

Employing auxiliary natural lighting systems within the elements of traditional buildings: A special study on employing one of the auxiliary lighting techniques within one of the elements of a mosque in the ancient urban fabric

Alaa Hadi Ubaid

Department of Architecture, University of Babylon, Babylon - Iraq

ABSTRACT

Technological development is considered one of the most important influences that contributed to the change of some design elements (formal and functional), both or each. Among these elements is the minaret. This was evident in the old urban fabric, and because of the existence of other basic reasons in the traditional fabric, including the increase in the population of the weaving area, which led to the dispensation of the inner courtyard. It had changed from an element that has a shape and function to an element that has a shape only, to indicate the presence of a mosque this was evident in the old urban fabric .Due to the presence of other essential causes in the traditional fabric like the increase in population among the inhabitants of the fabric which led to neglecting the internal area , moreover climate change led to the use of window openings as outlets for air conditioning instruments ,the researcher employed the minaret to enable sunlight enter the inner space of the mosque (prayer space) due to the importance of natural sunlight effect on people's psychological and physiological health . This research was conducted in a clear sky of Babil province for latitude of (32.8) north, small samples were made measuring 1:20 for the minaret and the mosque space, a device for measuring the sunlight amount (Multi-Function Environment Meter 4IN1) was used . Results showed an increase in natural sunlight reflected inside the space of the mosque. This study came out with the following recommendations, the importance of employing the archeological elements which their functions were altered by technological growth to enhance the internal environment with the finding of solutions to the amount of harmony in distributing sunlight (distributing natural sunlight harmoniously)

Keywords: Natural Sunlight Technology, Minaret, Traditional Cultural Fabric, Mosque, Metaphor, Communication, Internal Homogeneity of Lighting Levels

Corresponding Author:

Alaa Hadi Ubaid
Department of Architecture, University of Babylon,
Babylon – Iraq
Email: eng.alaa.hadi@uobabylon.edu.iq

1. Introduction

The idea of traditional city planning is not based on specific divisions of land use in areas allocated for that uses or places allocated for each class of society it works as one unit with one center, all main streets go to its center (AL-shahean-P 49). The internal spaces of an Arabian city are connected organically related to one another forming the urban fabric. Through the integration of functions which make houses, markets and mosques connected elements with each other, they are subject to a strict functional system (AL-shahean-P 49). The new technological development, the development of ways of old building to new ways of building, the increase in population and climate change all these factors greatly affected the cultural land marks of the ancient urban fabric of the Arabian city. (The architectural type of the old urban fabric). In terms of architectural concepts and elements the inside courtyard lost its essential function by neglecting some of its elements. And because of the increase in population and the climate change it was used in other purposes. It was covered by a roof using the

covered area as an additional place for the other different building, in their different functions which led to emerging big negatives inside the spaces due to the lack of natural lighting in the inner spaces. Natural light is very important for people's health and it has positive psychological and physiological health benefits on the first place. As for the technological elements of building of the urban fabric related to this research, which also deals with the small mosques buildings (Hussainiat) distributed among the old urban fabric which is the minaret element, Due to the technological growth and the use of amplifiers. the minaret became a landmark that mark the presence of a mosque without any other function mentioned as in Figure 1 Which led me to employ the structure in a way that cope with the technological growth without leading to change its shape. (Yasir Blasma).



Figure 1. describes the change in the minaret function from the climbing of the caller for prayers on it to call for the prayers to a sign of the existence of a mosque within the old urban fabric

This humble research was completed as follow: -

- 1- Employing one of the elements of the vertical natural lighting technology in the body of the minaret to enable natural lighting to reach the internal space without altering the outside shape of the minaret.
- 2- Study the change in lighting, these technologies can alter in sunlight inside the space of the mosque especially in winter.
- 3- The amount of homogeneity in distributing reflected sunlight that can reach the internal space of the mosque.

2. Related work

Adeky's Study 2013, This study dealt with the ways to produce buildings that combine between the traditional heritage of the urban fabric and the modern technical materials to achieve communication and overlap between the modern building materials and the traditional elements and materials to achieve rich architecture with meanings that can reserve the community and keeping pace with rapid technology development meeting pupils need without losing the identity of the society .(Adekeye page I).

Kipinis Study 1997, which referred to the mentioned formulation of the old formal elements in a new modern form by adopting contemporary technological applications to reach the best results. In the end it is always acceptable. (Kipinis)

Saleem and Abdulhameeds Study 2017, This study referred to the implementation of light pipes system technology to enhance the environmental society in the teaching buildings and connecting them functionally with the traditional systems (windows) to provide good environmental conditions that contribute to provide the feeling of sociological rest and enhance the level of lighting inside the teaching spaces. (Saleem 2017 page 41).

Al-Kreiza Study. Ibrahim and Mubarak. 2017, this study tried to connect between the work of technology and its effect on local architecture; therefor, the presence of technology in an effective way in the fields of designing and the technologies of modern building which led to some problems keeping the local architecture due to what technology has reviled some modern different elements. The need for combining these elements within the local architecture through the strategy of sourcing using technology as a basement that contribute in finding and creating new structures that carries essential of values to provide a modern local architecture using Analytical methods for the result selected in the study. (AL-kreiza from page 4-118 summary).

After presenting the previous studies at all they had studied of rooting vocabulary, technology and employing them. the study has taken for granted in a practical way the combination of one of the elements with one of the

elements of the traditional urban fabric. For one of the districts of Hilla city to provide environmental conditions for the inner prayer space of the mosque to enhance the level of its illumination. On this base condition the minaret element was selected to implement the technology of illumination without affecting as much as possible its shape and its external appearance. (AL-kreiza from page 4-118 summary).

The lack of natural lighting in the prayer space in the mosque which is located within the old urban fabric of the area selected for this study. (the district of Al-Jammeain) due to the cluster of buildings, the narrow windows and the narrow alleys in mosques from the open areas to each mosque (the inner court yard) which led to covering it and attaching it to the prayer area that led to its roofing and its annexation to the prayer space.(as in Figure 2) (The Researcher Satellite).

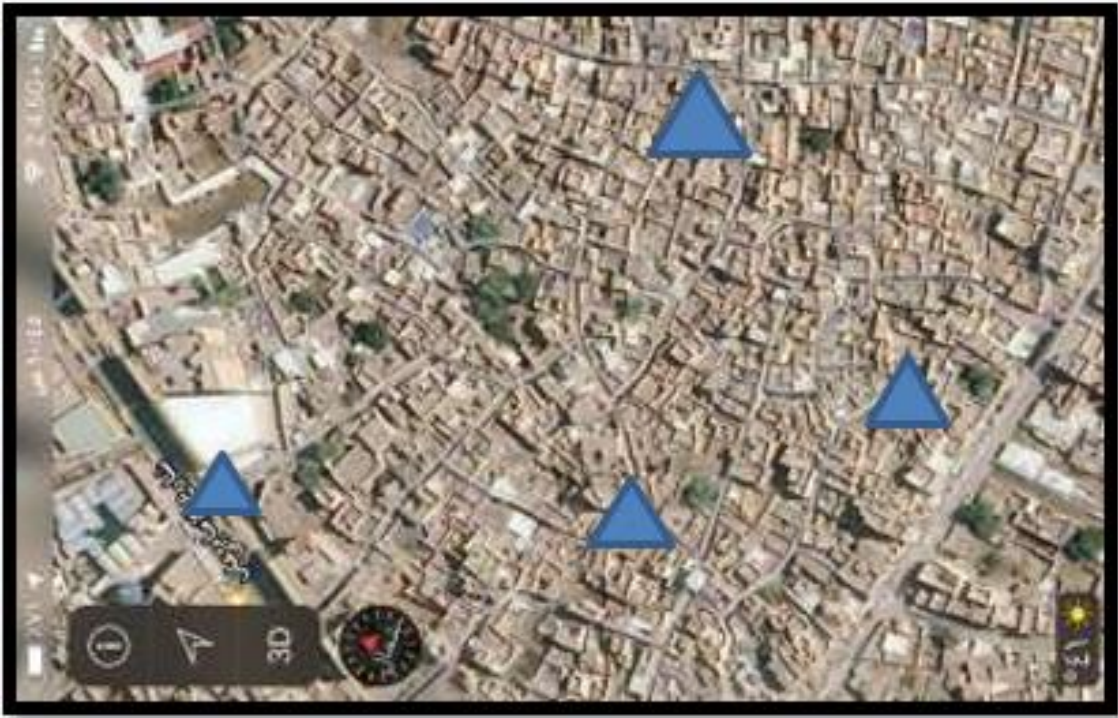


Figure 2. Describes the aerial plan of the study area .and indicate the Mosques in blue triangles

3. The minaret

Studies described the minaret as an architectural unit directed above and built, it is a sign of the existence of a mosque, The sound calling for the five times prayers comes from it to inform the inhabitants for the five times of prayers. After the Islamic conquests it was distributed everywhere in the world where Islam is dominating in all the Islamic cities and their streets, alleys, and open areas the minarets were erected as large flags that the caller for prayers descend them to remind the inhabitants for one of the five times of prayers to tell the people around the mosque of the place of prayers. With the development and new modern technology, it was changed. No longer the caller descend the minaret to call for the time of prayers using his own sound, instead of descending the long stairs inside the mineral, the electric cable was used to deliver the sound to the top of the minaret. Using amplifiers. Where the caller calls for the prayer from the prayer space (niche) In the mosque therefore the need for climbing the stairs inside the minaret was left. The minaret stayed as one of the elements of the mosque and a sign of its shape and a mark for its existence. Nowadays the height of minarets reached to (210 m) in Al-Hassan the Second in Morocco and (130) in Cairo Egypt. And (92 m) in Mecca Al-Mucaroma (Muhammed- P1)

3.1 History of the existence of the minaret emergence

The minaret was constructed from the tower built on the pillars of the mosque the silos are the nearest structures to the pillars.in size. As for minarets they were smaller in size, and it may be lower in height. Using the pronunciation of minaret indicates that the minarets were Architectural buildings borrowed from the lighthouses that were established on the coasts or on the steps of mountains in the ancient times. The two structures where boned (silos and minarets) where existed the minarets of the first mosques. (Hussain page 114) Figure 3 represent.

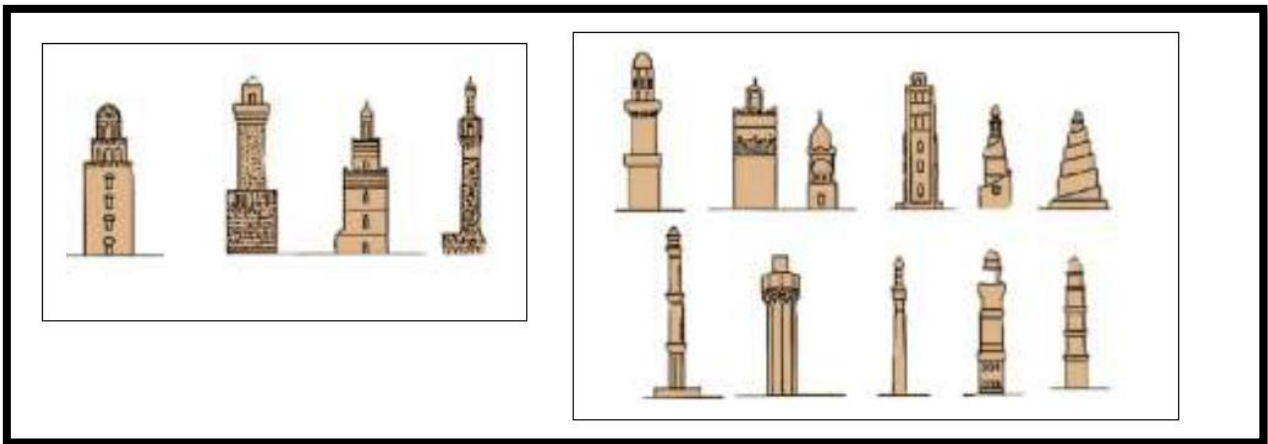


Figure 3. Types of minarets

3.2 Basics of minaret design (parts of the minaret)

The minaret consists of the following parts as follows in order from bottom to top.

1. The base (the foundation)
2. The rectangle square body
3. The balcony
4. The handrail.
5. A pillar from the handrail.
6. Round body. (Hussain page 115).as fig. no. (4)

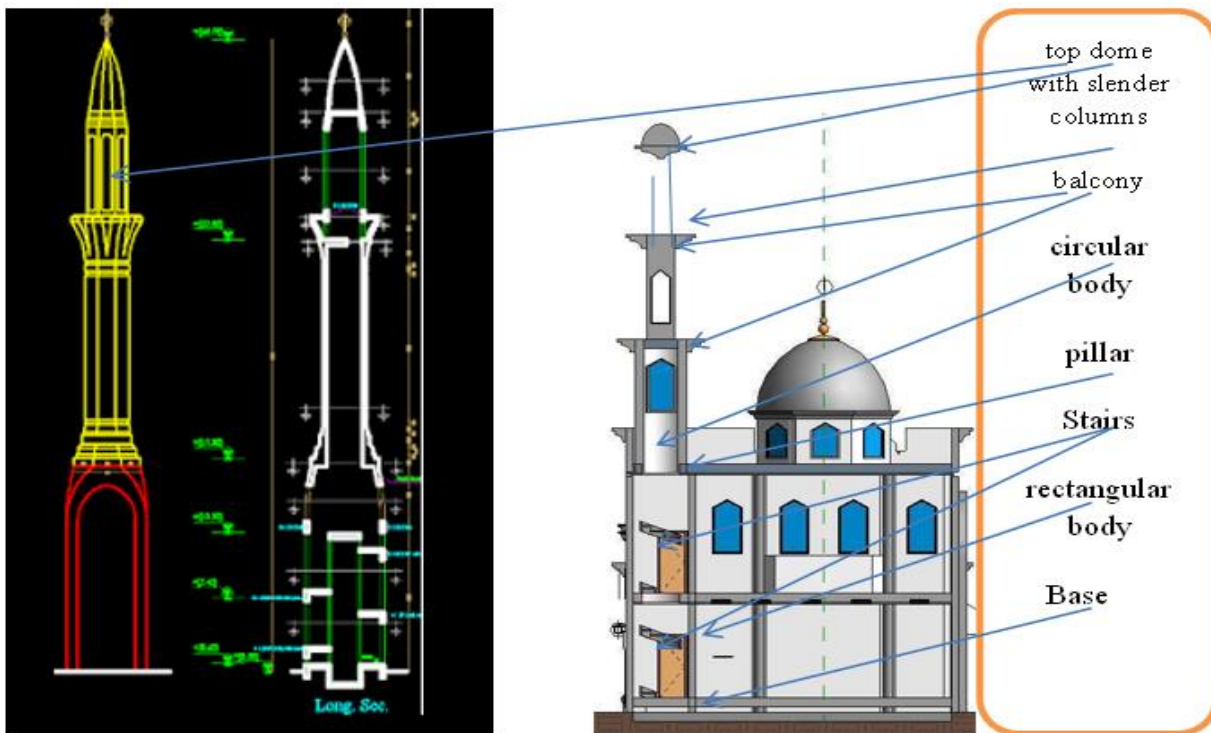


Figure 4. Describes a detail of the body of the minaret

3.3 Current changes happened in the body of the minaret.

due to the technological development happened in the world in general this resulted in the dispense of some of the elements that the caller for prayers (Al- Mueathin) used to do. Climb to the balcony of the minaret to call for the time of prayers this was neglected by putting the amplifiers in addition to technological growth that happened to the building materials which led to a decrease in the area of the minaret in the horizontal side. (The minaret plan) the diameter. On the other side the inner stairs inside the minaret became from steel. Leaving a circular space put on one side of the cylinder body. In most

cases the stairs was neglected the minaret became only an outer structure (external shape) (landmark) that indicates the presence of a mosque and the body of the pipe is empty from any part of it is like a small tower the amplifiers put on as Figure 5.



Figure 5. Transformation of the body of the minaret from a building to a shell made of metal only

4. Natural lighting in the old architectural fabric

As it was found the reality of the situation:

When having a look at the depth of the spaces of the mosque in the old fabric which has increased in depth especially when the people living around them covered the inner space in addition to close most of the window openings With air conditioning gadgets taking into account that the height of the windows is about (2.5 m) above from the base of the spaces it resulted that the deep spaces became in a depth about (7.5m) and above which led to the absence of natural lighting (sun lighting) to the space of the mosque . Sometimes when the minaret was neglected, some towers were used to fix the amplifiers for the call for prayers as in Figure 6 (the Researcher). To enable the building to have, as possible, natural lighting using the less of Artificial lighting there are ways made to provide natural lighting coming from the openings and vertical windows as the ordinary light wells. And the light wells with mirrors and the optical fibers systems that carries the light beams and lighting pipes. Which was associated with the roots of the buildings. In their designing the distribution of natural lighting was taken into account over the level of work bench to ovoid dazzling (AL-Gawady P12/7- P1/7 page).



Figure 6. Clarifies the reality of the mosques in the old urban fabric

implementing one of these ways is very important to highlight some of the concepts that describe and increase the efficiency of these technologies:

4.1 Behavior of natural sunlight

The natural sunlight reaching from the earth to the inner space of the mosque comes through three sources: The direct sunlight 2. the scattered lighting 3. Sky light reflected from the direct earth surface and the outdoor equipment (Koenigsberger page 7). In the hot dry areas and with the effect of direct sunlight of high heat loads caused by this sunlight ; therefore, people try to find natural sunlight for their buildings without affecting the heat comfort to a great expense and not accepted they reduced the number of windows openings ,the width of the inhabited alleys with the increase of their depth especially in the old urban fabric to provide comfortable

spaces and alleys from the heat side as possible especially in the critical times of hot summer. (AL-Ashaab P I).

4.2 Natural sun lighting in deep spaces

Experiments proved that the level of illumination at the end of the room facing a window is decreased as the depth of the room increased(when the height of the room and the shape of the window are the same) This is due to the small area that can be seen from the sky dome and if we put the window in a higher place close to the roof in these spaces it will enable the sunlight reach to the other places inside these spaces until the depth of the space reaches three times the height of the window. Room depth beyond this range requires supplemental artificial lighting (AL-Gawady - p 4-8).

4.3 Internal surfaces reflectivity of spaces

The roof is the most important element to control the inside day lighting its reflectivity reaches 70% to the light beams falling on it, comes after it the back wall that faces the window and in the third place the side walls and the fourth is the ground (12-page 27).

This helps the designer to color the roof or ding it in a light color as possible. and the table NO I. Shows the reflection coefficients of surfaces of interior spaces which can form a leader that constitutes a guide in this regard.

Table I. shows the amounts of reflectivity of the colors of some of materials used in interior buildings (Egan - page 27)

Its reflectivity	The color of the substance
85	White
82	Pale yellow
70	Shining yellow
54	Pale orange
45	Pale blue
28	Shining orange
17	Shining red
9	Dark green
5	Black

4.4 Reflective mirrors

Mirrors are considered the best means that reflect and provide sunlight to the close places that natural lighting does not reach them. Which can be used in the systems of solar patties. To reflect sunlight to the deep spaces which sun light cannot reach especially in winter to avoid the increase in heat load inside these spaces in summer. These were used as a completion part to solve the problems of urban space in this study (Research) the Researcher will constate on the use of mirrors within the technologies of optics for the environmental remedy to provide extra light for some of the spaces of the building of the urban fabric (The inner space of the mosque) In winter only (Shaaban- page 7).

4.5 Plane mirror's work system (reflectors) (the real sun and the imaginary sun)

If a blame of light fall from the sun (AB) on a reflecting surface (a plane mirror) as in Figure 7 it will be reflected in the direction (BE) in an angle . that's to say the falling angle (ABD) incidence angle is equal to the reflecting angle (BDC) Reflecting angle as the column (BD) represent the column on the mirrors surface. If the line AB stretched inside the mirror it will fell on the ground (the horizontal level) making angle (AL) it is the height angle of the sun in that time. (Altitude angle)

When the straight-line CB is extended inside the mirror it is the reflected beam (ray) it will meet the virtual picture of the sun inside the mirror (this picture is called (virtual angle) The beam ray (CB) which is considered from the virtual sun it will make, in this case, with the horizontal level an angle called. The angle of the height of the virtual sun (ALV)(Altitude angle for virtual sun). This angle is equal to angle (AL) when the mirror is vertical on the horizontal surface (Shaaban - page7) in case when the mirror is tilt from the horizon in every

angle except (90°) the value of (ALV) angle will not be equal to (AL-) angle due to the difference in the location of the virtual sun. on condition to fix. the site of the sun and change the side and direction the vertical line on the mirror according to the tilt of the mirror which leads to the change of the sun on the mirror the result will be a new reflectance angle which can be seen on the line vertical in mirror As in Figure 7 (AL- Mustanssereye - P 3)

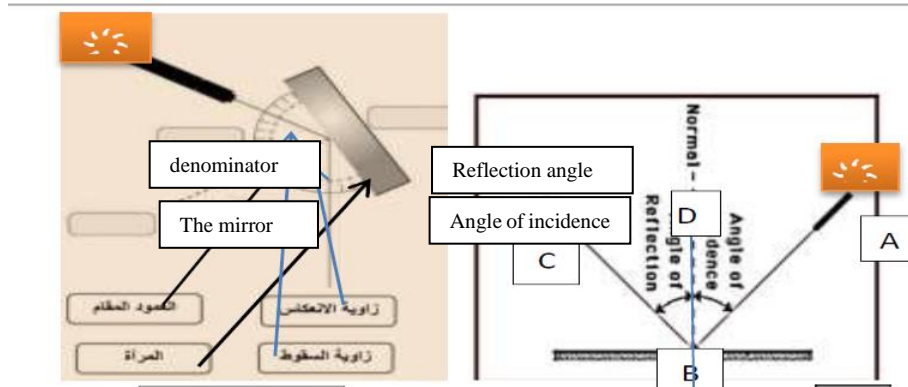


Figure 7. Demonstrates the work of horizontal and inclined plane mirrors

4.6 Concave mirror

It is a recessive mirror simi – spherical mirror made in a shape of a cut in a ball or in the shape of parabola. It is called a mirror of a parabola if the rays fall inside the mirror the rays will be reflected on its carved surface and gathered in a point called focus or on the contrary if we put a lamp inside the focus of the mirror and the rays are reflected on the surface of the concaved mirror the rays will be reflected as in Figure 8 (Concave Mirror - page 370).

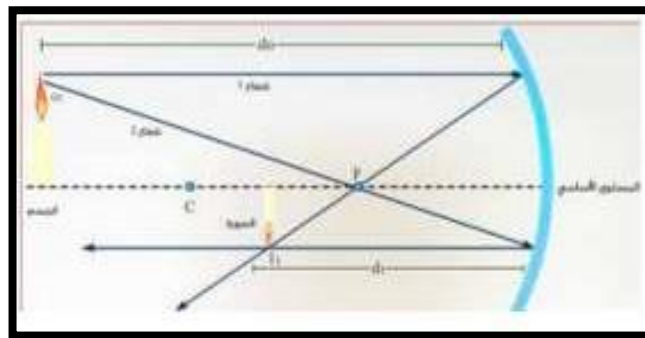


Figure 8. describes the way the concaved mirror works

4.7 Specifications of the mirrors used

No longer the mirrors used in the solar energy or in Architecture from the traditional type of died glass in tin because of its heavy weight and fragility in addition to its heavy weight and its fast decay in the outside conditions, in place of them alternatives were used instead of them. These were according to their reflexivity as in the table No.2 below (Egan - page 27).

Table 2. describes the reflexivity of some known materials (Egan - page 27)

Material	Reflectance
White plaster	90-92
Acrylic mirror	92% → more
Mirrored glass	80 → 90 →
Matte white paint	75 → 90
Polished Aluminum	60 → 70
Porcelain enamel	60→90
Aluminum paint	60→70
Stainless steel	55 → 65

Acrylic reflectance mirrors were used due to their high specifications in reflecting light. It reflects light in the best way and the best of all glass is a friend to the environment. (environmental friendly) can resist ultra (UV) , light does not break easily it can be fixed easily according to the space needed to be covered with it especially in well lighting wells and manipulators when making samples Arch. Samples and experimental samples (Dhuaacrylic).

5. Technologies of the vertical helping lighting systems

It is meant by vertical tech systems the helping systems which provide natural lighting from the top of the building sending it to the dark deep spaces and the aim of choosing the vertical in specific is to simulate the vertical shape of the minaret trying to mix them these technologies are: -

5.1 Mirror sun lighting systems

Mirror sun lighting system consist of as in Figure 9 from A (hydrostat) lenses and mirrors all these elements arranged according to a special statistic to deliver daylight to narrow spaces in buildings especially those built under ground. The aim (targets) of this system use to reduce their number of openings windows. Opened to the outside this at the end leads to reduce heat gain especially in summer as for winter normal mirrors are used to increase heat gain coal mirrors are used in this system which divide and extract the UV sunbeams from the sun spectrum (heat) and enables the seen beams to be seen which reduced heat gain in summer. In winter normal mirrors are used to increase heat gain in the field of lighting this system helps to reduce the need for artificial lighting during the day for this space where it helps to the rationalization of electrical energy (Bennett - Page 37). As For the Heliostat It Was equipped with a playback device it was suppressed from the conditions as rain, winds and dust which reduce its efficiency to prevent the direct rays of the sun (Bennett - page 37). All the lenses are arranged so that each lens reflect the picture from the previous lens and send it to the one that follows. The first lens is lighted next regularly by the rays coming from the (Heliostat) and send an amplified picture of the rays to the second mirror (lens) which consequently sends the picture as it is to the third lens therefore each lens has got an even number has an amplified picture for rays of the sun and each lens has a key number has a picture from the first lens (Clear - page 10).

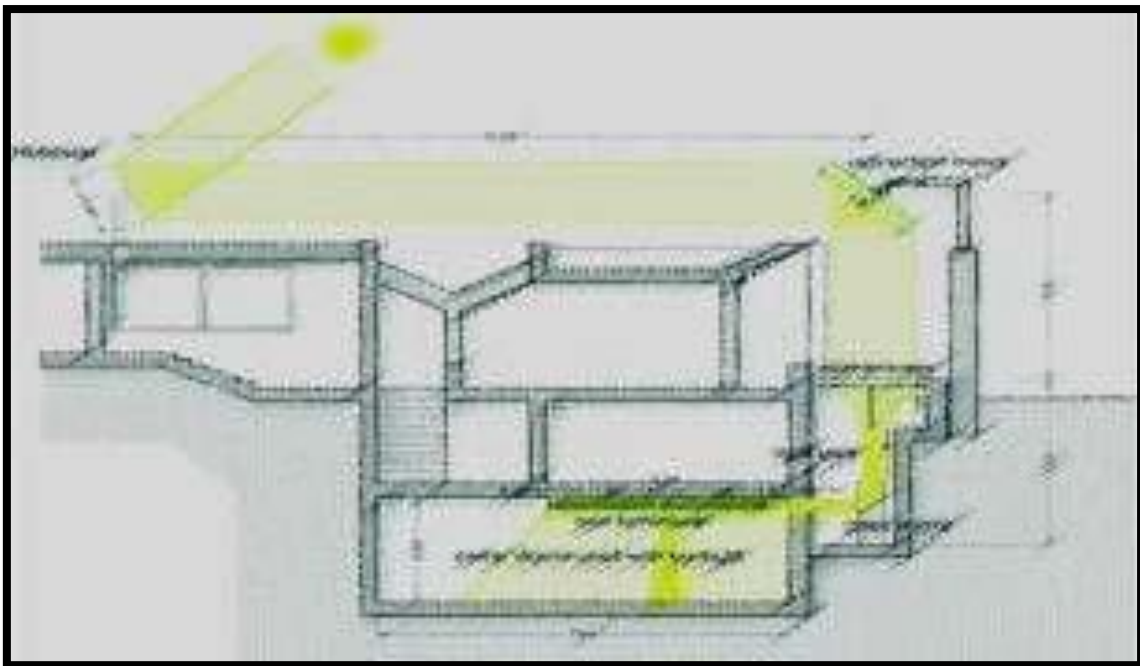


Figure 9. A section in a building describes the use of solar optics system

5.2 Vertical photovoltaic tube systems

A cluster of tubes scattered on the surface of the space with an inner surface with high reflexivity therefore light travel along them with less losses as in Figure 10 the tube brings the natural lighting to almost of the deep areas inside the building the sunlight come through the high clear dome and reflected down in the metal tube which is as a mirror. Reaching to prismatic roof diffuser which the light regularly all over the room where is this natural high tube illumination and good shape to each building or shop. (Hansen - page 64) Explains.

5.3 Light tube system

This include holes in the buildings walls or attached to it that collect light and deliver it by reflections inside the role in the wall as in Figure 11 sometimes that collect light and direct it to the space or windows on the tunnel as in Figure 11 (AL-Badry - page48 a)



Figure 10. describes the light tube and its installation on the roof of the building (Hansen - page 64)

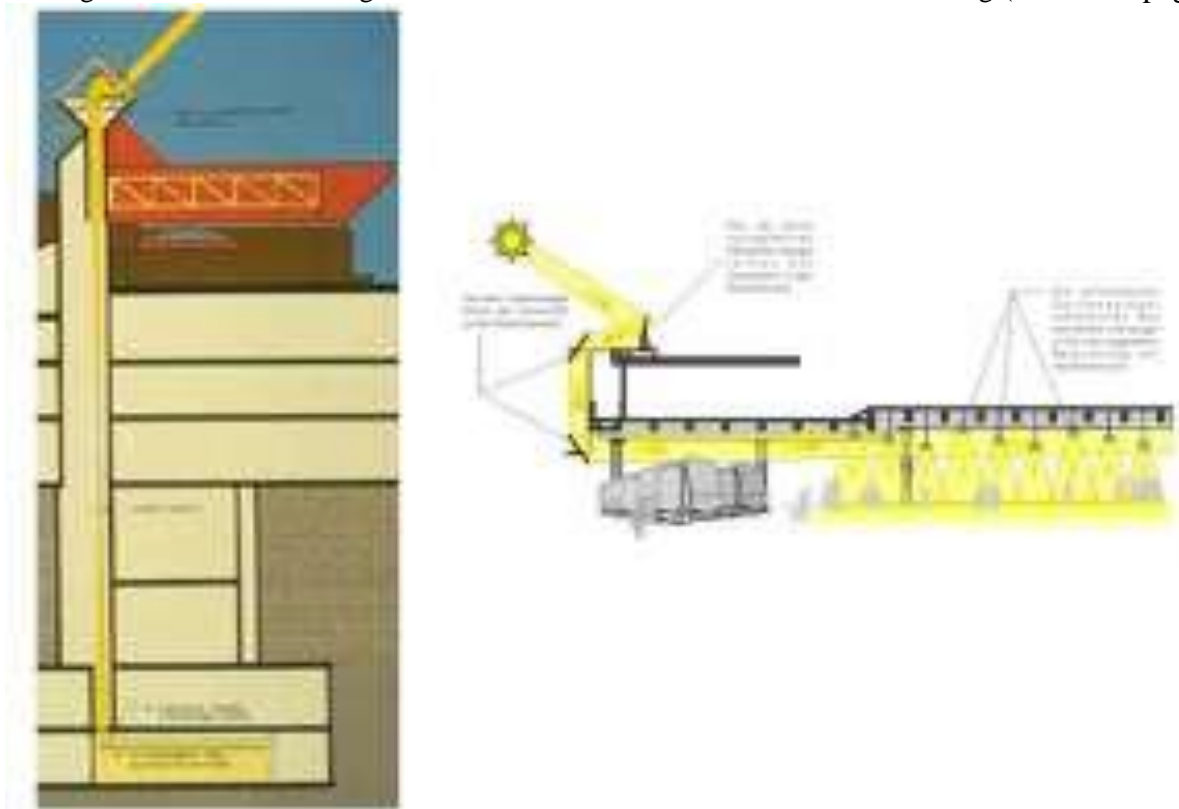


Figure 11. Building with a light tube

5.4 The metaphor mechanism and functional transformation of the form of architectural element

In this case it comes in building the function of a sample (we refer to the element of the minaret in this) from another sample. According to the mechanizing of communication the outer shape of the minaret was borrowed to enforce the technologies in it regarding them as essential Functional characteristics forewords for the metaphor existed, they are Target, catalyst, source, and relationship. (AL – Jumaily - from p. 50 to p. 69), The target is to improve the shape of the minaret from the functional side because the new modern development of the minaret became without any function the minaret was found for. Only the shape leading to the presence of a mosque. As for the catalyst for the metaphor it is the solving of environmental problems (provide natural lighting) to the inside of mosques with limited areas which are located within the traditional urban fabric employing technology to serve society in the old urban fabric in a way that doesn't affect the old elements or

demolish them. (The Researcher). As for the source of the metaphor though the sides of metaphor are three, they are the borrowed, the borrowed to and the borrowed from (Laffy - page 7), Which represent the source and the part borrowed from the source and the source borrowed to are the technologies of natural lighting specified and mentioned above. The parts borrowed are as in the following graph in Tab.No 3.

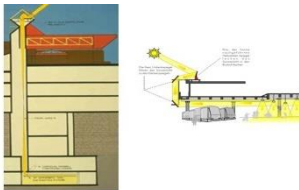
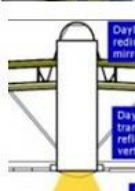
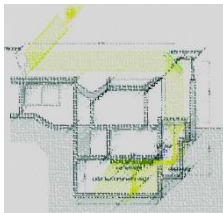


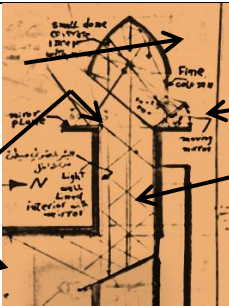

<p>3-photovoltaic well system Shortening the path of the rays with a change in its inclination to send the rays to the interior of the upper dome of the minaret, which contains the concave mirror, to send the rays in turn to the bottom of the well</p> 	<p>2- lighting tube Metaphor a tube coated with a mirror material</p> 	<p>1-solar optics system Borrowing the tunnel and reflecting mirrors, opening the paths of the reflected rays, the height of the light tunnel, choosing the type of reflectors and simulating them</p> 	<p>Metaphor from</p> <p>Technologies borrowed from</p>
<p>Deleting the pointed part and replace it with thin columns to raise the dome of the minaret above it</p>  <p>In addition to lining the dome of the muzzin with mirrors to turn it into concave mirror</p>			<p>Metaphor For</p> 
<p>concave mirror</p> <p>Mirror surface</p> <p>Mirror inclined with 25</p>		<p>Movable mirror</p> <p>Mirror inner surface</p>	<p>The result after metaphor process</p> 

Table 3. describes the process of metaphor of vertical lighting technologies to enforce it inside the body of the minaret (The Researcher)

6. The practical side

After the process of metaphor from the systems of lighting and enforcing it inside the body of the minaret in a way that doesn't affect the outer shape of it, we reach to select the final model from the side of its efficiency reflected natural to transfer lighting to the inside space of the mosque (The Researcher).

6.1 The method of calculating the natural lighting inside the mosque

To calculate the natural lighting inside the mosque using the (4 in 1) multi-functional environmental meter.) And also the use of the model on a scale of (1/20) under the natural sky pure sky this model consists of the following. A space of (11m.) length and its width (5 m.) Its Height. (4. m) as is the distance (11 m.) is the length of the

enclosed court (which is dismissed which is equal to (5. m) added to it the length of the prayer*s space which faces the court and which is 6 m) And the minaret is closed to its side (5.m) from the inside space of the mosque a minaret of a drawing scale of (1/20) its height is about, from the ground of the mosque to the highest part of it, is (10m.) As for the height of the minaret balcony is (5 m .) above the roof of the mosque the minaret top is like a small dome above the balcony about (1.70 m.)and its diameter dimensions are (1.20m.) which cover the light receptor completely. The dome is based on the balcony by thin rods (which are neglected in the model) as in Figure 12 (The Researcher) As for the inner body of the minaret the new technology was used in its designs and building on condition not to be outside the body of the minaret. where the thick stent which the stairs stand on was altered into the light well (light stand) with the use of two measures of the states in two cases (the Researcher). The first case is to keep the service stairs inside the light well where the width of the stairs is (0.60m) as hypothetical distance for one person only, according to the ratio used in architectural designs. It starts from the roof of the mosque. As for the diameter of the well it is (0.60 m) as a hypothetical distance it starts from the balcony of the minaret with the moving mirror surface to make the total diameter of the minaret over the roof of the mosque about (1.20 m) (the Researcher). The second case is when the diameter of the light well is (1.m) as a hypothetical inner distance that starts from the balcony of the minaret with the moving mirror surface and opened on the plane mirror situated inside the mosque's space taking all the diameter of the minaret which is about (1 .20 m) (The Researcher) .

The opening of the well ends in the top with the balcony with the reflecting roof mirror that moves and reflect light. As from the bottom it ends in a step put on it a mirror opened to the space of the mosque The height of the step, the mirror and the opening is (2.80 m) from the level of the inner mosque's ground. (About the level of the heads of the prayers. It is lower than the roof of the mosque about (1,20m.) As in Figure 13. (The Researcher.)

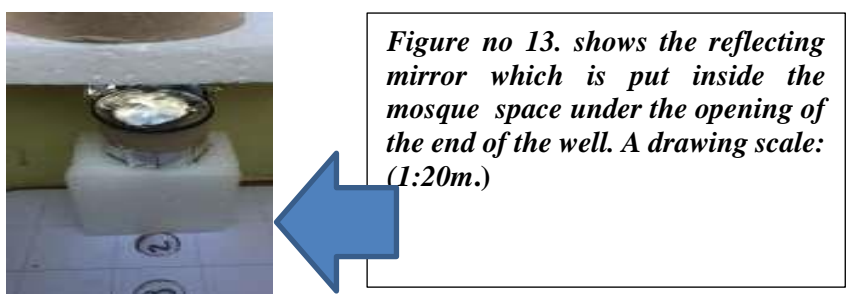


Figure 14. pictures of the standard model, showing the above information

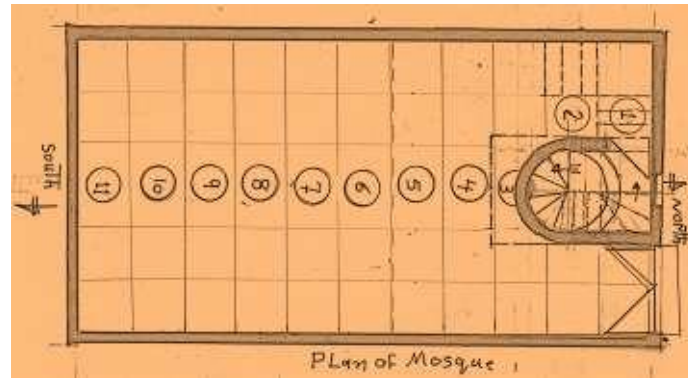


Figure 15. Plan of the internal space of the mosque with the minaret its dimensions (5*11) m2 the division of it are explained their dimensions are (1*1m2) the places of the cell locations and numbers (photovoltaic cells) (The Researcher)

It is possible to say that the balcony of the minaret was covered by a reflecting mirror material and I divided the covering of the balcony to parts one moving to the south (in the direction of sun rays to send it to the concave lens in the bottom of the upper tomb of the minaret .The minaret tomb was covered from the inside with concaved reflecting mirror parts that takes the shape of the dome from the inside) it receives the sun rays reflected from the tilted plane mirror that bends away from the level of the balcony in an angle of (30 °) after examining its tilt to send the sun rays reflected before (11 am) as in Figures (12 , 16, and 17) through the light well to the inside mirror which will reflect it to the roof of the mosque which will distribute it totally to the mosque's inner space. The moving part of the balcony was marked after observing the mirror dome lining on the balcony mirror which an evident to reach the sunlight to the inside of the mirror dome from the place of the picture. As for the mirrors that are died from the inside of the light receptor they receive lighting from the tilted in an angle of 45 ° in direct way of the light well which is lined by a reflecting mirror without passing by the balcony and the concave mirrors that cover the dome of the minaret from the inside. In general, it is very necessary that the reflectivity of the linings well is very good.



Figure 16. Plane mirror tilted with movement which is a part of the covered mirror of the balcony of the minaret (The Researcher)

The sun light reflected from the straight mirror which inclined from the level of the balcony in a (30°) angle after choosing its inclination to send the sun rays reflected before 11 o'clock am. As in Figures 12, 16 and 17 through the light well to the inside mirror which will reflect it to the roof or the mosque which consequently inner will spread it to the space in general of the mosque. The moving part was pointed of the balcony after observing the dome lining. mirror the mirror of the balcony which as approve to reach the sun light to the inside of the same mirror from the picture place. As for the mirrors covered from the inside of the optical coil it receives the sun lighting and tilted at an angle of (45°) in a direct way to the well (optical coil) which is died with the reflective mirror without reaching the balcony mirror and the concaved mirror. Which covers the tomb of the minaret from the inside. In general, it is essential to take into account to keep the reflectivity of the well lining perfect.

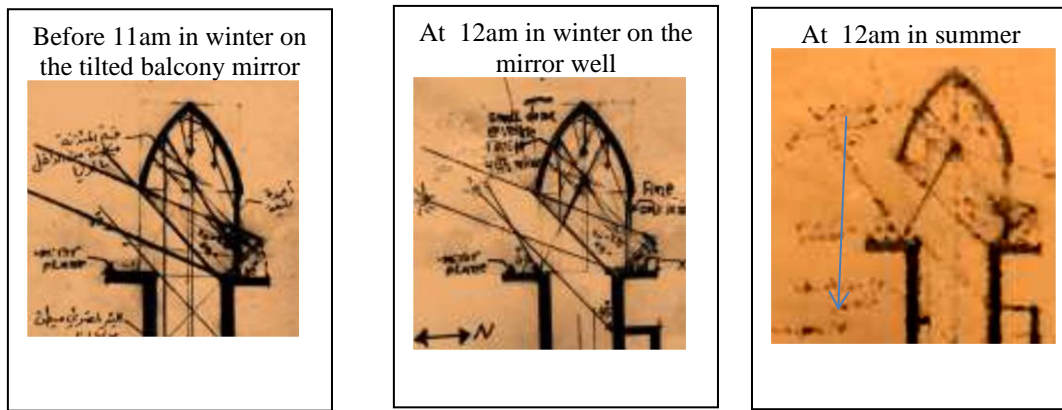


Figure 17. Falling solar rays and their reflections (The Researcher)

As for the inner mirror it is straight and tilted in a (30°) angle to examine the rate and the kind of sun light sent precisely. As in Figure 13 (The Researcher) I would like to point the presence that the reflectance of the windows on the walls of the mosque because they are small, and the inside rods are narrow and deep. distribute the air conditioner on the mosques walls in a way led to close them as in Figure 3.

6.2 Practical experiments specialized in natural lighting of the inner mosque's space

The inner ground of the mosque space is divided into equal parts each one is (1 × 1.00) m²) the minaret is located in the middle of the short side which is 5m as in Figure 15 measures were taken by putting the natural illumination cells inside each of the equal areas on the mosques ground from (1 - 11) to measure illumination in that point to know the amount of illumination in each point (The researcher)

6.3 Measurement method and results

The planer inverter (mirrors) is used to send the coming sun light in the lighting well to the middle of the internal roof of the mosque which is put on a tilted surface in an angle equal to (30°.) All the readings were taken during the midday in (12.00) pm. from December the day of the coming of winter which represents the shortest day and the longest night. The movement of the sun in it is laud to the remotest point and largest angle that the sun can reach (45°) the reflected aluminous in winter because of the heat load increase in summer and because of the shortage of the type of reflecting mirrors which don't let heat to transfer with the reflected sun lighting. (The Researcher). readings of the amount of sunlight reaching the mirror in the bottom of the optical well inside the space of mosques will be 10 lux when unlined from the inside with a reflecting material (without mirrors) and 1000 lux when lined with reflective material (with mirrors). This was measured by a gadget and is described in table no 4, with its situation highlighted in Figure 15. The area of the mirror is equal to the area of the circular well which is 30² X 22/7 (sotor page 1).

Table 4. describes amount of reflected illumine to the roof of the inner mosque's surface from the aluminous cells described Figure 15 when the diameter of (light illumine well) is (0.60m) (The Researcher)

Cells raw No.	Left cells (B.)	Middle cells	Right cells (A.)
raw No 1	36 lux	Optic well opening	36 lux
raw No 2	100 lux	Optic well opening	100 lux
raw No 3	400 lux	600 lux	400 lux
raw No 4	550 lux	800 lux	550 lux
raw No 5	600 lux	100 lux	600 lux
raw No 6	310 lux	600 lux	310 lux
raw No 7	200 lux	300 lux	200 lux
raw No 8	100 lux	200 lux	100 lux
raw No 9	60 lux	100 lux	60 lux
raw No 10	48 lux	78 lux	48 lux
raw No 11	78 lux	120 lux	78 lux

Results when the diameter of light the illuminc well equal to (1.00m), when the light well is not died from the inside with a reflective substance (without mirrors) the amount of natural sun light reaching the mirror which is in the bottom of the well inside the space of the mosque (30lux) on condition that the area of the mirror is equal to the circular cut it is equal to $(30^2 \times \frac{22}{7})$ (sotor page 1). when the light well is died by a reflective material (with the mirrors) The amount of natural sunlight reaching the mirror which is in the bottom of the well inside the mosque space equal to (2700 lux) the Researcher. It was measured by the mentioned great above. Described in Figure 14.

Table 5. Describes the amount of naturel sun light reaching the points of the particles mentioned in it Its places(locations) were highlighted in Figure 15 from the points of the light cells their position was declared in Figure 15 when the diameter of the light well equal to (1,00m) (The Researcher)

Cells raw No.	Left cells (B)	Middle cells (C n)	Right cells (A)
raw No 1	120 lux	Optic well opening	120 lux
raw No 2	300 lux	Optic well opening	300 lux
raw No 3	600 lux	1194 lux	600 lux
raw No 4	900 lux	1230 lux	900 lux
raw No 5	900 lux	1230 lux	900 lux
raw No 6	900 lux	1194 lux	900 lux
raw No 7	480 lux	900 lux	480 lux
raw No 8	480 lux	600 lux	480 lux
raw No 9	360 lux	480 lux	360 lux
raw No 10	300 lux	360 lux	300 lux
raw No 11	400 lux	480 lux	400 lux

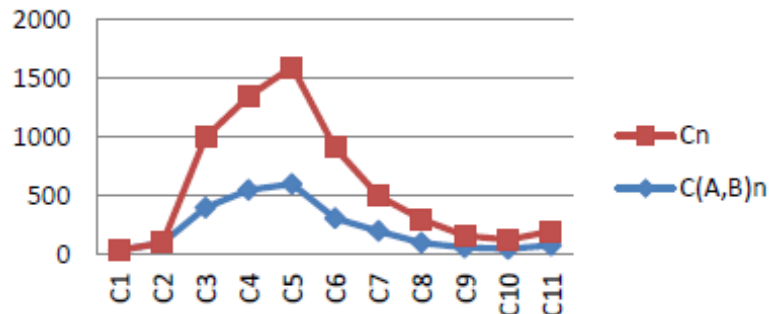
6.4 Results of the measurements mentioned above

The traditional urban fabric of narrow alleys resulted in a lack of natural lighting entering the spaces, which was neutralized by the windows of the buildings opened on two sides. To measure the amount of lighting reflected to reach the venue of prayers, a new technology was used and included in the body of the minaret, which was located on one of the walls from inside and had a moving mirror put in its balcony on the top of the roof outside, facing south. All these measures were taken on the 21st of December the winter turning at 12 o'clock am. At the time of Alduhir prayers at the time when the prayers came together in it to pray. This day is the shortest day and the longest night when the setting of the sun is on (4.45 pm). The researcher found that the mirror tube with a diameter of 0.60 m located in the roof of the mosque's space reflects natural lighting onto the fourth photocell on the ground, which is 800 lux, and gradually reduces towards the two sidewalls, where it reaches 600 lux in cells 5B and 5A. As for the cells (3and 6)) on the two sides of the reflected lighting spot. The amount of reflected. Natural lighting is (600 lux) and the amount of the two cells (3a and 3b) near the side walls is (400 lux) and 6a,6b near the sidewalls is (310 lux) as for the reflected lighting on the cells (7a and 7b) is (200 lux) , and the tab. No. 6 below clears the reflected lighting on the cells (8.8a ,8b , 9,9a,9b,10 ,10a,10b , 11,11a and 11b). Table 6 below clears the reflected lighting on the cells (8.8a ,8b , 9,9a,9b,10 ,10a,10b , 11,11a and 11b)

Table 6. clears the reflected lighting on the cells (8.8a ,8b , 9,9a,9b,10 ,10a,10b , 11,11a and 11b)

The name of the cell	The amount of reflected sun light
8	(200 lux)
(8a and 8b)	(100 lux)
9	(100 lux)
(9a and 9b)	(60 lux)
10	(78 lux)
(10a and 10b)	(48 lcx)
11	(120 lux)
(11 a and 11 b)	(78 lux)

It is observed that the amount of the reflected sun lighting measured by back wall the neighboring cell facing the position of the minaret increased a little from the previous cell which carries no (10) and (10a and 10b) in general this means that the back wall which is facing the minaret take part in some of the reflected lighting facing it therefore the amount of natural lighting increases reaching sells (no11 , 11 a and 11 b) especially cell (no11) As in Graph no.1 (the researcher) Homogeneity of the distribution of Reflected sun lighting inside the mosque's space.



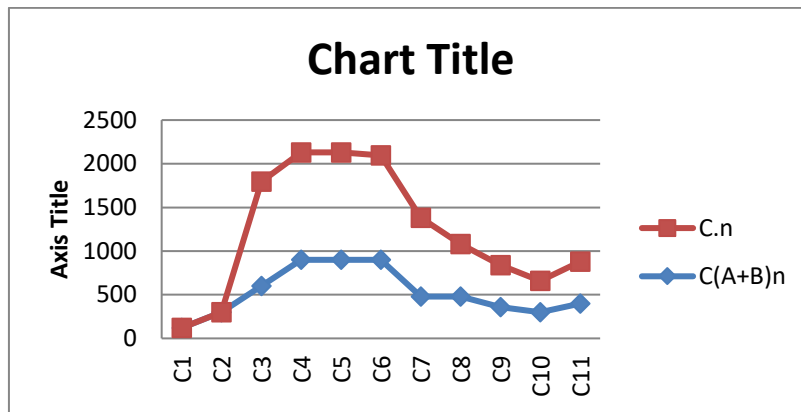
Graph 1. Homogeneity of the distribution of inside reflected natural sun lighting from the spot light from the mirror in the deep well measured (0.60 m) of diameter

Observing the reading of light cells we found that the reading of the two cells (4 and 5) in specific found to be higher than the cells near them it reaches the less of its levels in reading the cells near the front and near facing the minaret the factor of homogeneity for the sun light inside each space should be within the numbers given that's to say not less than (0.4) and not more than (0.7) which is equal to (the least lighting / the medium af lighting for all the levels of lighting found in the space) (Berhad page 4). The homogeneity of lighting inside equal to (0.2) which means the obscene of homogeneity in the readings of cells which means the absence of homogeneity in distributing the natural lighting reflected inside the space. Though it was increased in a seen way the graph no.1 describes that (the Researcher).

As for the mirror tube measuring (1,00m), The reflected beam from the inside mirror to the roof of the mosque's space is in front of the 5th light cell and part of the area of the 4th cell. located on the grounds of the mosque space the amount of the reflected natural lighting in the two cells (no 5 and 4) was higher than the other amounts it reaches (1230 lux) the amount of the reflected natural began to be reduced facing the two side walls as in two side walls as in the cells (4a , 4b , 5a , 5b) it reaches (900 lux) as in table no 5 (The researcher)

As for the two cells (no 6 , 3) on the sides of the reflected spot light was (1194 lux) the value of the two cells (3a and 3b) near the side walls (600 lux) and the value of the light cells (6a and 6b) near the side walls (900 lux) As for the reading of the reflected lighting on the cell no (7) reaches (900 lux) the value of the reflected lighting (7a and 7b) equal to (480 lux) the reading of cell no (8) was (600 lux) the value of the reflected light in the photo cells (8a and 8b) was (480 lux) the value of the reflected lighting on cell no (9) reaches (480 lux) the value of the reflected lighting on the cells (9a and 9b) was (360 lux) the value of the natural reflected lighting in the cells no (10a and 10 b) equal to (300 lux) as for their reading of the natural reflected lighting from cell no (11) reaches (480 lux) the value of the natural reflective lighting in the cells (11a and 11b) was (400 lux).

It was observed that the value of natural reflected lighting and measured by the neighboring cells of the back wall facing the minaret site was more than the cell before it which carries no(10 , 10A and 10B) in general this means that the back wall facing the minaret site contribute in reflecting some of the lighting reaching it the value of the lighting reaching (11, 11A and 11 B) increases especially cell no (11) (the researcher) moreover the value of the natural lighting entering from the inside of the light well with the diameter (1.00) is more than the inter lighting reaching from the light well with the diameter of (0.60m) which is the same area of the mosques space , It is obvious from the reading of light cells located in the mosque's space. and graph no 2 describes that. When observing the readings of the light cells we found that the readings of cells no (6,5,4,3) in specific were high compared to the other neighboring cells also. It reaches the least value in reading the cells near the walls (the front and the one facing the minaret). The factor of homogeneity for natural illumination inside any space must be within the borders appointed officially. That's to say not to be less than (0,4) and more than (0.7) which is (the value of the illumination minimum ratio/ The average of illumination for all the levels of illumination found in the space). (Berhad page 4) .



Graph 2. Inconsistency of natural lighting reflected inside the mosque space (the researcher)

The homogeneity of the illumination (lighting) inside the space equal to (0.21) this means the absence of homogeneity in the readings of cells in illumination. Which means the absence of homogeneity on the distribution of reflected natural lighting) inside the space. Though it was increased in an evident case. The graph no 2 describes *the* highlights that (the Researcher).

7. Conclusions

- It is recommended to use illumination technologies to provide natural lighting for the space of a mosque that are found in the traditional urban fabric in a Way that doesn't alter the identity of the mosque and the original traditional fabric.
- To benefit from one of the mosque*s elements, the minaret, because its main function was neglected and changed into something shows the existence of a mosque only. This change was cause by the technological development where the caller for prayers (Almuathin) is not obliged to climb to the top of the minaret to call for prayers this change contributed to provide reflected natural lighting the space of mosque especially at the time of prayers.
- It is obliged to use the technologies of lighting (illumination) to make its designs and shape don't alter the factor that contained it (the minaret)
- On this condition the technology that suit this was chosen to be hidden inside the body of the minaret to keep the shape and identity of the minaret and to keep it representing the presence of a mosque within the traditional Urban fabric.
- A reflected lighting was provided inside the space of the mosque reaching from (the pipe or the well) coming through the body of the minaret in a good ratio but the distribution of this (lighting) illumination inside the space is not homogeneous. To increase the rate of homogeneity in the amount of lighting distributed inside the space of the mosque measured by the cells distributed in it and to reduce the ratio of glare it is possible to create a change in the reflecting mirror put in the depth of the light well inside the space of the mosque by braking it into pieces putting every part in a tilted way from the other part to provide different (many) reflected spot lights reflected from these parts from the mirror to the roof of the mosque space on condition that these reflected spot lights in a mentioned spots from one another according to the tilted level of the mirror and the falling angle of the sunlight and the reflecting angle which is equal to the falling angle As in Figure 18 (The Researcher)
- If there are more than one minaret in the mosque it is possible to direct the inclination of reflective mirrors put in the depth of the light well inside the mosque space in every minaret in a way different from the tending of the reflecting mirror in the depth of the light well inside the space of the mosque. To insure finding more than one light spot to the roof of the mosque space to create a kind of distributing sunlight reflection inside the mosques space on condition that the number of minarets will not exceed four and be erected in the corners to keep the identity of the mosque.

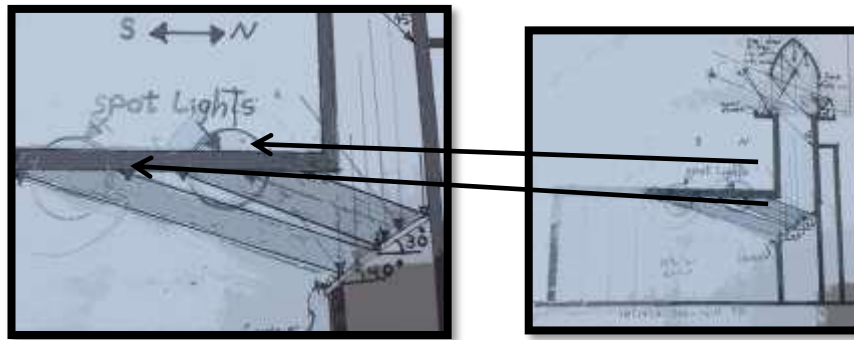


Figure 18. describes the attempt to divide the mirror into two each one tilted in a different angle from the other to provide light spots more than one to increase the homogeneity the distribution of sun light inside the mosque space (The Researcher)

8. Recommendation

- Being confident of the ability to transfer lighting using the minaret, this research recommends using the element of the minaret as a lighting technology in the environmental climate after providing it with the new technological growth to use it in mosques.
- To keep the identity of the mosque specially and form the urban fabric in general, this research recommends using the technology of the lightning minaret and get rid of the towers and empty structures of the it.
- From the technology of the body of the minaret the research recommend Using cold reflecting systems that don't let heat enter the mosque*s spaces to enable us to use the technology of the minaret in transferring light in summer due to the increase in heat in summer in Iraq and to change the minaret into an independent, smart lightening technology in the name of the technology of the smart lightning minaret (The Researcher).

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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