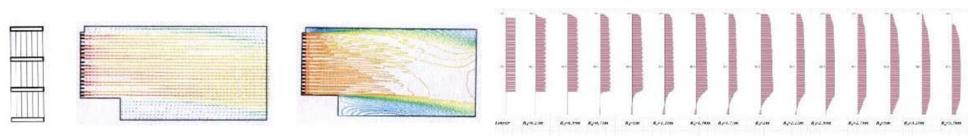
Table: 1 : Airflow velocity, directions, contours and pattern at the middle section of the room for Rowshan type (I).

ROWSHAN TYPE I:

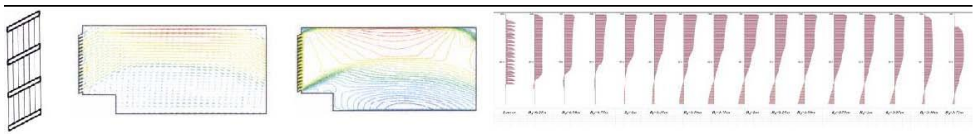


Louversangle

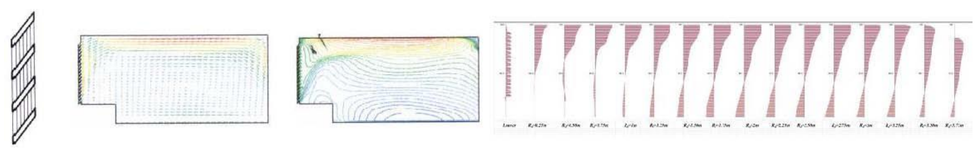
Velocity Directions Velocity Contours Airflow Pattern at Test Points



Θ=0



Θ=30



Θ=60

The following discussion is based on the results shown in the previous table:

. The most rigorous solution to enhance ventilation indoor in the occupied living zone was observed at the inclination θ=0° as wind direction was not deflected or altered, shaping the most preferable flow regime at the middle zone in both plain and projected Rowshans.

. The presence of louver inclination had directly altered the airflow pattern in the room. When the louver inclination was set to θ=30°, the flow near the Rowshan was maximized at ceiling and Rowshan area. Occupants' living zone was also ventilated near the inlet, and due to the effect of inclination, the flow lessened nearly in the middle of the room.

. The flow pattern was more effective at the middle zone with horizontal inclinations and diversities of flow were shown in relation to the degree of inclination. The practical advantage of the latter inclination is when occupants require protection from direct airflow while the room is still ventilated or when there is a need to release the room from excessive heat and contaminants near ceiling.

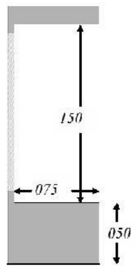
. The pattern and maximum velocities at a particular location within the room were easily controlled by the louvers angle as the various inclinations involved in the solution had noticeably changed obtained results.

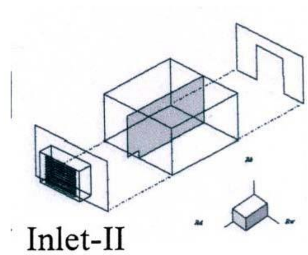
. In general, the greater the angle, the less effective ventilation at middle zone and the more effective near the ceiling and floor. Middle zone was not well ventilated whilst a bi-directional flow was found around other zones.

From the various combinations examined, the effect of Rowshan configurations was not effective to alter the flow patterns within the room when θ=0°. The Rowshan configuration was a determinant factor when examined at other inclinations. Tables 2 and 3 present the results of simulating two different Rowshan types, each ofthem has two cases of a room with inlet as Rowshan and two meters height door as outlet.30 and 60 degrees louvers angles were selected for each case.

Table: 2 : Airflow velocity, directions, contours and pattern at the middle section of the room for Rowshan Type (II).

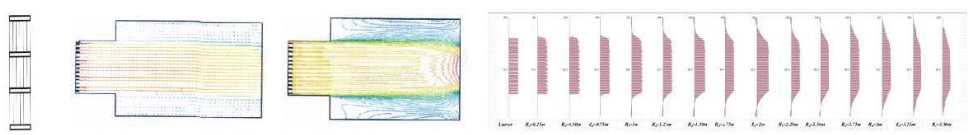
ROWSHAN TYPE II:



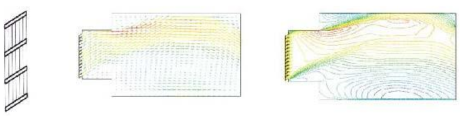


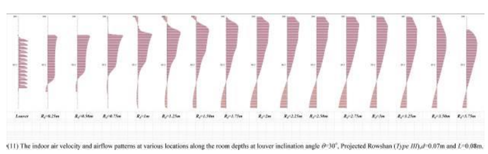
Louvers angle

Velocity Directions Velocity Contours Airflow Pattern at Test Points



Θ=0





Θ=30 Θ=60

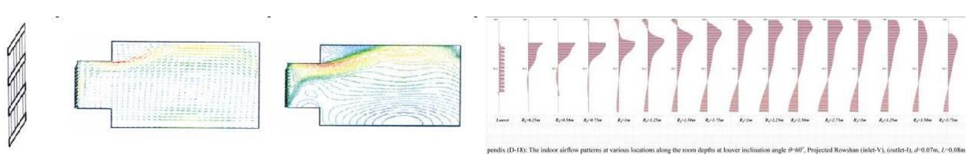
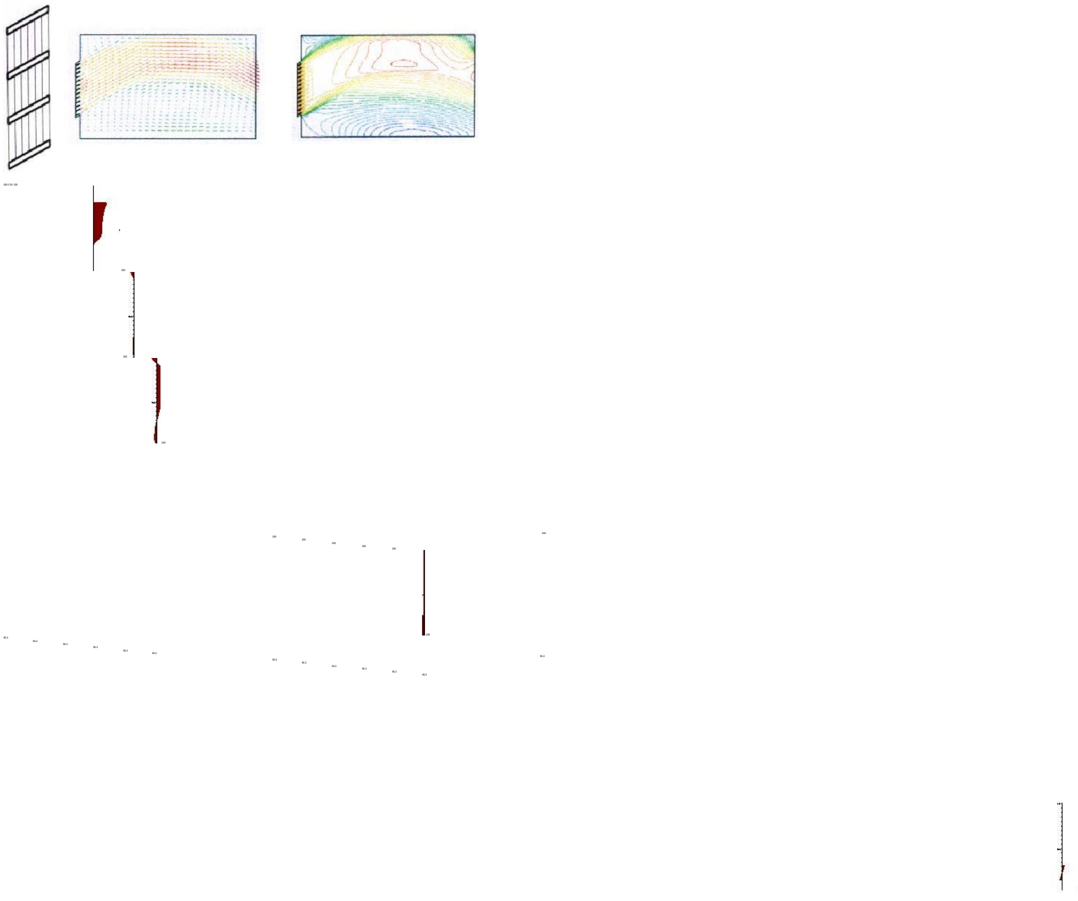


Table: 3 : Airflow velocity, directions, contours and pattern at the middle section of the room for Rowshan Type (III).

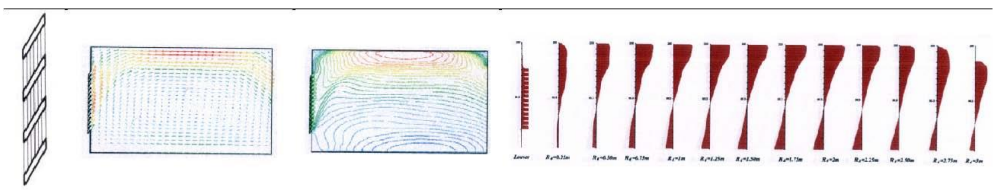
ROWSHAN TYPE III:

Louvers Angle

Velocity Directions Velocity Contours Airflow Pattern at Test Points



Θ=3 0



Θ=6 0

Out of Tables (1, 2 and 3), It could be noticed that:

. The Rowshan sitting zone was evenly ventilated, being next to the louvers. This solution is ideal when the maximum ventilation or direct flow to the occupant zone was desired. However, airflow at ceiling and floor showed the po`orest performances. This was corrected with the increase of louver numbers as found in inlet-I and inlet-II, which enhanced the flow in the various zones. It also depends on proper selection of louver aperture L.

. Increasing louver numbers had improved flow along the room (Inlet-I, Inlet-II). As to the far locations in the room, the flow of air increased near the ceiling while minimizing at the middle.

. Some flow was observed at the floor zone with opposite direction. The bi-directional flow between various zones in the room is a better solution when direct flow is not desired or when an air re-circulation is needed. The phenomenon was even more obvious at steeper louver inclinations. For example, when examining the flow pattern at θ = 60° the velocity profile along the room height was much improved around the ceiling and near the floor.

. The examined cases showed that the minimum flow was round middle zone. Similarly, Rowshan sitting area was poorly ventilated. The increase in louver number did not correct that and the only Rowshan type that seemed to solve this was type III.

. While enhanced flow was near the ceiling, the middle zone was better ventilated with the plain Rowshan than with the projected one.

- The simulation illustrated that sizing the projected Rowshan, as the case in inlet I, could alter the flow to be more effective in the middles zone. Where it forced air to flow more to the occupants' zone. But the flow of air was directed towards the ceiling
- As far as the floor zone was concerned, the bi-directional flow was more encouraged with the presence of plain Rowshan and steeper inclinations. As shown in the tables, this finding was for both observed inclinations.
- Comparing the flow direction results of Rowshan types II and I, It could be

noticed that: with the presence of steeper louver inclinations, the flow was neither changed near inlet nor changed in the middle of the room. The variation of flow regime found at the ceiling level was minor and negligible. But the previous fact was shown in the projected Rowshan. On the other hand, when the vertical velocity profile was plotted for the plain Type III, the case changed.

6. CONCLUSION:

- Computational fluid dynamics (CFD) prove to be a useful tool to simulate and comprehend the complications existing in the real environment.
- The Rowshan configuration played a main role to shape the flow pattern and direction inside the room.
- The utilization of louver inclination is of importance for the designers to create various flow patterns in the room.
- For various louver apertures, maximizing the flow in a certain location within the room could be achieved using of louver inclination.
- As far as the airflow near the floor was concerned, the simulation of flow patterns had shown that tilting the louvers to steeper angles would be proportional to the percentage of bi-directional flow near the ground whilst flow in the middle zone is minimized. This provides an absolute solution for getting rid of the excessive heat and humidity near the wiling and provides breeze of flow near the ground level.
- The presence of steeper louver inclinations angles induced a bi-directional flow within the room unlike the horizontal inclination. The latter inclination however is the optimum when direct ventilation at occupants living zone is desired.
- The plain Rowshan is generally a better choice than the projected Rowshan. Yet the flow in the living zone could be obtained be correctly sizing the projected Rowshan.

منسقة:تعدادات نقطية ورقمية

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