# Skylight as a passive design strategy in Tunisian dwelling using BIM technology

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**Abstract**

In Tunisia, energy saving in construction has become a necessity. Currently, it occupies third place of 27% of the final national consumption. It will be the first in the head with a percentage of 33% in 2030. The decision-making of the climatic parameters at the preliminary design stage by the designer can reduce CO2 production and improve energy conservation. Therefore, the solar design must take advantage of solar radiation in an arid climate. A horizontal glass surface known as passive solar heating in the winter in which contributes to heating the space and reducing artificial lighting. This paper focuses to study skylight design using Revit architecture. The two conceptual mass modes with separated and grouped skylight are investigated. This study is based on based on Energy Use Intensity, Annual Energy Cost, and Life Cycle Energy Cost parameters to assess performance energetic and environmental of skylight system. The found results show that the skylight system improves the energy efficiency and life cycle of the building only if certain parameters of design are considered.

**Keywords:** Revit; skylight; design; sustainable

## 1.Introduction

Roofed atrium buildings first appeared in the 19th century as a result of the advancements in architectural technology in iron and glazing manufacturing [1]. The atrium has a popular form to allow penetration of daylight into a building and to act as focal points with a high sense of spaciousness [2]. The performance of daylighting has many aspects, including the comfort and health, visual function, use of energy and the economy, which are all high priority. As known daylight cannot be replaced by artificial light completely during the day. Glazing transmits daylight and solar heat gains. During heating period these thermal gains are welcome, but during cooling periods they increase the cooling load and thus the temperature of the room. Therefore, windows need light (glare) controls and solar (thermal) control, especially for conditions sunny clear sky. These are defined in many directions by the reduction factors (%) of light transmission and solar heat many theoretical and experimental studies have focused on increase the efficiency of skylight system, it takes account parameters such as Daylight Factor, Daylight Autonomy, and Useful Daylight Index.



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This research show magnitude of stores in solarium and active users that close the blinds as soon as they perceive glare risk [3]. In addition, reach 3% improvement in energy efficiency thanks to the controls of daylighting. This paper focuses on study Energy Use Intensity (EUI), Annual Energy Cost and Life Energy Cycle Cost of skylight system in Tunisian standard home using Revit architecture 2016. The literature review shows that BIM is rarely adopted in the developing country [4, 5, 6]. The advantages of this technology have been cited surveys have been carried out to determine the barriers and problems that prevent the adoption of BIM in the construction field [7, 8, 9, 10]. Thus, the parameters of cooperation, the development of trust and the lack of communication were investigated.

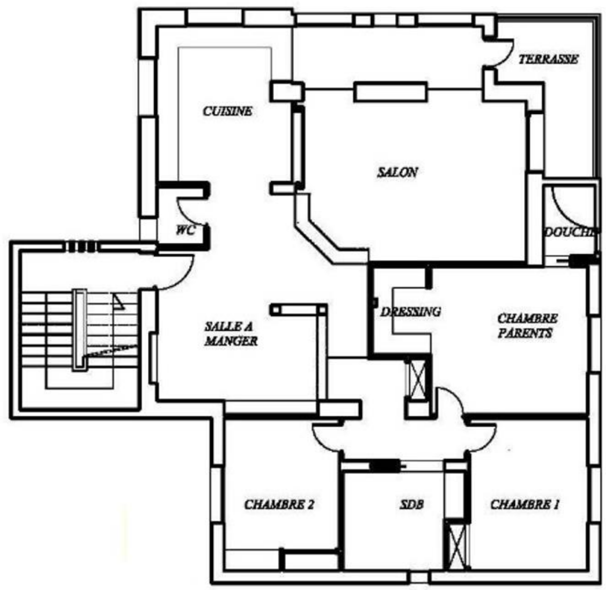


Figure 1– Plan of standard appartment in Tunisia

## 2. Study model

Skylights in a horizontal orientation are the most efficient for daylighting because it is setting up in the face of full sky's hemisphere of 180°, receiving relatively high luminance from its zenith. The window area of a skylight need only be 20% of the floor area for a daylight factor of 5%, compared to 50-60% for vertical openings in roofs or walls[3]. The light transmittance of skylights like windows is influenced by the type of glazing and the area of casement frames. Although additional requirements like thermal insulation and solar control have also to be fulfilled by the glazing, a high light transmittance and true color rendering are indispensable for daylighting. Our study is limited in Sousse city of Tunisia. In Sousse the period of heating and cooling concerning residential buildings are similar [11]. My selection is made for an apartment setting up in second floor “Fig 1”.

## 3. Input energy setting

This study needs to create an energetic model then to set “energy setting” workflow that specify different parameter like: common, detailed model parameter. After that, the Common and Energy Building Services parameters for model study were adjusted. By against, the parameters for Detailed Model and Energy Model setting are not similar.

**Common Parameters**



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Concerning common part of energy setting dialog box, is needed to specify a location and building type (residential) [12]. Figure5 shows the interface of "Common Part" features.

### Energy model Building Services

Energy model Building Services dialog box divides to different parts as: operation schedules, HVAC system, outdoor information.

### Operation Schedules

For this study model, a system that works half a year (12/7) for period heating has been chosen.

### HVAC System

A system for heating, 11 EER Packaged VAV, 84.5% heating boiler has been assumed

### Outdoor Air Information

According Roulet air renewal rate is sum of ventilation and infiltration [13]. This rate is considered steady in heating period that corresponds to 2.25 vol /h. According Ouartani air renewal rate is varying in summer [11]. During the daytime, she considered previous winter value but at night, she adds 10vol/h because, in cooling period occupant opens window at night to aerate his dwelling. Thus in summer air renewal rate is 12.25 vol /h. The outdoor air per area of a model is 2.18 l /s.m² in winter and spring. Meanwhile, in summer the outdoor we opt for 12 l /s.m² air exchange per area (table2).

### 3.1 Energy model

In order to design skylight system, a model is divided to 4 zones and is affected 3.5m to Core Offset of the model. In addition, in parameter energy model, is specified 30% percentage glazing and 1m ''target still height''. Moreover it is based on "massing site" panel and setting by surface for condition type. In this case, 5% percentage skylight and 1.17 m width and depth were selected. In "Conceptual Construction" dialog box, a Lightweight Mass Construction Low Insulation for Mass Exterior Wall for three tests were considered. A thermal quality of glazing is expressed by Solar Heat Gain Coefficient (SHGC) and Visible light transmittance (Tvis) [14]. SHGC coefficient depends on the climate, the building type, and the amount of glass. Tvis value performs amount of daylight. Concerning skylight model (Table 2 and Table 3), Double Pane clear- Low Emissivity, Low SHGC, were considered and divided the year to 3 periods according table 1.

- Period of cooling (summer) from July to October
- Period of heating (winter) from November to February.
- Period without conditioned system (springer) from Mars to June.

Table 1 –The detailed setting

| Simulation period | Condition Type |
|---|---|
| winter | 4Heated zones |
| Summer | 4Cooled zones |
| Spring | 1Natural vented only+3Unconditioned zones |



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| Mass Model | |
|---|---|
| Design Option | Main Model |
| Mass Exterior Wall | Lightweight Construction – No Insulation |
| Mass Interior Wall | Lightweight Construction – No Insulation |
| Mass Exterior Wall - Underground | High Mass Construction – No Insulation |
| Mass Roof | No Insulation - Dark Roof |
| Mass Floor | Lightweight Construction – No Insulation |
| Mass Slab | High Mass Construction – No Insulation |
| Mass Glazing | Single Pane Clear - No Coating |
| Mass Skylight | Single Pane - Tinted |
| Mass Shade | Basic Shade |
| Mass Opening | Air |

Figure 2– Conceptual Constructions workflow for skylight system

## 4. RESULT FOR SIMULATION

Energy analysis results of three tests using Conceptual Mass Mode show that annual energy use in standard house shown in as following:

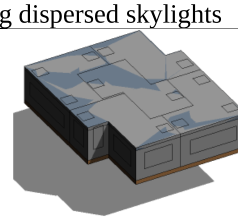
**Test 1**

Table 2 –Annual intensity of energy use

| Period of simulation | Condition Type | Outdoor air flow (l/m².s) | Annual EUI (MJ/m²/yr) |
|---|---|---|---|
| winter | 4H | 2,18 | 977 |
| Summer | 4C | 12 | 887 |
| Spring | 1NV+3UN | 2,18 | 395 |

**Test 2**

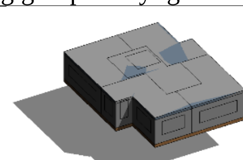
Table3 –Annual intensity of energy use using dispersed skylights



| Period of simulation | Annual EUI using dispersed skylights (MJ/m²/yr) | (EC)($) | LCEC |
|---|---|---|---|
| Winter | 1018 | 3634 | 49498 |
| Summer | 930 | 4573 | 62285 |
| Spring | 401 | 1474 | 20070 |

**Test 3**

Table4 –Annual intensity of energy use using grouped skylights



| Period of simulation | Annual EUI using grouped skylights | (EC)($) | LCEC |
|---|---|---|---|



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| | (MJ/m²/yr) | | |
|---|---|---|---|
| Winter | 1009 | 3601 | 49039 |
| Summer | 902 | 4421 | 60219 |
| Spring | 394 | 1444 | 19668 |

**Difference results between Test 2 and Test 3**

Table5 –Annual intensity of energy use between model without skylight and using grouped skylights of study model

| Period of simulation | Annual EUI without skylight (MJ/m²/yr) | Annual EUI grouped skylight (MJ/m²/yr) |
|---|---|---|
| winter | 977 | 1009 |
| Summer | 887 | 902 |
| Spring | 395 | 394 |

Table 2 and Table 3 show that in winter period a model without a skylight system is need lower energy than a model with a skylight system. Thus, dispersed skylight increases thermal heat leakage through glazing. In addition, test1, displays maximal load energy need, it exhibits in winter period. Moreover, to compare test 2 and test 3, the results shnow that Energy Use Intensity of grouped skylight design is better than dispersed skylights model. Indeed, Table 5 emphasizes on the difference of EUI between model without skylight and model with grouped skylight. It determines out that this difference decreases in winter and summer because of the leakage of heat load through skylight rises in these periods. Meanwhile, model with grouped skylight system is more efficient than a model without skylight in spring period. It is able to reduce EUI of skylight model in unconditioned period. However, EUI of our model without skylight remains lower than model with grouped skylight in heating and cooling period. Hence to improve this gap, is needed to reduce the leakage of heat load through roof glazing. Therefore, a thermal quality of skylight system should be improved. In addition, roof skylight supplies high illuminance levels [15]. It is more efficient in heating period than cooling period. It is able to create uncomfortable solar glare if glare value is too high and the glass area is large. If the value is too low and the glass area is too small, it do not get the benefit of natural daylight. Obaidi indicated that the skylights with reflectors have the best overall daylight and thermal performance among all the systems [15]. Figure 3 displays that skylight system can deliver both good daylight illumination and an effect of depth in the interior space

Figure 3–Skylight system in the roof of the Carthage hall, Bardo Museum



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Revit workflow possesses selective coatings allow high Tvis and low SHGC as following:

**Test 4**

Table6 –Influence of improvement of skylight glazing and EUI in winter period

| Conceptual Construction | U W/(m² • °K) | SHGC | Tvis | EUI (MJ/m²/yr) | (EC)($) | LCEC ($) |
|---|---|---|---|---|---|---|
| Double Pane Clear – LowE (Emissivity), Hot Climate, Low SHGC | 1.68 | 0.44 | 0.70 | 989 | 3521 | 47962 |
| Double Pane Clear - High Performance, LowE, High Tvis, Low SHGC | 1.63 | 0.27 | 0.64 | 982 | 3487 | 47490 |
| Double Pane - Reflective | 2.40 | 0.19 | 0.10 | 985 | 3496 | 47610 |
| Triple Pane Clear - LowE Hot | 0.22 | 0.47 | 0.64 | 990 | 3529 | 48063 |

Table7 –Influence of improvement of skylight glazing and EUI in summer period

| Conceptual Construction | U W/(m² • °K) | SHGC | Tvis | EUI (MJ/m²/yr) in winter | EC ($) | LCEC ($) |
|---|---|---|---|---|---|---|
| Double Pane Clear – LowE (Emissivity), Hot Climate, Low SHGC | 1.68 | 0.44 | 0.70 | 894 | 4377 | 59617 |
| Double Pane Clear - High Performance, LowE, High Tvis, Low SHGC | 1.63 | 0.27 | 0.64 | 890 | 4356 | 59334 |
| Double Pane - Reflective | 2.40 | 0.19 | 0.10 | 890 | 4359 | 59370 |
| Triple Pane Clear - LowE Hot | 0.22 | 0.47 | 0.64 | 895 | 4383 | 59694 |

**Test 5**

Table8 –Best improvement using mass glazing, exterior wall and skylight system ( EUI, AEC and LEC in cooling period).

| Description of conceptual construction parameters | Period of simulation | EUI (MJ/m²/yr) | (EC) ($) | LCEC ($) |
|---|---|---|---|---|
| Lightweight Construction with low insulation + Double Pane Clear - High Performance, LowE, High Tvis, Low SHGC + Roof mass construction with low insulation | winter | 701 | 2605 | 35484 |
| | Summer | 784 | 3784 | 51540 |

Furthermore, table 6 shows that each glazing provides energy rating. For heating period the best improvement EUI is shown for Double Pane Clear - High Performance, LowE, High Tvis, and Low SHGC. This Conceptual Construction has 0.27 as SHGC and 0.64 as Tvis. Moreover, this glazing provides 3487$ as Annual Energy Cost (EC) and 47490$ as Life Cycle Energy Cost (LCEC). LCEC value corresponds to Fuel amount of our analyzed model may use during 30 years period. Regarding Table 6, AEC and LCEC previous values present the lowest



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values in heating period. In order to find the best possible solution in cooling period using skylight, a similar variety of glazing used previously have to be generated, which are then reduced by assessment. Findings results in Table 7 show that “Double Pane - Reflective” and “Double Pane Clear - High Performance, LowE, High Tvis, and Low SHGC” reduce EUI in cooling period. Meanwhile, glazing that named a last one; it assigns lowest LECC and AEC value. Despite prior improvements energy use intensity rest low during cooling and heating period. Therefore, this study needs to mix different strategies in order to improve energy saving EUI, EC, and LCEC using skylight system. Then, to use Double Pane Clear High Performance Low E High Tvis, low SHGC that provides a compromise between Tvis and SHGC value then lightweight mass exterior wall with low insulation and finally low mass roof insulation. The findings results in test 5 shows that combined improvement able to reduce EUI, EC and LCEC of skylight system in cooling and heating period. Moreover, all prior tests show that annual EC and LCEC for 30 years are higher in cooling period than heating period.

## 5. Conclusions

This paper aims to assess Energy Use Intensity, Annual Energy Cost and Life Cycle Energy Cost of skylight system in Tunisian standard home using Revit simualtion in heating and cooling period. Test 2 and 3 show that gouped skylight is more efficient than dispersed skylight system. Findings results for Test 4 determine out that glazing kind, “Double Pane Clear - High Performance, LowE, High Tvis, and Low SHGC” presents a compromis value between SHGC coefficient as Tvis value. Despite prior improvements EUI, EC, LCEC remain higher than energy needed of our dwelling model without skylight system. Meanwhile, combined vary strategies like lightweight roof insulation and taken account SHGC, Tvis glazing value is essential. Therefore, is identified that last strategies enable to reduce EUI, EC, LCEC. As a result, mixed strategies allow 10% EUI save in cooled period and 28% in heated period. Further that, Revit shows that natural daylighting based on skylight system promotes energy saving. Thus, it increases building suistanability in Tunisian climate condition only with a compromise between Tvis value and SHGC value and with roof insulation, it enables to carried out environment suistanaibility in heating and cooling period only with accurate improvements. In future research work, the study of the thermal efficiency of the skylight of the Bardo Museum using Revit will be proposed to expand the investigative compaign.

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