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# The role of double skin-faced openings to Allow air flow easily

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**ملخص البحث:**

إنتشر في الآونة الأخيرة مصطلح المباني المريضة، نتيجة سوء التهوية وعدم السماح للمبنى بالتنفس، ونجد إنتشار ذلك المصطلح عادة مع المباني ذات الواجهات الزجاجية والتي تعتمد على التهوية الصناعية بإستخدام الآلات الميكانيكية، وقد تتناسب مثل هذه الأنواع من الواجهات لطبيعة المناخ البارد، إلا أنها لا تتناسب مع طبيعة المناخ الحار، لأنها تساعد على زيادة إرتفاع درجات حرارة الفراغات الداخلية، وسوء الراحة الحرارية للمستخدمين، بالإضافة إلى زيادة الإكتساب الحراري للمبنى، وإستهلاك كم هائل من الطاقة اللازمة لتبريد وتكييف الفراغات الداخلية.

وتلعب الفتحات دوراً هاما في التهوية الطبيعية بالمباني، ولها تأثير مباشر على تحديد كمية وسرعة وإتجاه تدفق الهواء الداخل أوالخارج من المبنى، كم أن الإختيار السليم لمساحة وموضع وإتجاه الفتحات بنظام الواجهات مزدوجة الأغلفة يؤدي إلى المساهمة في خفض درجات الحرارة داخل الفراغات الوظيفية للمبنى، كما يساهم في تحقيق الراحة الحرارية للمستخدمين، وتمكين الفراغات المعمارية من القيام بوظائفها.

يهتم البحث بوضع منظومة تساعد القائمين على إنتاج المباني من إختيار الفتحات المناسبة بنظام الواجهات مزدوجة الغلاف، وذلك من خلال مرحلة التخطيط، وهي أحد أهم مراحل العملية الإدارية، وذلك بإستخدام المنهج الوصفي التحليلي لمقارنة ودراسة كيفية إتخاذ القرار التصميمي المناسب، ولتحقيق الهدف المطلوب يهتم البحث بالتعرف على مفهوم الإدارة، ودراسة الفتحات بنظام الواجهات مزدوجة الغلاف، ومدى توافقها مع إستراتيجيات عمل النظام، وصولاً لوضع قائمة مقارنة تساعد في إتخاذ القرارات التصميمية المناسبة الخاصة بالفتحات.

## ABSTRACT:

'Sick buildings' is a recent spread term due to poor ventilation that building is not allowed to breathe. This term is usually found with glass facades buildings, which relay on mechanical ventilation. These types of façades may be suitable for cold climates, but they do not match the nature of the hot climate, as they increase the interior spaces temperature, cause the thermal discomfort of the users, and increase the heat acquisition of the building that consume a large amount of energy for cooling and conditioning Internal spaces. The building openings have an important role in the natural ventilation and have a direct effect on determining the quantity, speed and direction of the air flow inside the building. The proper selection of the area, position and direction of the openings in the double-skin facades system contribute to reducing the air temperature inside the building spaces. It also contributes in achieving thermal comfort for users, and enabling architectural spaces to perform their functions.

The research is concerned with the development of a system that helps the building producers to select the appropriate openings in the double-skin facade system through the planning stage, which is one of the most important stages of the administrative process, using the analytical descriptive method to compare and study how to make the appropriate design decision. To achieve the desired goal, the research is interested in identifying the concept of management, studying the openings in the system of double skin-facades system, and their compatibility with the strategies of the system, to develop a comparative list to help in making appropriate design decisions for the openings in the system.

**KEY WORDS:** Sick buildings, Openings, Natural Ventilation, Double Skin-Facades.

## 1. Introduction:

There are some important definitions that must be referred to for understanding the steps of the appropriate management process of a successful design of openings within the strategies of double skin-facades system, lying on proper management principles and planning techniques

## 2. System for the designing of openings in the system of double skin-facades in hot climate:

The economic system can be set to choose suitable openings in hot climatic zones, applying on the double skin-facades system through the planning stage in project management stages where the design decisions are in the planning stage, where planning steps can be simplified through Figure (1), it begins by collecting information, then analyzing it, then setting the goals, and ending by the final stage of the planning, which the stage of decision is making.


**Figure (1) shows the steps of the planning stage.**
**source: author**

## 2.1. Collection & Analyzing information:

### 2.1.1. Elements of the double skin-facade system:

The double skin facades system contributes the rationalization of energy consumption and convenience of users (utilization of natural light, reduction of heat transfer, maintenance of natural ventilation rates, air purification, acoustic insulation) through the compatibility of system elements of the skins, openings, shading devices, and air cavity between the skins. [1], The strategies of double skin facades system is to protect the building from forces that influence the elements of the climate (sun, wind) depending on the proper employment of the system elements described in Figure (2), ( materials of skins, windows, shading) These elements act as an integrated system together with different strategies to achieve the utilization of climatic elements.

**1- Hot air exit, 2- double glass units for the inner skin, 3- shading devices, 4- single glass units for the outer shell, 5- galvanized iron mesh, 6- External window to enter the air, 7- window to enter the air, 8- window to air exit.**

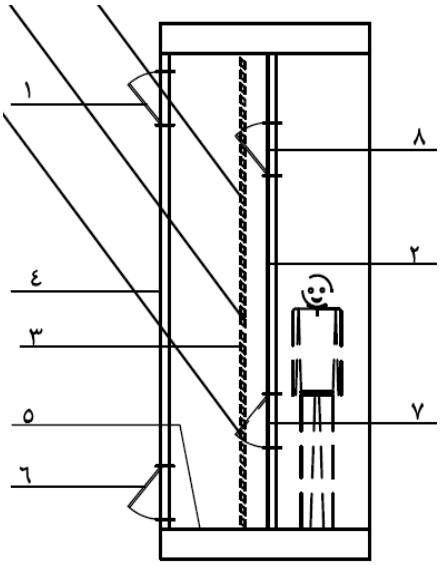



**Figure (2) shows the components of double-faced facades.**
**source: author**

## 2.1.1. The role of openings in the system:

It is important to determine the type, space, position, and direction of the opening of the internal and external openings of the cavity, due to the large influence of the openings on the flow and speed of air, and thus affect the temperature of the air internal spaces, and inside the cavity also, and also affect the rate of ventilation and comfort Thermal for building occupants. [2]

## 2.1.2. Places and Position of openings in each skin:

The outer skin of the double skin facade system has usually a window to enter the air at the bottom of the façade, and another on to exit the [hot air at the top of the façade. The inner skin may be has one window for entry or exit the air. It also can has two windows as the outside skin, one on of them at near the floor level and the other at the nearest point of the intersection at ceiling with the interior skin of the facade. [3] The placement of windows helps to ventilate the spaces and reduce air temperatures; Figure (3) shows the direction of the airflow in the spaces by moving the hot air to replace it with cold air based on the intake system in bringing cold air, and pull hot air through the interfaces with double skin-facade system. [4]

## 2.1.3. Window-type materials:

Openings of wood, porches, etc. (or units of glass or UPVC, single, double, or triple-layers), may be layered.

Table (1) describes the thermal transfer coefficient and transparency coefficient of some types of glass opening material. [5]

## 2.1.4. Area of openings:

Air vents are usually wide and the exit slots are narrowed, to act on air flow velocity. Vents have an important role in the air flow velocity, where they are working together with the basic principle of air transfer (the effect of zones pressure), and controlling the amount and direction of air in internal spaces. [6], the figures (4: 9) shows the effect of the area and position openings in the horizontal and vertical sections on the air volume and direction of flow, Figure (10) shows shape and direction of window openings. [4]

## 2.1.5. Opening window Direction:

The ratio of air passing through the window varies according to several criteria such as, speed and amount of wind, as well as the position of the opening and the direction of opening window. [7], Table (2) shows air passage rates according to the direction of opening.

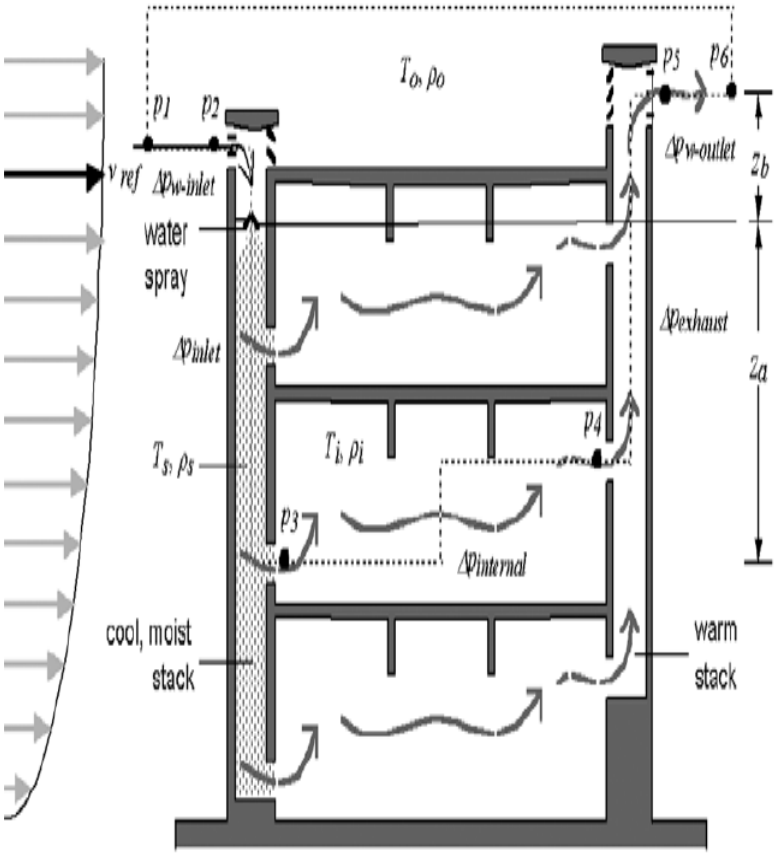
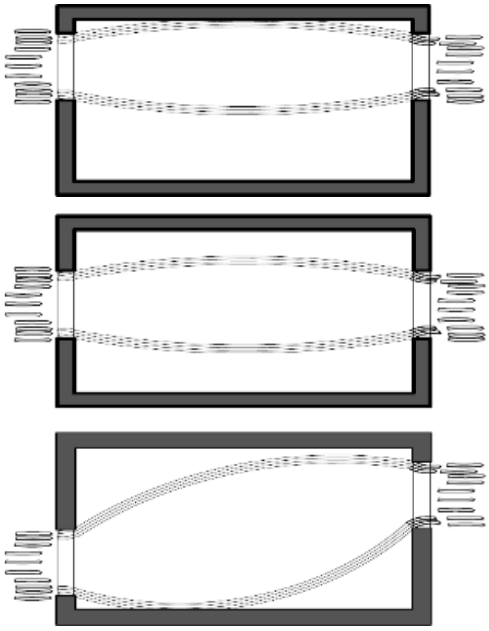


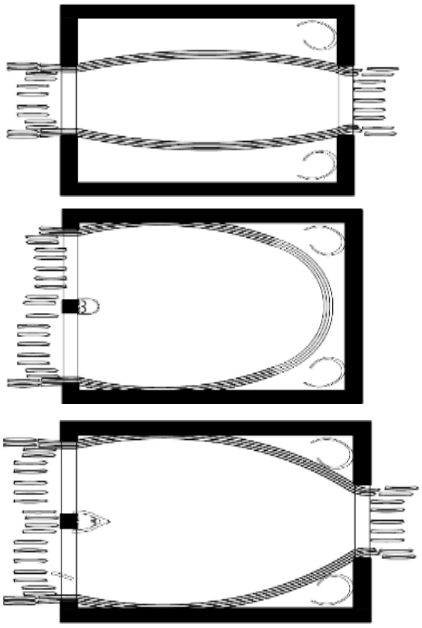

**Figure (3) shows the effect of the position of the openings on the air flow of air inside the internal space.**
**Source: G, Cristian, Natural Ventilation In Urban Environment Assessment and Design**

| Types | U–value (W/m2 K) | Transmission of daylight (%) |
|---|---|---|
| Single glazing Double glazing | 4.6–5.0 | 89–90 |
| Double glazing | 2.6–2.9 | 80–82 |
| Double glazing with one low emissivity coating | 1.4–1.8 | 74–78 |
| Double sealed glazing with argon filling | 2.5–2.6 | 80–82 |
| Double sealed glazing with argon filling and one low emissivity coatings | 1.2–1.4 | 74–78 |
| Triple glazing | 1.9–2.0 | 74–76 |
| Triple glazing with two low emissivity coatings | 1.0–1.1 | 62–67 |
| Triple sealed glazing with argon filling | 1.7–1.9 | 62–67 |
| Triple sealed glazing with two low emissivity coatings and argon filling | 0.8-0.9 | 62-67 |

**Note: To maintain interior daylight quality, loss in transmission must be compensated by larger windows.**
**Table (1) describes the thermal transfer coefficient and transparency coefficient of some types of glass opening material.**
**Source: Berge, The Ecology Of Building**



**Figures (4: 6) illustrate the effect of the openings on air flow in the vertical section.**



**Figures (7: 9) illustrate the effect of the openings on air flow in the horizontal section.**

**source: author**

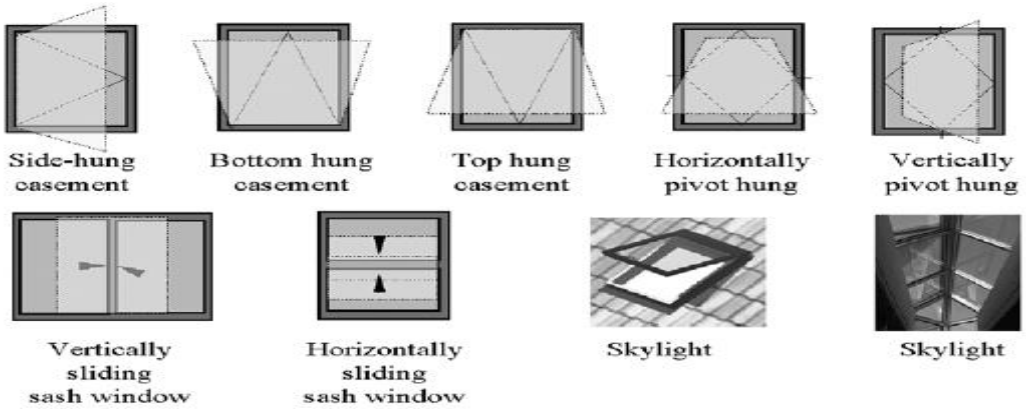



**Figure (10) Illustrates models of shape and direction of window openings.**
**source: G, Cristian, Natural Ventilation In Urban Environment Assessment and Design**

| Type of inner opening | Relative Ventilating Effectiveness in relation to the elevation Area of Opening Light |
|---|---|
| Bottom hung tipped casement | Up to 25% |
| Horizontally sliding casement | Up to 70% |
| Slide down, top hung casement | Up to 80% |
| Vertically sliding casement | Up to 90% |
| Side-hung casement | Up to 100% |
| Vertically pivoting casement | Up to 100% |
| Horizontally pivoting casement | Up to 100% |

**Table. (2) Describes Relative Ventilating Effectiveness in relation to the elevation Area of Opening Light.**
**Source: : Poirazis, "Double Skin Facades**

## 2.1.6. Opening principles:

The air velocity and the type of flow inside the cavity depend on the type of the interior openings and the type of the exterior openings (for natural ventilation). [7] it is an important factor of the air flow because it has a significant impact on the obstruction or ease of flow through the direction and shape of the window. [4], the opening or closes windows confirm the direction of the direction of air flow according to hot or cold weather. The figures (11: 13) show how the direction and shape of the aperture affect the flow of air in the system.

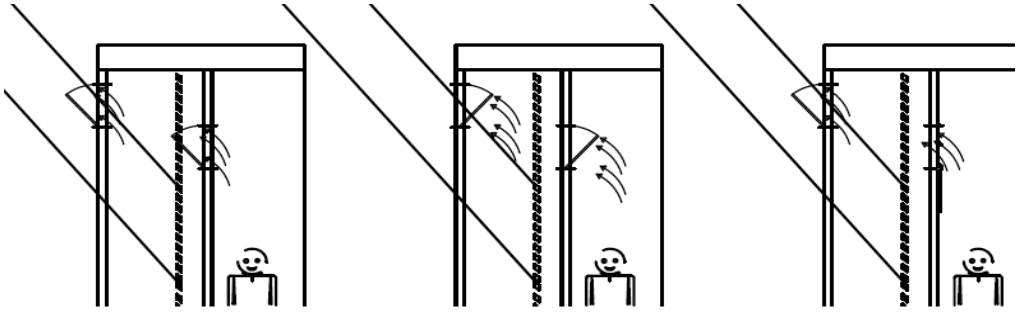


**Figure (11) Same as the previous window, but open to outside helps to move the air out.**

**Form (12) Horizontal pivotal window obstructing the air flow.**

**Figure (13) vertically sliding window helps to air flow.**

**The shapes illustrate the effect of the opening direction of the windows on the airflow.**

**source: (author)**

## 2.2. Goals determined:

The objectives are divided into main goals, sub-objectives, and objectives of the use of openings of double skin-facades system projects can be defined as follows:

## 2.2.1. Main Goal:

The main objective can be defined as: "contributing to the thermal comfort of users".

## 2.2.2. Sub-objectives:

The sub-objectives system can be defined as the following:

- Natural lighting. - Allow airflow - Reduce the actual temperature of the internal spaces.
- Reduce thermal acquisition inside the building.
- Rationalize energy consumption in buildings.

## 3. Selection of the list chosen:

By defining the main goal, and the sub-objectives, can be selected the appropriate openings chose list for achieving the objectives:

## 3.1. Contribution to the achievement of natural lighting:

We must check whether any of the designing alternatives can contribute to the natural lighting more without glare, as this reduces the energy needed for lighting.

## 3.2. Air flow:

Check whether any of the designing alternatives can contribute to the smooth flow of air inside the cavity and thus into the spaces, which helps to reduce the heat of the interior spaces.

## 3.3. Openings suitable to direction of different facades:

It is necessary to verify that any of the designing alternatives can contribute to the direction of different facades, to the achievement of the objectives.

## 3.4. Reducing the air temperature of the internal spaces:

It is necessary to verify that any of the designing alternatives can contribute to the reduction of the temperature of the internal spaces, as this contributes to the achievement of the main objective of achieving the thermal comfort of the users.

## 3.5 Reduction of heat gain of internal spaces:

Check whether any of the designing alternatives can contribute to reducing the heat acquisition of internal spaces, as this will consume a large amount of energy to cool the spaces.

## 3.6. Rationalization of energy consumption:

This is done by reducing the actual heat of the façade surfaces.

## 4. Demonstration of the available designing alternatives:

It can be inferred the possibility of achieving the objectives of each of the design alternatives available through the study shown in the following table No (3).

## 5. Appropriate decision-making process:

This is done by comparing the design alternatives to reach the appropriate decision, as shown in the tables No (4, 5, 6, 7) and Figure (13) shows the most appropriate solution for Types of windows on the double- facade system to achieve the desired subjective.

| Cases | Analysis | Types |
|---|---|---|
| **Case (1) Vertical pivot** | **- This type allows the largest amount of light to the large area, and allows north, north-east and north-west air to pass, which contributes to the thermal comfort, reducing the thermal acquisition of the building, and rationalize the energy consumption needed for lighting and the adaptation of internal spaces.<br>- used to entry or exit hot air from the air cavity to internal spaces.** |  |
| **Case (2) horizontal pivot (internal)** | **- This type has small area, so does not allow the passage of a large amount of light, and allows the passage of hot air rising from the bottom to above, which causes the exit of hot air from the interior spaces in building to air cavity in summer, therefore it can be used for the eastern, western and South facades, To exhaust hot air.<br>- But it can't be used for air entry from the air cavity to internal spaces because interfere with air movement with the opening direction.** |  |
| **Case (3) horizontal pivot (external)** | **- This type has small area, so does not allow the passage of a large amount of light, and allows the passage of hot air rising from the bottom to above, which causes the exit of hot air from the interior spaces in building to air cavity in summer, therefore it can be used for the eastern, western and South facades, To exhaust hot air.<br>- But it can't be used for air entry from the air cavity to internal spaces because interfere with air movement with the opening direction.** |  |
| **Case (4) vertical sliding window (external or internal)** | **- This type allows the largest amount of light to the large area, and allows north, north-east and north-west air to pass, which contributes to the thermal comfort, reducing the thermal acquisition of the building, and rationalize the energy consumption needed for lighting and the adaptation of internal spaces.<br>- used to entry or exit hot air from the air cavity to internal spaces.** |  |

**Table (3) shows the extent to which the design alternatives have been achieved for the specific objectives.**
**source: author**

| NO | Comparative elements | Types of windows | | | | Notes |
|---|---|---|---|---|---|---|
| | | Vertical pivot | horizontal pivot (internal) | horizontal pivot (external) | vertical sliding window | |
| 1 | Natural lighting. | *** | * | * | *** | Relative value of Allow air flow easily, reducing the temperature of the interior spaces, is 100% greater than the rest of the values |
| 2 | Allow air flow easily. | *** | * | -- | *** | |
| 3 | Openings suitable to direction of north facades. | *** | -- | * | *** | |
| 4 | Reducing the temperature of the internal spaces. | *** | * | -- | *** | |
| 5 | Reduce the heat acquisition of building | *** | * | -- | *** | |
| 6 | Rationalize the energy consumption needed to cool and adapt the internal spaces | *** | * | -- | *** | |
| 7 | Easy maintenance | *** | *** | *** | *** | |
| Total of score points | | 21 | 8 | 5 | 21 | |
| The Best sequence | | 2 | 3 | 4 | 1 | |
| The decision | | | - | -- | √ | |

**Table (4) shows the making of the design decisions by choosing between the suitable designing alternatives for the Types of windows at north, eastern north, and western north facades (entrance the fresh air).**
**source: author**

| NO | Comparative elements | Types of windows | | | | Notes |
|---|---|---|---|---|---|---|
| | | Vertical pivot | horizontal pivot (internal) | horizontal pivot (external) | vertical sliding window | |
| 1 | Contribute to the achievement of natural lighting. | *** | * | * | *** | Relative value of Allow air flow easily, reducing the temperature of the interior spaces, is 100% greater than the rest of the values |
| 2 | Allow air flow easily. | * | * | *** | *** | |
| 3 | Openings suitable to direction of south facades. | -- | -- | *** | *** | |
| 4 | Reducing the temperature of the internal spaces. | * | * | *** | *** | |
| 5 | Reduce the heat acquisition of building | * | * | *** | *** | |
| 6 | Rationalize the energy consumption needed to cool and adapt the internal spaces | * | * | *** | *** | |
| 7 | Easy maintenance | *** | *** | *** | *** | |
| Total of score points | | 10 | 8 | 19 | 21 | |
| The Best sequence | | 4 | 3 | 2 | 1 | |
| The decision | | | - | | √ | |

**Table (5) shows the making of the design decisions by choosing between the suitable designing alternatives for the Types of windows at east, south, west facades (To entrance the hot air).**
**source: author**

| NO | Comparative elements | Types of windows | | | | Notes |
|---|---|---|---|---|---|---|
| | | Vertical pivot | horizontal pivot (internal) | horizontal pivot (external) | vertical sliding window | |
| 1 | Contribute to the achievement of natural lighting. | *** | * | * | *** | Relative value of Allow air flow easily, reducing the temperature of the interior spaces, is cavity is huge greater than the rest values |
| 2 | Allow air flow easily. | * | *** | * | *** | |
| 3 | Openings suitable to direction of south facades. | -- | *** | -- | *** | |
| 4 | Reducing the temperature of the internal spaces. | * | *** | * | *** | |
| 5 | Reduce the heat acquisition of building | * | *** | * | *** | |
| 6 | Rationalize the energy consumption needed to cool and adapt the internal spaces | * | *** | * | *** | |
| 7 | Easy maintenance | *** | *** | *** | *** | |
| Total of score points | | 10 | 19 | 8 | 21 | |
| The Best sequence | | 3 | 2 | 4 | 1 | |
| The decision | | | | | √ | |

**Table (6) shows the making of the design decisions by choosing between the suitable designing alternatives for the Types of windows at east, south, west facades (To hot air exit).**
**source: author**

| Windows Type | Vertical pivot | horizontal pivot (external) | horizontal pivot (internal) | vertical sliding window |
|---|---|---|---|---|
| 1- entrance the fresh air | 21 | 8 | 5 | 21 |
| 2- entrance the hot air | 10 | 8 | 19 | 21 |
| 3- Hot air exit | 10 | 19 | 8 | 21 |

**Table (7) vertical sliding window is suitable than other types.**
**source: author**

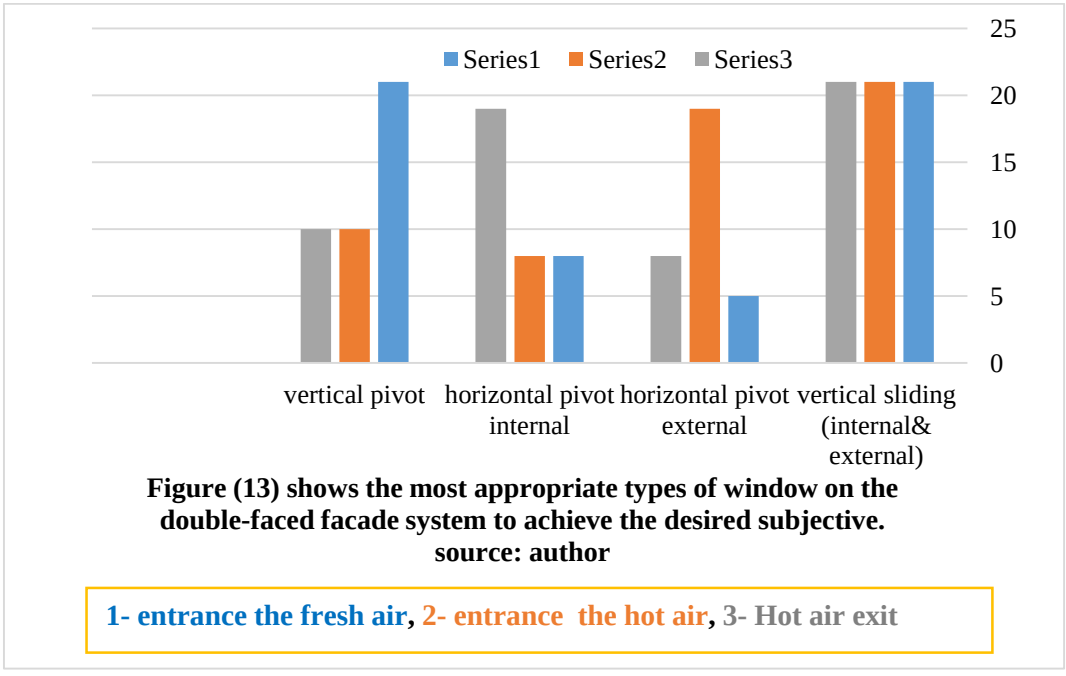



**Figure (13) shows the most appropriate types of window on the double-faced facade system to achieve the desired subjective.**
**source: author**

**1- entrance the fresh air, 2- entrance the hot air, 3- Hot air exit**

## 6. CONCLUSIONS:

**Through analysis and comparisons of research:**

7.1 The process of collecting and analyzing information is very important stage in planning to contribute to making the right decisions.

7.2. Making design decisions to manage the strategies of double-skin facades, enhances the likelihood of the best decisions by comparing them to other choices.

7.3. The opening of the windows differs according to the work strategies of double skin-facades.

The direction and position of the vents contribute to determining the direction of the airflow, thus contributing to reducing or increasing the temperature of the air in internal spaces.

The shape, position and direction of the windows contribute to the double skin-facades in the thermal or loss acquisition for interior spaces.

The best shape for the direction of the openings in double skin-facades is (vertical sliding window).

## 7. Recommendations:

- Windows positions, area and direction in each skin should be taken into consideration with the double skin facades system, and agree that with the system's operational strategies.
- The openings of the second and third type should be avoided to be use at the northern facades (horizontal pivot), and it is allowed to be used at the internal or external skin with precautions of hot air entry and exit.
- The northern facades best opening windows are (vertical pivot), where the best opening windows are (vertical sliding window).

## 8. LIST OF REFERENCES:

1. Alison, G, Walter T, 2007, The Green Studio Handbook, Environmental Strategies for Schematic Design Alison, first Edition, 42: 43.

2. H, Richard Heimrath, others, 2005, BESTFAÇADE, Best Practice for Double Skin Façades, p 23: 25.

3. Neveen, H, A, ISLAM, Non-Uniform Double Skin Façade Cavities, pp, 38.

4. G, Cristian, A, Francis, Natural Ventilation In Urban Environment Assessment and Design, second Edition, p, 147: 150.

5. Berge, B, translated by, Butters, C, & Henley, F 2009, "The Ecology Of Building Materials", Second edition, pp, 358, 359.

6. B, Zbigniew, 2009, Eco-Resorts: Planning and Design for the tropics, first edition, p, 132: 135.

7. Poirazis, H, 2006, "Double Skin Facades For Office Buildings", pp, 40.