ENERGY IN ARCHITECTURE THE DIALECTIC OF FORM FUNCTION AND COMFORT

Abdel Al Mohammed Abdoun

PhD, Lecturer and researcher at Cairo University, Holds Master in Architectural and Environmental Engineering, Egypt

Original Article

pii: S238315531600004-5

Received: 26 Mar. 2016
Accepted: 10 Aug. 2016
Revised: 21 Nov. 2016
Published: 15 Dec. 2016

*Corresponding author's email: e_abdelal_abdoun@yahoo.com

ABSTRACT:
Firstly can we develop research in the external effect on architectural forms? In this article new vision has been put to define how to deal between the architectural form and the natural environment energies, where it in previous studies it was examined one natural energy, and its relationship with various architectural forms, we have been using a group of computer programs to study the effect of wind and solar heat and also the drag together on architectural forms, like Flow design program and Ecotect Analysis - Autodesk 3ds max. in order to study the wind behavior with the shape and efficiency natural cooling through the drag coefficient on the shape, relationship between the forms, and the amount of gain energy from direct solar radiation the results were checked by specialist has been shown that there is an architectural forms suitable for hot zones and other forms suitable for cold zones according to the effect of the wind and the extent of its contribution to cooling the heat from direct solar radiation through the drag rate on a different architectural forms. This study aims to help the architect to distinguish between appropriate architectural forms in different regions climate.

KEYWORDS:
Natural Environment Energies, Expression of Local Materials, Symbolism.

INTRODUCTION

The observer product architect stages of human evolution noted deeper in the architectural thought, the observer in the architectural product through human evolution that is noted the relationship between energy and construction appeared deeply in the form of construction and its function and that the concepts of energy has converged with the design stages in architectural work that is going through stages in relation to energy, and growing that relationship in order to reach human comfort, those comfort that need to be documented by scientific system that benefits us and also the future generations. In searching relations monitors between the shape of the blocks on the one hand and the different natural environment energies on the other hand, there is a change in the reaction of various geometric blocks with wind (windward-leeward) and solar radiation and drag. According to the shape of each block, here it is possible to take advantage of the behavior of the previous three energies around the cover in achieving comfort in the interior voids of the blocks. Research showed the effect of these three energies together, because it is supposed to affect at one time at the thermal comfort of the human person in the cooling and heating in different climate latitudes and longitudes types. There is a paper "http://www.ntua.gr...SummaryUK2.pdf" refers to monitor several attempts in this field to achieve the results in the same path.

Study the effects of geometric shape on the amount of solar irradiation on a solid surface
In order to explore the relationship, 7 generic convex solids have been studied in 71 variations of proportions & orientation, each one for 3 values of ground albedo (Entitled Form Insolation Index) Notes on the Relation of Geometric Shape & Solar Irradiation, National Technical University of Athens, Department of Architecture and this has resulted in the study at different latitudes that equation =R/F Where- The amount of solar energy = e – ground reflected = R – surface of area = F (Figure 1)

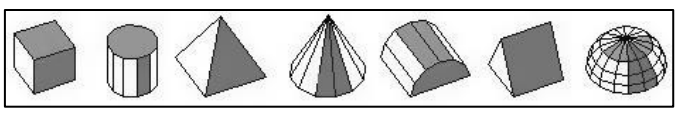

Figure 1. The generic shapes of the study

The study, after adoption in 2000, showed that any absorbed energy generated its own energy from the amount of solar energy in the natural environment, and absorption capacity is less and decreased when the body shape was specifically resisted to direct exposure and reflex and diffuse from the environment. This capacity increases when there is no resistance from the shape of the body to process exposure according to the orientation.

Investigating “energy in architecture" depends on studying main forms which cubic cylinder ball pyramid and Cone (Figure 2). The measurements has been signed by programs 1-flow design Autodesk 2-Ecotect Analysis 3- Autodesk 3ds max run effects in the third dimension.

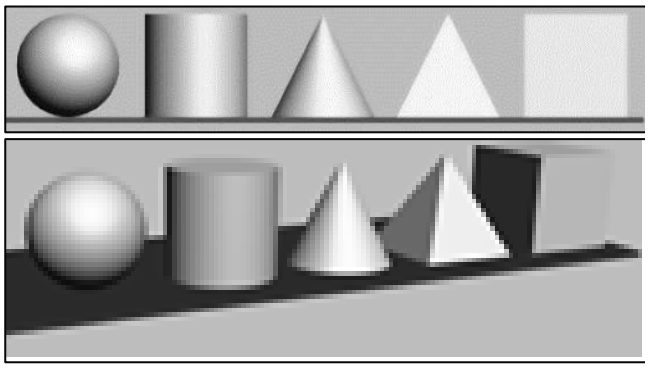

Figure 2. The main forms of the study -front View and three-dimensional

The results were recorded in terms of exposure to wind as well as solar radiation and also a drag on every form and the development of the physical effects of the incident on the form at this time. We can report the authority shape in a hot or cold areas and the success of the shape to achieve thermal comfort internally through the envelope. Here we put all the choices and alternatives to the architect as tools in the design, so as to get a better relationship between form and surrounding environment to try to a sustainable way design. The study helps to understand how the impact of a group of energy at one time on the form of what, begins the emergence of impact energy on the envelope and on the internal environment of the form.

A – CUBE

The cube is done by exposing the cube of the wind by flow design program and insolation by Ecotect analysis program and drawing results in the third dimension by *Autodesk 3ds max program* and the results were as follows:

A1 - The wind (windward) moving away from the cube anyway and any orientation (Figure 3) and (leeward) attach to the cube. We find that the wind does not have a cooling effect on the cube body, because the wind speed is reduced in (leeward) (Figure 4) decrease of the speed from 19m/s to 4 m/s and less in the experiment.

A2 - Drag coefficient 2.17 horizontal 1.39 Vertical (Figure 4) which is a high value at the edges which collide with the wind which may cause the loss of heat from the inside at the edges.

A3 - Through thermal analysis in the Ecotect program (Figure 5) it is shown that Cube surface exposed of the solar radiation is gaining equal amounts of energy on the unit area.

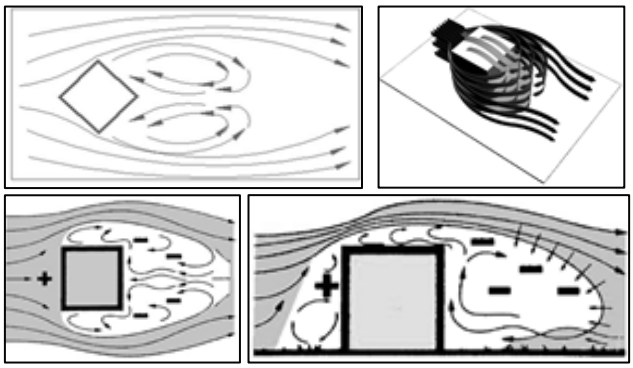

Figure **3.** windward moving away from the cube and lee ward Attach to the cube (drawing by author)

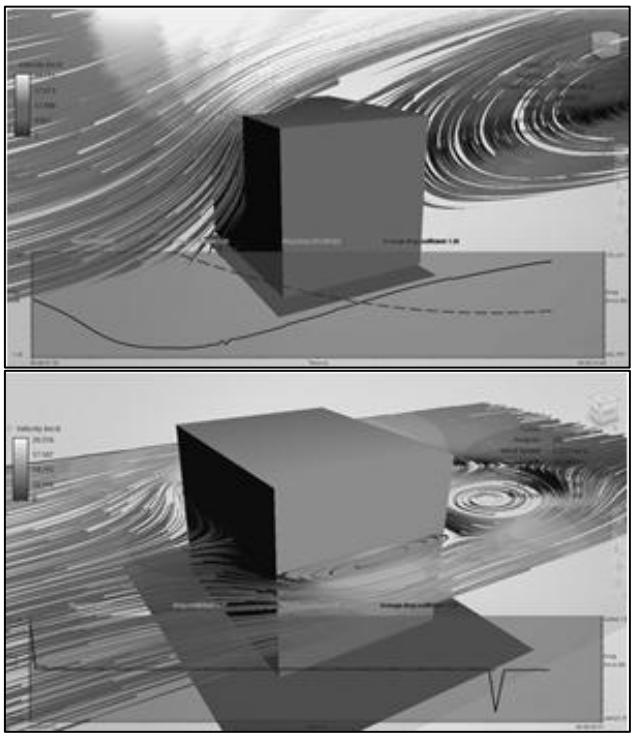

Figure 4. Drop speed from 19m/s to 4 m/sand less

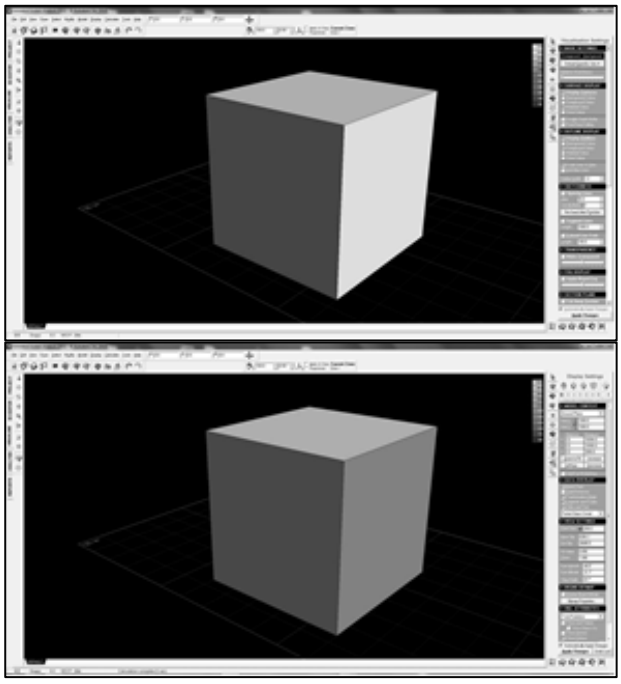

Figure 5. the face of the cube Exposed to radiation solar heat gain Are equally to the unit area

B - PYRAMID

Experiments have been conducted on the pyramid and the results were as follows:

B1- The wind (windward) moving away from the pyramid in horizontal like cube figure 6 and (windward) Attach to the pyramid in vertical figure 7 the wind does not have a cooling effect on the pyramid body, due to the presence of edges where they cause wind spacing from the body.

B2 - Drag coefficient 1.59 horizontal 1.77 Vertical (Figure 7) which is a high value at the edges which collide with the wind which may and that can cause a loss of power from the internal vacuum through the edges of the pyramid.

B3 - Through thermal analysis in the Ecotect program (Figure 8) turns out that the face of the pyramid exposed to solar radiation that is gaining equal amounts of energy on the unit area which increases the energy gain in the internal vacuum and this benefit serve cold regions and increases the gain energy in the pyramid with sun rise.

B4 - Architect "Norman Foster" used the previous property; He designed the parliament building in Kazakhstan a pyramid shape glass and storage of the energy gained during the day in the spaces underground (Figure 9).

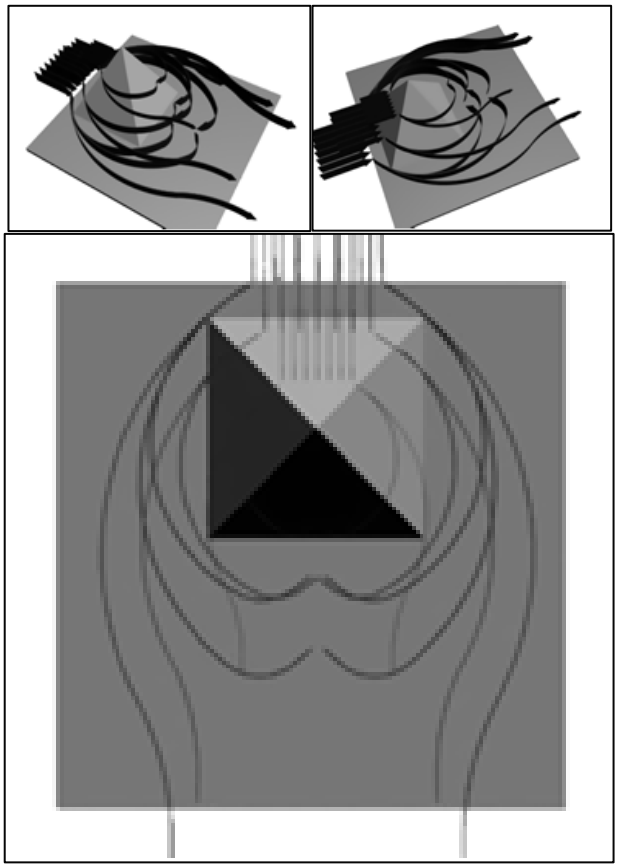

Figure 6. The wind (windward) moving away from the pyramid (drawing by author)

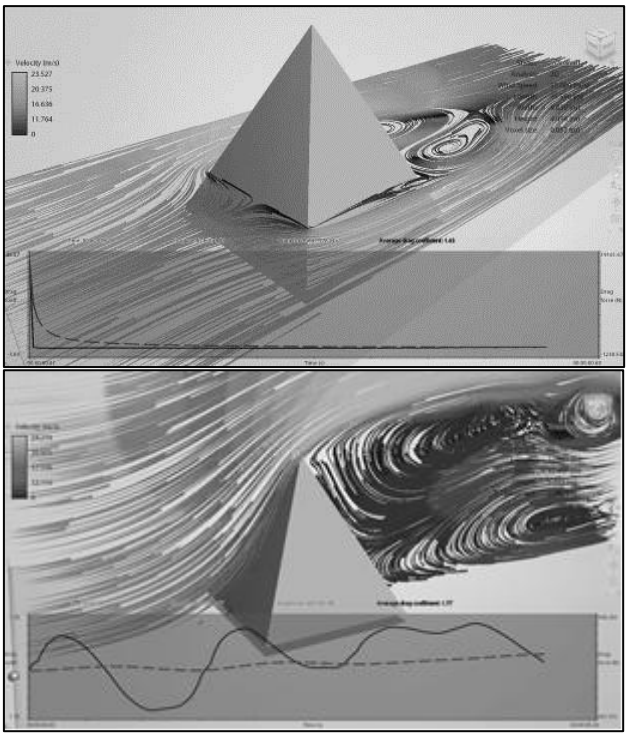

Figure 7. Windward attached to the pyramid in vertical

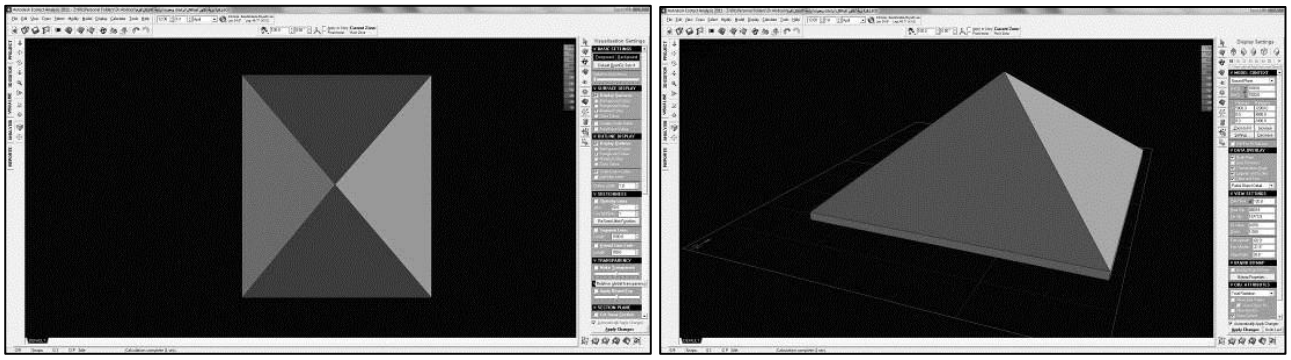

Figure 8. Radiation solar heat gain are equally to the unit area

Figure 9. Architect Norman Foster designed a pyramid shape glass, where very cold climate

We talked for a square shape and now we speak of circular shapes, where it is deal properties with wind and solar radiation differently. The results of Ling et al. (2007) revealed that the circular shape is the optimum shape in minimizing total solar insolation compared to other square shapes.

In study performed by Ahmad and Gadi (2003) on computer simulation of solar radiation by curved roof in hot-arid regions, it is proved that the circular surface gain less energy compared to the surface level when studying the circular shapes start cylinder:

c- CYLINDER

Experiments have been conducted on the cylinder and the results were as follows:

c1- Cylindrical shape or any circular shape affects around 360 degrees on the opposite square shape (Figure 10).

c2- The "Coandă" effect is the tendency of a fluid jet to stay attached to a convex surface (Figure 11). Therefore the movement of wind around the circular shape to be adjoined to the body shape figure 12 from aerodynamics laws and Coandă effect With circular shape is clear that air friction is cooling these forms.

c3- Through the flow design program show that the drag coefficient. 42 horizontal 1.85 Vertical (Figure 13) in the cylindrical shape, the drag coefficient horizontal 42 is few where the allowing a larger friction with the circular body, but the drag coefficient vertical 1.85 is big, so the wind where the allowing a less friction with the circular body so that collide wind with the upper edge of the cylinder.

c4- Through thermal analysis in the Ecotect program figure 14 shows that circular body does not receive solar radiation equally, on each surface but in orthogonal space with radiation level only and also less gain energy as we move away from the orthogonal space with radiation, this is another reason why the cylindrical shape and circular less to gain energy.

c5- If adding color and material of surfaces with the physical properties for cylinder it can use light color reflective to radiation as well as heat-resistant material, we might get to a higher heat resistance in hot environments and extreme heat (Figure 14).

c6- The architects Hamzah & Yeang (1994) took advantage of cylindrical shape in the design of "Menara Mesiniaga (Chan et al.)" (Figure 15) in Malaysia so as to relieve the hot humid climate and also the effectiveness of wind on the cylindrical shape and deserved the project the Aga Khan Award for Architecture.

c7- Because the body perpendicular to the cylinder so the higher sun angles least gain energy in the body of the cylinder (Figure 16) and it appears in Form 17, the fundamental differences between the

circular shape and square shape, since the effect of solar radiation disappears by the wind effect.

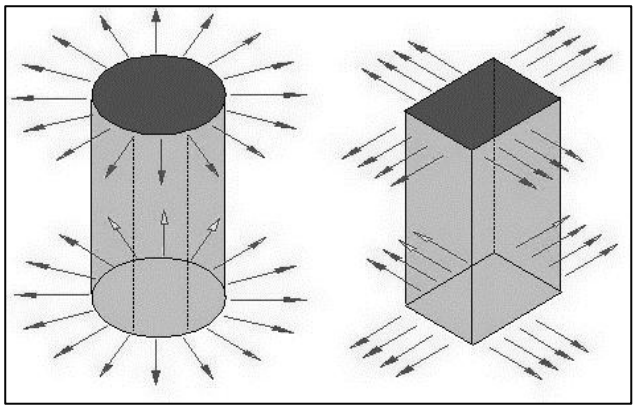

Figure 10. Circular affects around 360 degrees

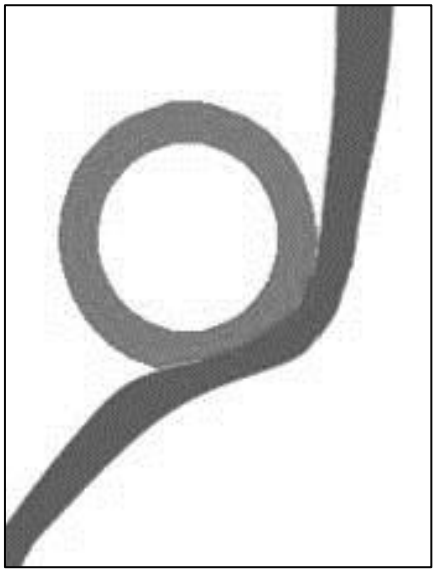

Figure 11. Coandă effect

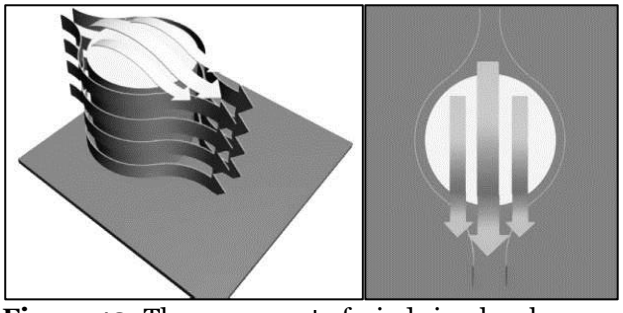

Figure 12. The movement of wind circular shape

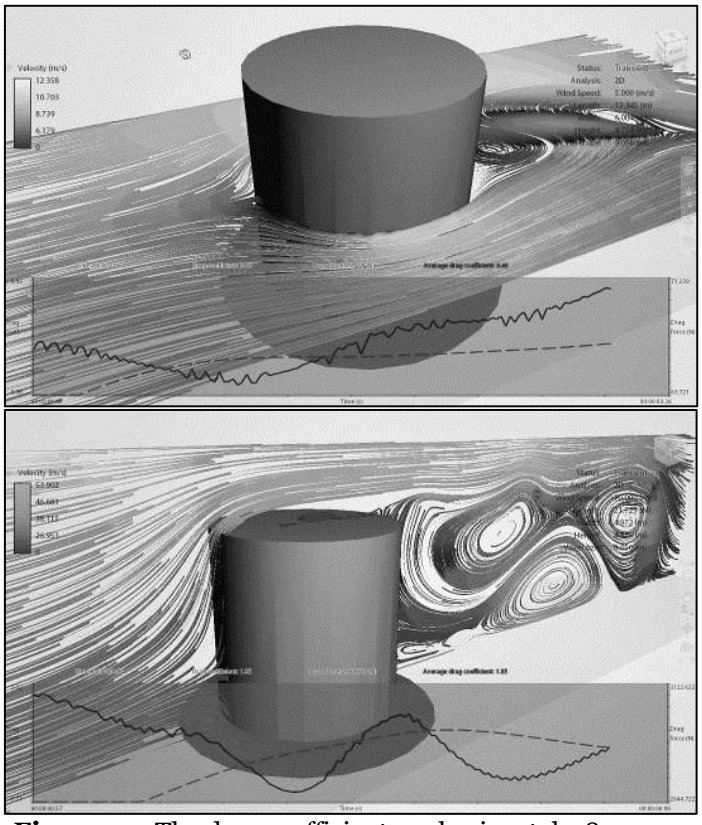

Figure 13. The drag coefficient. 42 horizontal 1.85 Vertical

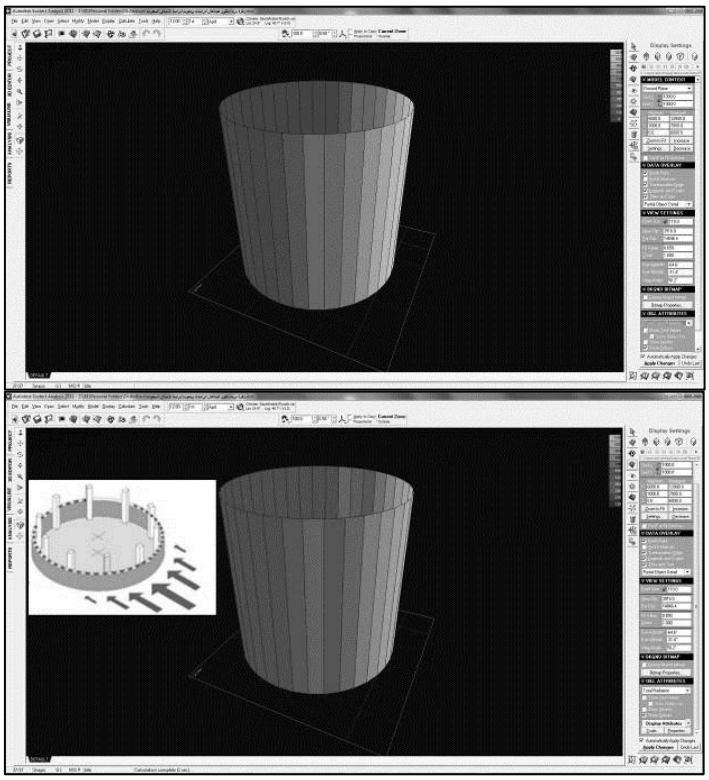

Figure 14. Circular body does not receive solar radiation equally

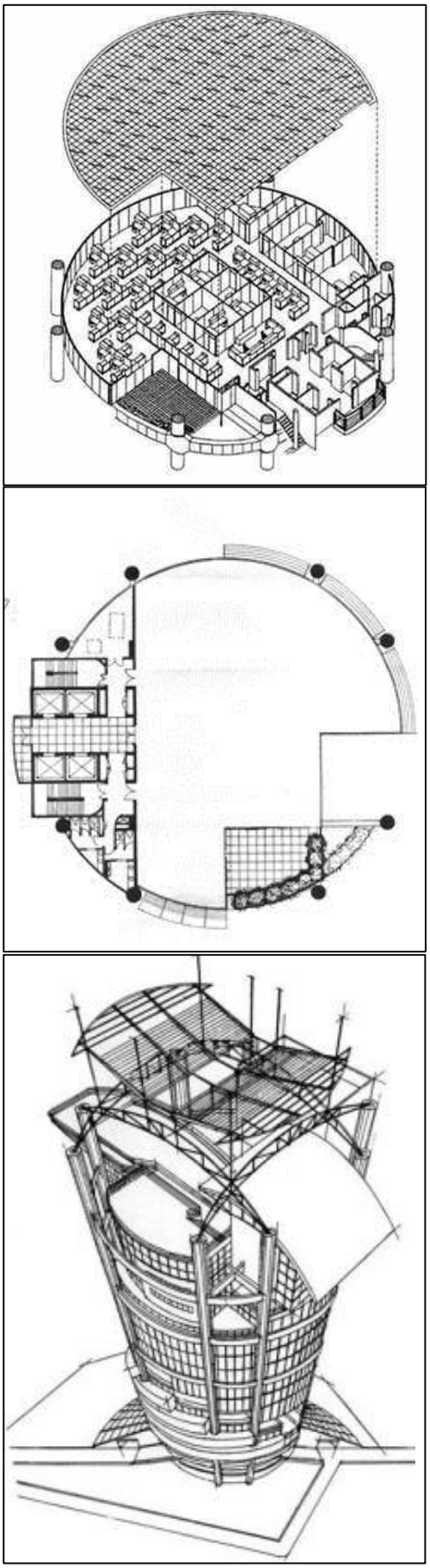

Figure 15. Menara Mesiniaga

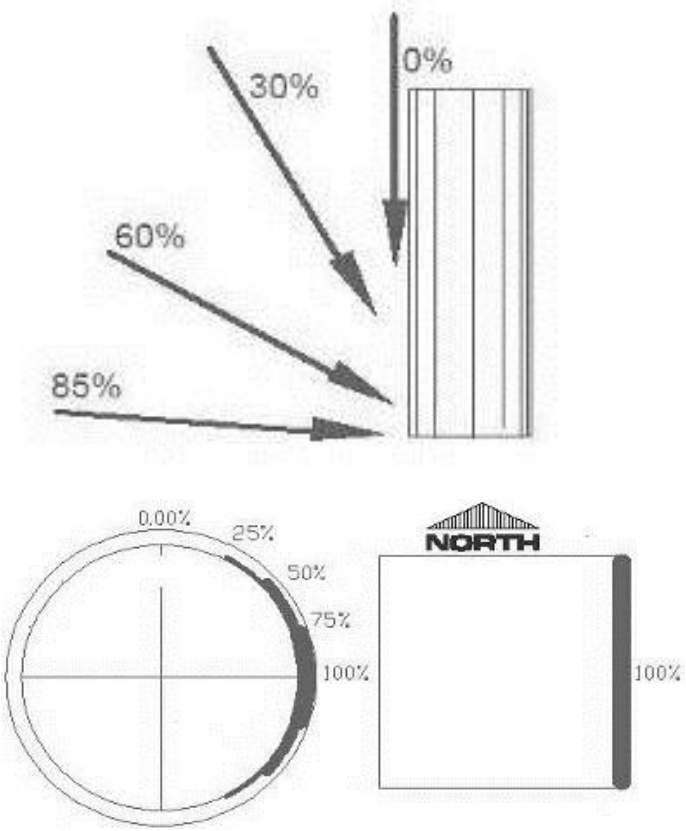

Figure 16. Ratios influence of the sun angle on the cylinder

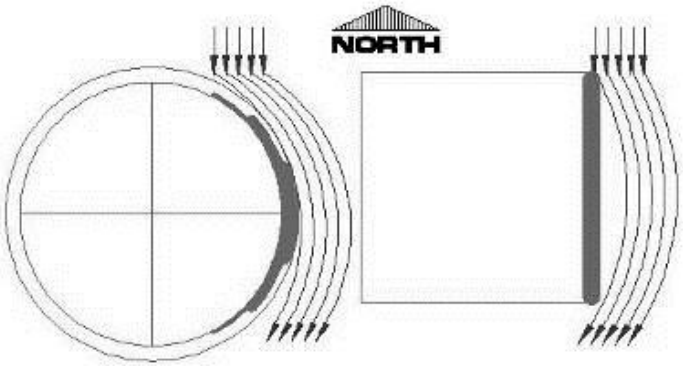

Figure 17. Differences between the circular and square shape

The primary difference between the cylinder and the cone perpendicular it is that the upper circle in the cylinder has turned into a center point.

d- CONE

Experiments have been conducted on the cone and the results were as follows:

d1- Cone shape subject to the same cylinder properties In terms of dealing with the wind (Figure 18).

d2- Through the flow design program showed that the drag coefficient.74 horizontal 1.89 Vertical

(Figure 18). It is noted here that the drag coefficient of the vertical and horizontal has increased compare the value of the cylinder, especially in the horizontal, This value increases when we go for the cone base, This means decreasing cooling when we go for the cone base by repeating the experiment (Figure 19).

d3- Through thermal analysis in the Ecotect program (Figure 20) shows that Maximum exposure When the sun rise in the early hours where the perpendicular radiation on the body of the cone (Figure 21) and More an area of overexposure when the sun rise.

d4- architects "Ashton Raggatt McDougall" resorted to the cone shape in the project Melbourne Central is a large shopping centre, office, and public transport hub in the city of Melbourne, Australia (Figure 22) and the goal was to maximize energy for heating and lighting, this is because the Average temperatures are low in Melbourne Between 19 and 25 ° C throughout the year.

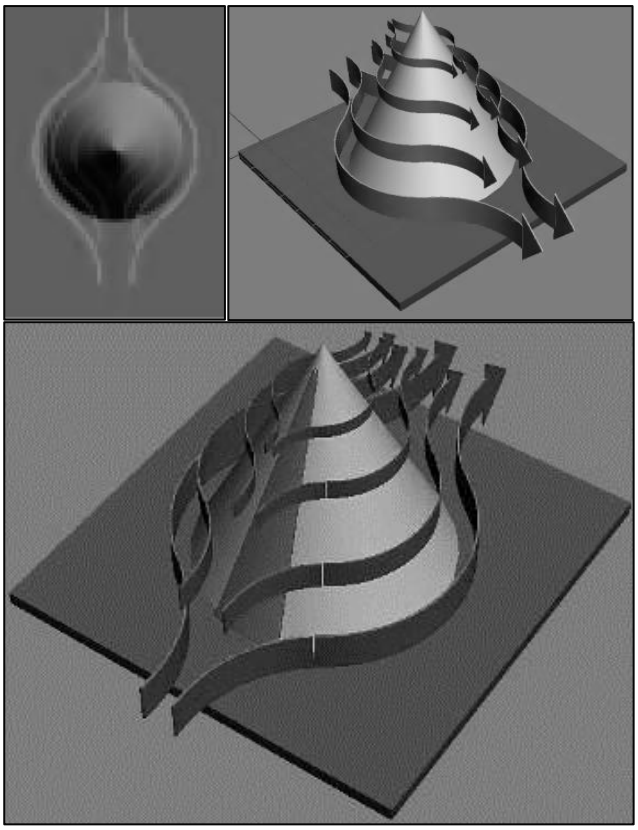

Figure 18. Description Wind movement (drawing by author)

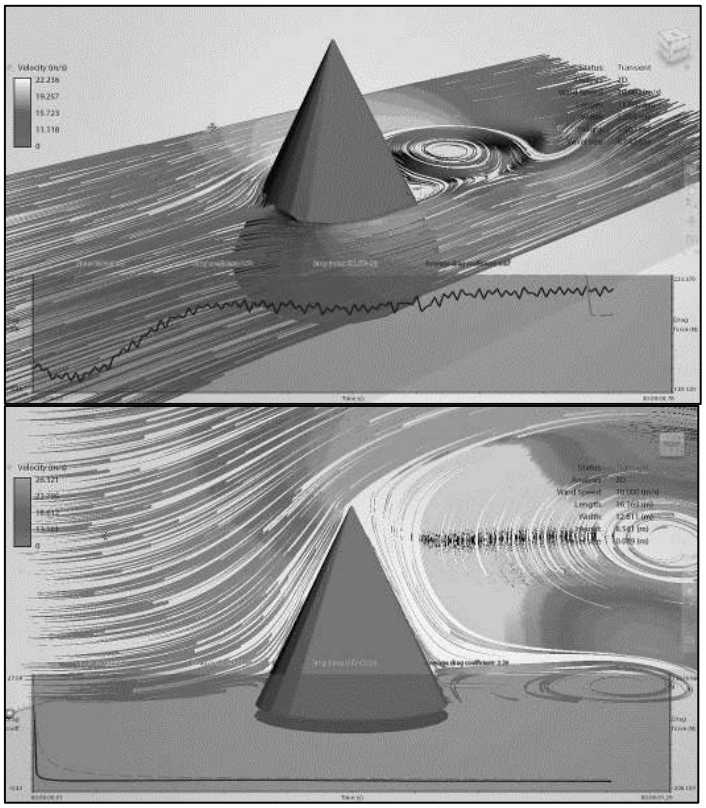

Figure 19. Wind movement analysis

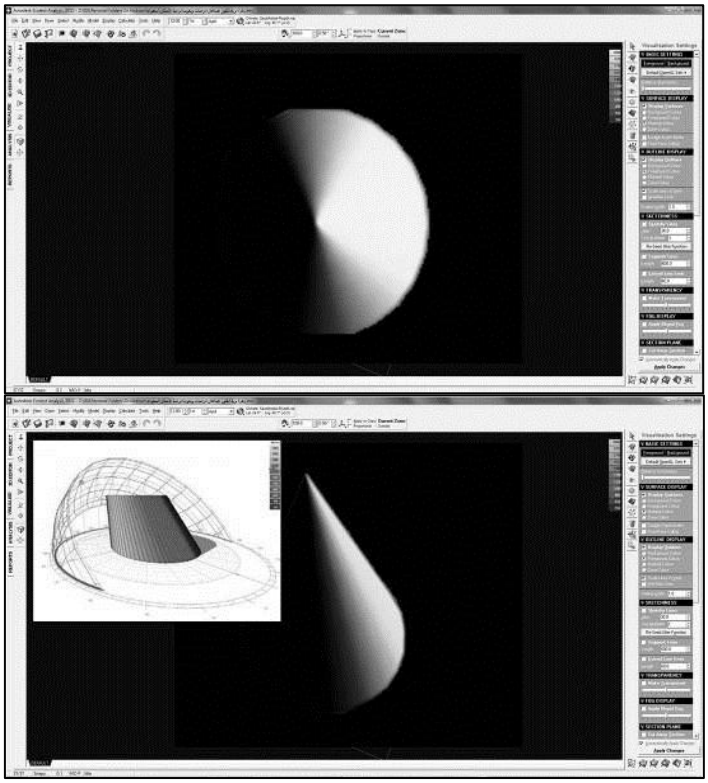

Figure 20. Maximum exposure

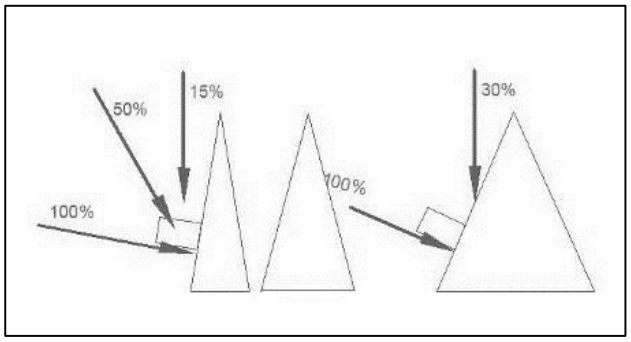

Figure 21. Over exposure when the sun Rise (drawing by author)

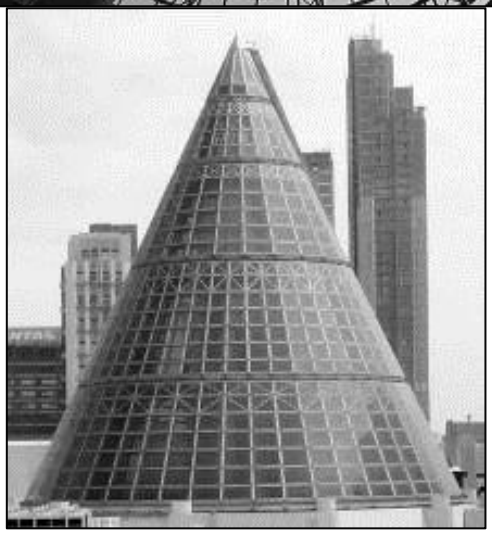

Figure 22. Melbourne Central

BALL and the dome is a three dimensional image full docking between architectural form and external natural environment In the case of Harmony, Domes half of a sphere have a long architectural lineage that extends back into prehistory.

e- BALL and dome

It is the shape of the curve in all directions and Experiments have been conducted on the ball and dome and the results were as follows:

e1- Dome is the development of the cube in nature the environment to decrease exposure to less valuable space and the ball and the dome is one of the more forms that come into contact with the wind In a large area by (Coandă effect) (Figure 23), the wind clash with spherical shape in the small possible space. Therefore hot wind does not arrive a large amount of energy to the spherical shape, and the drag Value on the dome less than the cylinder..

e2- By the results of the program "flow design" showed that the drag coefficient.8 horizontal.58 Vertical in dome (Figure 24), the drag coefficient.7 horizontal.61 Vertical for the ball, it is the lowest coefficient of drag from all shapes (Figure 25).

e3- Thermal analysis in the Ecotect program, (Figure 26) shows that the exposed area. It is the least possible area, and taking into account that the shape of dome and ball it is convex in all directions.

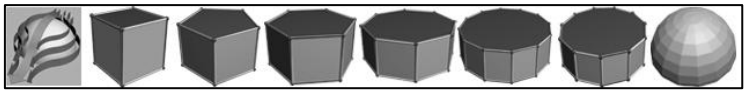

Figure 23. Development of the cub (drawing by author)

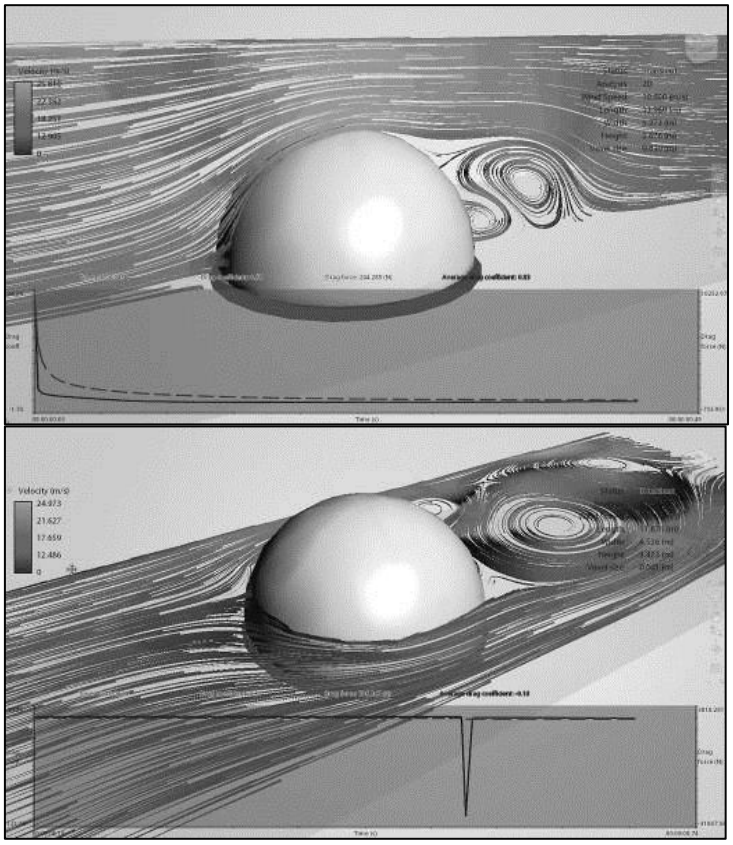

Figure 24. Wind movement

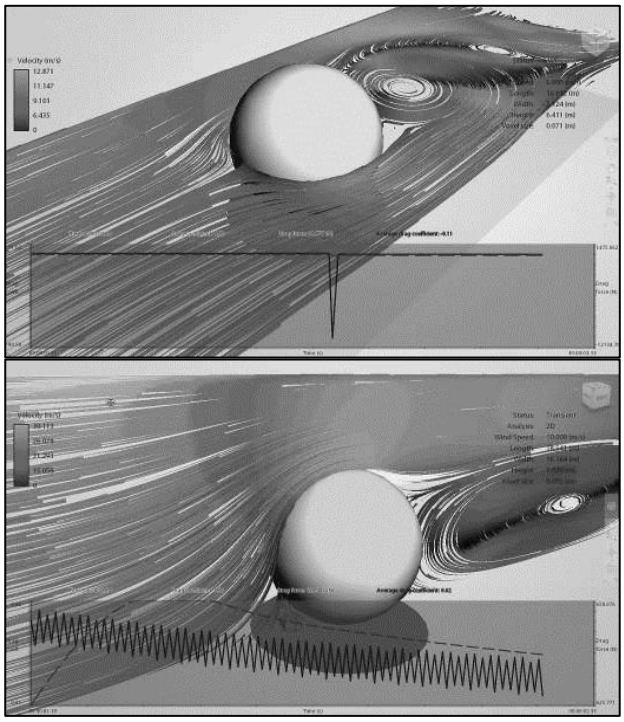

Figure 25. Wind movement analysis

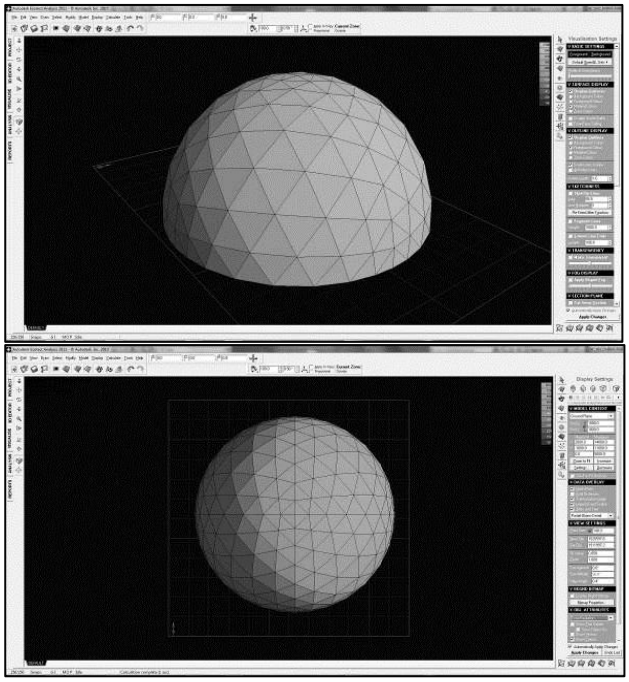

Figure 26. Maximum exposure

e4 - Through a case study a golf ball with dimples can travel almost twice as far as a smooth golf ball. By adding dimples to the ball, why do golf balls have dimples? the golf ball manufacturers see that ball golf speed is slow and it must reduce the drag on the ball in order to increase speed and it was found physically that the dimples on the surface of the ball reduces the drag coefficient, which increases the air friction with the dome body or ball. Figure (27), This means that the outstanding ornaments on the dome surface can be help to reduce the drag coefficient And increases the air friction thus resulting increases the cooling.

e5-The architectural Fabrizio Caròla has used the form of the dome with double skin in the Project Kaedi hospital in Mauritania which helped to achieve property wind chill. The result was a 25-degree heat inside the hospital when the temperature outside 50 degrees, and deserved the project the Aga Khan Award for Architecture (Figure 28).

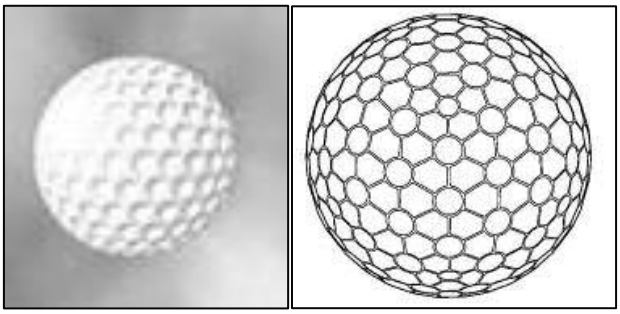

Figure 27. Dimples of a typical golf ball

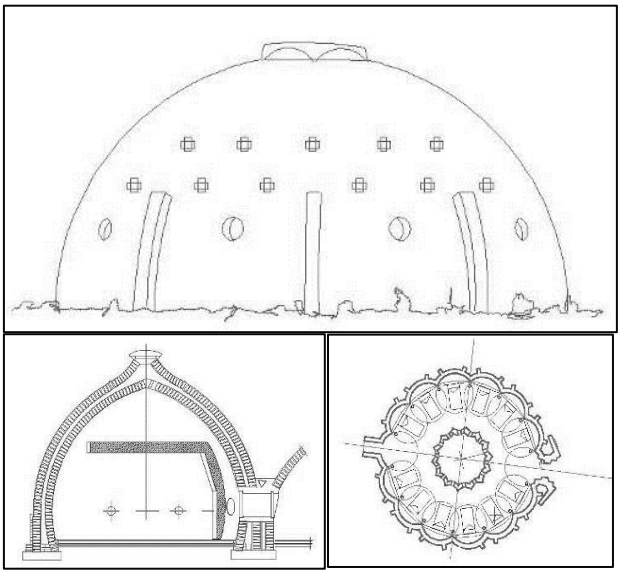

Figure 28. Kaedi hospital Mauritania bumps on the surface of the dome

e6- The researcher knew the capabilities of the dome through the design of a mosque (Rahman) dome-shaped with a diameter of 22 meters in 1991 The project has been nominated to contest the Aga Khan Award, The project arrived for maximum thermal comfort inside the vacuum dome, through the efficiency of the air touches with the surface of the dome, and increased the air friction with ornaments placed on the dome, and smaller exposure area (Figures 29 and 30).

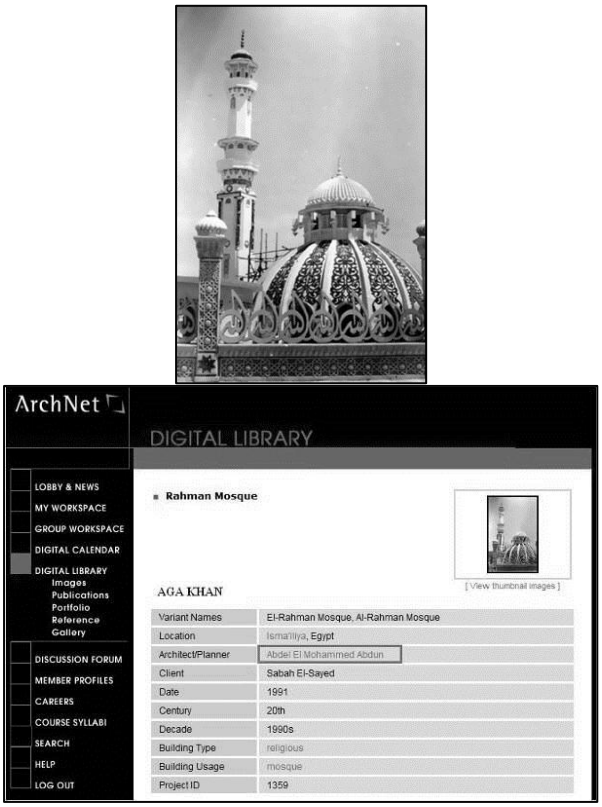

Figure 29. Mosque (Rahman)

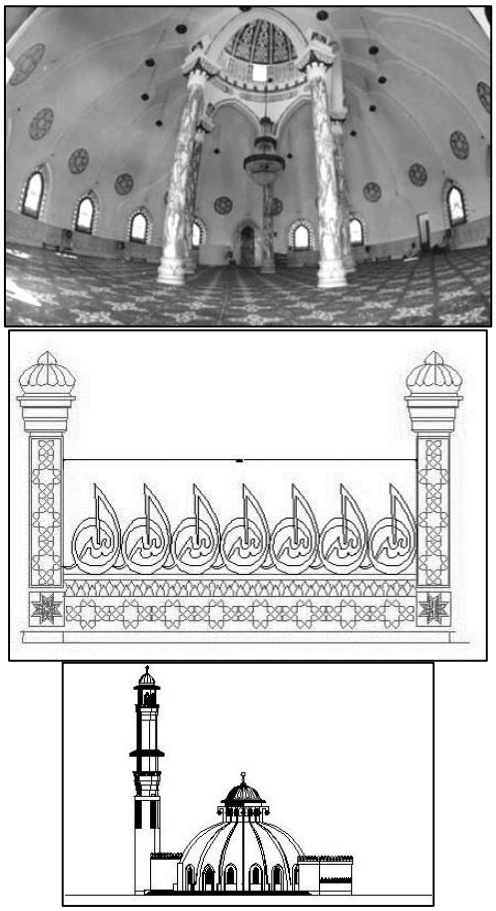

Figure 30. Forming and ornaments inside the dome (drawing by author)

SAMPLE RESULTS:

❖ The cube-shaped in the absorption of energy incident on its surface, because the cube has the largest area of exposure, and also it has the largest area of confrontation with the wind From here the surface of the cube can be affected by hot or cold wind confrontation, energy cannot move from the surface of the cube to the perpendicular surface of the same cube. Therefore, the budget cannot be happening between the surfaces of the cube on the issue of energy, depending on the property transfer energy from the hottest to the coldest.

❖ Pyramidal shape comes second after the cube in the exposure area but more than the exposure area when the sun rises. This is the opposite cube that reduces exposure to the area when the sun rises, it has the large area of confrontation with the wind from here the surface of the pyramid can be affected by hot or cold wind, energy cannot move from the surface of the pyramid to the perpendicular surface of the same pyramid quartet, the wind (windward) moving away from the pyramid in horizontal like cube, therefore met in two forms weak cooling by the wind and also the lack of free movement of energy from the surface to another in the same format.

❖ Cone shaped surface is curved in horizontal so they can balance the energy on its surface, where the move from area that are exposed to hot into cold area in the same cone, but more than the exposure area when the sun rises, at a time when the wind touches the body of the cone at the base very well and less when they are heading up, it can be said that the cooling operation the body Cone better in this case.

❖ cylinder shaped surface is curved in horizontal so they can balance the energy on its surface, where the move from area that are exposed to hot into cold area in the same cylinder but less the exposure area when the sun rises, at a time when the wind touches the body of the cylinder is equal in value from the base until the top, it estimates the cooling of the cone.

❖ Ball and dome shaped surface is very curved horizontal and Vertical, through pictures, thermal analysis shows that incidence of thermal balance in each direction on the surface of the ball or dome, have less space exposure of each circular shapes in the face of thermal radiation and the collision with wind shape. This means that there is a concentration of energy in less space with a larger cooling area.

CONCLUSION

❖ When the geometry of the natural environment in a huge, and be the size of a small tree for the size and height of the building, the shape is the capabilities to deal with the energies of the natural environment is the determining factor, from here previous studies to be an important abstract shapes in order to simulate the situation in nature.

❖ Square shapes be negative with the hot and arid regions twice the cooling and increased exposure on straight surfaces, the cube and pyramid is not communicating with the natural environment, heat and wind energies effectively positive, which may impact on the thermal comfort for humans in those regions.

❖ Square shapes be positive with the cold regions, it can be said that the wind does not touch no direct contact with the square shape and thus do not exhausted energy from the surface of the shape or inside it, and straight surfaces helps to gain the largest amount of energy as well as property increased exposure area in these forms.

❖ Circular shape may be positive to a large extent in the humid tropics and arid, due to the directly touching the wind with most of the body and also decrease the exposure area in terms of both the wind and the sun.

❖ This former property is varying in value between the circular shapes It shall be the highest possible on the ball and the dome and the medium in the cylinder and then lower in the cone through previous measurements.

❖ Here it must be said that the color and material shape is a primary factor in shootout as for these two factors have a clear impact on gain or lost energy from the shape and can also be adjusted for these factors the previous classification to a limited degree.

❖ All of these measurements and previous information is as tools in the hands of architect find the moment of a concept of Form, which will design and linking it to the building and posed Format with the natural environment in pursuit of creating thermal comfort as much as possible, through the streamlining performance in the selection process between formats.

Table 1. A summary of the results

Shapes	Description geometry	Description exposure	Horizontal Drag coefficient	Vertical drag coefficient	Change in exposure	Energy balance on the surfaces shape	Notes
Cube	Square shape Horizontal& Vertical	The full face	2.17 Less with the bow	1.39 Less with the bow	Less with sun rise	There is no a balance between faceted	Proper a cold region
Pyramid	Square shape Horizontal	The full face	1.59 Less with the bow	1.77 Less with the bow	Increases with sun rise	There is no a balance between faceted	Proper a cold region
Cone	Circular shape Horizontal	Part limited	.74 Less with dimples	1.89 Less with dimples	Increases with sun rise	There is the budget on the ring& straight face	Proper a cold hot region
Cylinder	Circular shape Horizontal	Part limited	.42 Less with dimples	1.85 Less with dimples	Less with sun rise	There is the budget on the ring& straight face	Proper a hot region
Ball and dome	Circular shape Horizontal& Vertical	Part limited	.7&.8 Less with dimples	.61&.58 Less with dimples	Do not change with rising sun	There is the budget on the ring face In all directions	Proper a hot region

DECLARATIONS

Acknowledgment

Research is as part of the requirements of the PhD; Arab Republic of Egypt Ismailia 4 sharqia street, Egypt

Authors' Contributions

All authors contributed equally to this work.

Competing interests

The authors declare that they have no competing interests.

REFERENCES

Ahmad, A.B.E. and Gadi, M. (2003). Simulation of solar radiation received by curved roof in hot-arid regions. http://www.ibpsa.org/proceedings/bs2003/bs03_0283_290.pdf

Al-Homoud, M.S. (2001). Computer-aided building energy analysis techniques. Building and Environment 36: 421–433..

Beausoleil-Morrison, I. (2001). The adaptive coupling of computational fluid dynamics with whole-building thermal simulation. (2001). In: Proceedings of Building Simulation, Rio de Janeiro, Brazil.

Blocken, B., Stathopoulos, T., Carmeliet, J. (2008). Wind environmental conditions in passages between two long narrow perpendicular buildings

Chan B, Fung M, Lam K, Liu V, Case Study: Arch 366: Environmental Design. Menara Mesiniaga, 1 of 10. http://www.solaripedia.com/files/723.pdf

Cochran A J and Farrally M R (ed) (1994). Science and Golf II.

Deaves D.M., Harris, R.I. (1978). A mathematical model of the structure of strong winds.

Ekstrom E. A. (1999). Science and Golf III ed Farrally and Cochran (Leeds: Human Kinetics).

Elseragy. A.A. (2003).B architectural and solar potential of curved and flat roofs in hot arid regions.

Gomes, M.G. (2003). Wind effects on buildings. Experimental evaluation of pressure coefficients

Hamzah & Yeang Ken (1994). Bioclimatic Skyscrapers, Ellipsis London Limited, London.

Hairy Haskell Golf Ball History 2014.

http://www.ntua.gr/arch/geometry/tns/phd/SummaryUK2.pdf (https://www.ntua.gr/el/).

Hira A. and Mendis P. (1995). Wind Design of Tall Buildings. Conference on High-rise Buildings in Vietnam. Hanoi, Vietnam.

http://archnet.org/library/files/one_file.jsp?file_id=108. Site accessed 3 March 2009.

http://www.akdn.org/architecture/project.asp?id

http://www.akdn.org/architecture/project.asp?id=1356

https://en.wikipedia.org/wiki/Coand%C4%83_effectECOTECT

Kurokawa K. and Aratani F. (2004). Perceived Technical Issues Accompanying Large PV Development.

Lam, J.C. and Goodsall, C.J. (1994). A Survey of Building Envelop Designs for Commercial Buildings in Hong Kong, Building Research and Information.

Ling Ch.S., Ahmad M.H. and Ossen D.R. (2007). The Effect of Geometric Shape and Building Orientation on Minimising Solar insolation on High-Rise Buildings in Hot Humid Climate. Journal of Construction in Developing Countries, Vol. 12, No. 1, 27-38. https://core.ac.uk/download/pdf/11783886.pdf?repositoryId=392

McDonald, R. I., Fargione, J., Kiesecker, J., Miller, W. M., & Powell, J. (2009). Energy sprawl or energy efficiency: climate policy impacts on natural habitat for the United States of America.

Paterson D. and Cole I.S., (1999).Numerical Simulation of Flood Flows around an Isolated Domestic Dwelling,

Sachs P. (1978). Wind Forces in Engineering, Pergamon Press, Oxford.

Stoms, D. M., Dashiell, S. L., & Davis, F. W. (2013). Siting solar energy development to minimize biological impacts. Renewable Energy

Sampò Luca and Francis Kéré (2011). Contemporary Architecture in Africa (Boundaries · International Architectural Magazine, Issue 1.

Smyth, M. Solar photovoltaic installations in American and European winemaking facilities. Journal of Cleaner Production, (2012).

Tang R, Meir I.A, Etzion Y., (2003). An analysis of absorbed radiation by dome and vaulted roofs as compared with flat roofs energyand buildings, 35: 539-548

Tsang, C.W., Kwok, K.C.S., Hitchcock, P.A. (2012). Wind tunnel study of pedestrian level wind

Environment around tall buildings: Effects of building dimensions, separation and podium. Build. Environ.

Tang R, Meirb A, Wu T, Thermal performance of non air conditioned buildings with vaulted in comparison with flat roofs building and environment, Vol. 41, pp. 268-276

Vivendo, pensando, facendo Caròla. (2009) memorie di un architetto16 Jan

Yeang, K. (1996). The Skyscrapers: Bioclimatically Considered.

Yeang, K. (1994). Bioclimatic Skyscrapers. London, UK

Yeang, K. (1969). Designing with Nature January.