Title: **Looking for Cultural Response and Sustainability in the Design of a High-Rise Tower in the Middle East**

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Looking for Cultural Response and Sustainability in the Design of a High-Rise Tower in the Middle East

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Hatice Sözer

Dr. Sözer got her bachelor of architecture degree from Istanbul Technical University. She then was selected as one of the few research fellows by Higher Educational Council in Turkey and was awarded full scholarship for her graduate degrees. Dr. Sözer got her master of architecture from University of Colorado and PhD of Architecture from Illinois Institute of Technology (IIT). During her PhD, she had chance to work with pioneer architects and engineers on various tall building projects. She developed a PhD thesis titled “Identification of Barriers to the Building Integrated Photovoltaic Design Process as Applied to Curtain Wall”. After her graduation, she worked at IIT for over two years and got involved in PhD research activities, projects and courses.

Dr. Sözer is currently an Assistant Professor in Turkey where she also works as a licensed architect. Besides, she is Rector’s technical advisor as well as one of the consultancies of municipality of Istanbul.

Dr. Sözer has an advanced research background and practical experience in sustainable design, integration of renewable technologies and building design process. She has many journal and conference publications about these topics and various numbers of awards.

Raymond Clark

Mr. Clark is a Retired Partner of Skidmore, Owings and Merrill LLP. While at SOM he was the partner in charge of the MEP Engineering Design for numerous international tall building projects. His projects included the 88-story Jin Mao Tower in Shanghai, the tallest building in the Peoples Republic of China, the 73-story Tower Palace III in Seoul recently becoming world’s tallest structure and still growing. Mr. Clark is currently a faculty member in the PhD program in the College of Architecture at the Illinois Institute of Technology.

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Abstract

Middle Eastern culture has exhibited for generations various fundamental principles of sustainable ways of living. It is the intention of this design to revive and utilize these fundamental principles into a modern design of an 80-story residential tower in Dubai. The main goal in this design is to create an innovative and next generation sustainable tower design specifically for the Middle East by taking advantage of cutting-edge technologies while respecting the traditional way of living that reflects the cultural roots. Issues discussed in this paper are:

- Comparing the Environmental effect on Middle Eastern culture and its relation to architecture, such as the open glazing concept offering view and daylight penetration strategies of western culture versus the traditional solid masonry walls and wide use of mashrabias in Middle Eastern cultures
- Middle Eastern cultural response to a high-rise building

  An example of a high-rise tower design that brings the idea of Islamic and Middle Eastern culture;
  - Cultural adaptation of high-rise living style from the low-rise (Eight story low-rise living to high-rise living)
  - Unique floor plan shape, offering shading and traditional masonry appearance
  - Importance of green space and its application to high-rise buildings
  - Modern adaptation of traditional mashrabia for solar protection and privacy
- Conclusions on sustainable tower design.

Keywords: Cultural and environmental responsible design, energy efficient design, traditional Middle Eastern Architecture

Introduction

Construction development in Dubai for the last 20 years has been growing incredibly fast. Included with this is a very high demand for tall buildings by the market. This brings a unique opportunity to explore what role traditional Middle Eastern architecture can play in modern architectural design of a tall building. Traditionally, Middle Eastern architecture was very particular about their ecological system, climate, culture, beliefs, functionality, and proportion of the buildings that fits very precisely with the surroundings. That gives a unique style and character that would not fit in any other parts of the world. This is often referred to as Islamic architecture because it represents Islamic life style or Middle Eastern architecture that represents the specific environment and culture.

Buildings such as *mosques, hans* and *madrasas*, specifically represent the Middle eastern culture in their own very sophisticated mathematical way. There is a methodology between the proportion of spaces' length and width (A.J.,1998). This works extraordinary well with masonry arches, which have many applications on buildings through not only doorways but in domes or courtyards.

Figure 1. Example of masonry arch looking at courtyard (left) and dome (right) (Steele, 1997)

Relationship between form and space, functionality and scale, aesthetics and practical benefits, public and private areas are solved in an extraordinary impressive way.

Climate has an incredible affect on Middle Eastern culture through their life style and they ingeniously have taken advantage of those aspects for their architecture. Courtyards, most of the times include gardens and two or three story buildings surround them. Also, partially enclosed bazaars, narrow streets, loggias (avlu), and arcades, are very fundamental architectural elements for protecting the spaces from the harsh climate and in most cases creating privacy. Figure 2 shows a skillful integration adding a kind of wealth and power to the architecture as well.

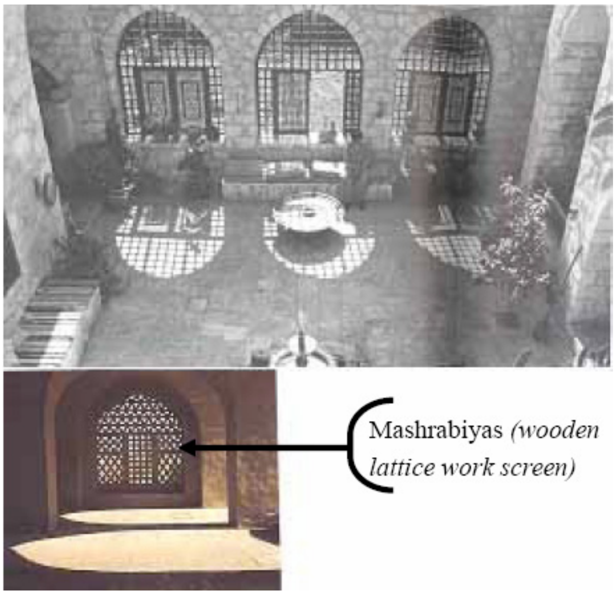


Figure 2. Courtyard (top), loggias with mashrabiyas (down) (Steele, 1997)

It is clearly noticeable that the dressing style and the architectural design roots evolved from the same principles, refer to Figure 3. Similar approaches are used both to cover the space and to cover the person. Long white dresses that completely protect the body from the harsh sun can be compared to the thick light colored masonry walls that the sun and also the sand in the wind of the dessert climate while providing privacy for women. A parallel can be drawn between this and the architectural elements of mashrabias, refer to Figure 4, providing privacy, very affective ventilation and reducing visual glare.

Figure 3. Dresing and architectural style (Steele, 1997).

Consequently, there are very basic elements that are strongly emphasized in the Middle East life style which is actually contradictory to basic elements in the Western life style. As an example, the attitude toward sun-light is very different between the east and west culture. The west enjoys a very open glazing concept for view and daylight whereas the Middle East employs a more private and protected attitude utilizing traditional masonry walls with very little glazing, and when glazing is used it is protected with mashrabias. Buildings in the Middle East create their own inside environment with courtyards and gardens, refer to Figure 4, on the other hand buildings in the West are built in already built environment and they face to surroundings such as streets and parks.

Figure 4. Middle Eastern buildings with their inside environment; courtyards, gardens (up); and their facades-covered by masonary wall or mashrabiyas (down) (Steele, 1997) .

High-Rise buildings in the Middle East

> *"Unfortunately, the eye doesn't suffer like the ear. When you hear dissonance, you jump. But when you see an ugly proportion, or whatever it is, the eye doesn't have tears, or get red, or suffer pain."*
>
> Hassan Fathy (Richard,1985).

With growing populations in the cities, high-rise buildings are becoming an important part of city life in every part of the world including the Middle East. The idea of high-rise buildings brings a new scale into Middle Eastern architecture. High-rise buildings also require the application of new technologies and expertise in every aspect of the design and construction, and require a very good understanding of the living life style and culture of the region where they are to be located.

Tall buildings have come to represent a city life style, that instead of growing horizontal as in the old cities, they grow vertically. So designing a high-rise building for a specific location needs great understanding of the people and culture and the building technologies while engaging them in a meaningful way.

Different architectural approaches between different environments:

> *"Climate is clearly one of the prime factors in culture, and therefore built form. It is the mainspring for all the sensual qualities that add up to a vital tropical architecture"*
>
> Tan Hock Beng (Olgay, 1992)

A consciousness of climate can be integrated with an instinctive understanding of local culture, to result in regionally responsive architecture. This is evident when looking at the old dwellings in different climate zones that clearly demonstrate an understanding of environmental principles as well as a need for security and protection. This is evident in North American Indian dwellings, subterranean settlements in China, human carved underground cities and sanctuaries carved into rocks and caves of Cappadocia, Turkey. All of these examples demonstrate that native forms of these dwellings were formed by the environment.

Hassan Fathy had explained very perfectly the reason behind indigenous forms. "*Old Islamic houses have filigreed windows and central courts, for example, to admit light without glare, coolness without air conditioning. The same principles could easily be incorporated even into high-rise buildings*" (CNN,1974). Fathy was urging to utilize the logic of traditional architecture. "*To me, it's a sin to put a Swiss chalet beside palm groves"* (CNN,1974).

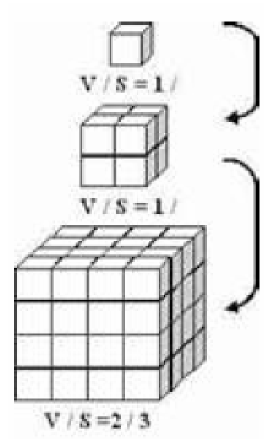
Design for the Middle East should also take advantage of traditionally excluded climatic elements of sun and wind and use them in a positive way by providing energy through photovoltaic and wind turbine systems.

Middle Eastern cultural response to high-rise buildings

Here, an example of a high-rise tower design that brings the idea of Islamic and Middle Eastern culture is presented based on the terms of culture, architecture, modern technologies and adaptation of these to high-rise building design. A whole building approach was applied from the beginning of the design to maximize the benefits.

Design strategies, applied to our design

> *"A basic principle for adapting buildings to extremes of temperature is that the ratio of internal volume to external surface must be as high as possible*"
>
> (Abdullac, 1982).



Internal Volume / External Surface: Heat Exchange from outside to inside

Since volume unit is m3 and surface area unit is m2, when the internal volume increases, surface area doesn't increase with the same amount. Figure 5.

Figure 5. Relation between external surface and internal volume (Abdullac, 1982).

This strategy is very evident in Middle Eastern architecture. The buildings are attached wall-to-wall to reduce the external surface area and border around the buildings for protection of the sun and hot climate.

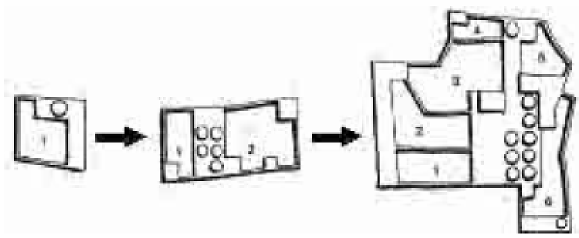


Figure 6. Example of attached wall. Telbisseh, Syria (Abdullac, 1982).

Courtyard design for houses has the same approach. Courtyards could be included in a single house or multiple houses could share the same open space to take advantage of outdoor space in a protected way. In addition, when houses are attached to each other wall-to-wall their exterior surfaces are reduced considerably. This results in very compact cities, with close neighborhoods and many shared common areas (Abdullac, 1982). Accessibility to common spaces by the surrounding units is functionally very critical.

The term of neighborhood is very important also in the Middle Eastern architecture. Each neighborhood has its own character, an entrance gate might represent this, and inside this neighborhood, they have common spaces to meet most of their needs like shops, hammams and mosques for daily prayer.

As discussed earlier, courtyards can be in different sizes and accommodate multiple functions. It can function as a hall to connect different rooms of a single house, or as a main street for neighborhood, gathering area for a family or common space for families. In addition, they also function to reducing cooling loads in the hot climate. At night, cool air comes in and cools the thermally massive courtyard walls and floor and these elements hold the "coolness" throughout the hot day. The size and shape of the courtyards are determined in part by local building techniques and climatic conditions and in part by the local cultural aspects.

Floor plan:

- *Unique floor plan design*

The floor plan has three main strategies that reduce the cooling load significantly by design such as; reduced external wall surface, shading effect that comes from backyards and cablings that covers the backyards.

The floor plans were designed functionally not to disturb the Middle Eastern life style while taking advantage of modern practical living. The typical floor plan for residential has 6 apartment units and each of them looking down to the backyard. Figure 7 represents a typical floor plan for residential and common spaces. This is one of the ways of fitting the courtyard idea into our design.

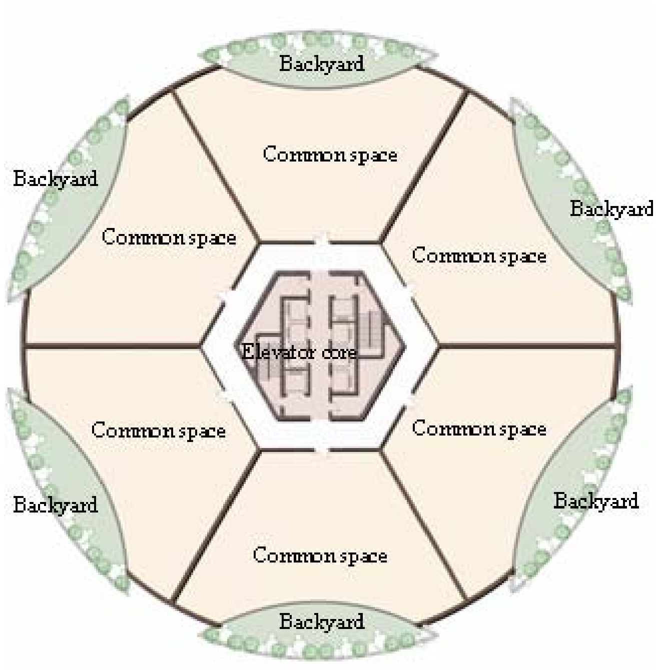
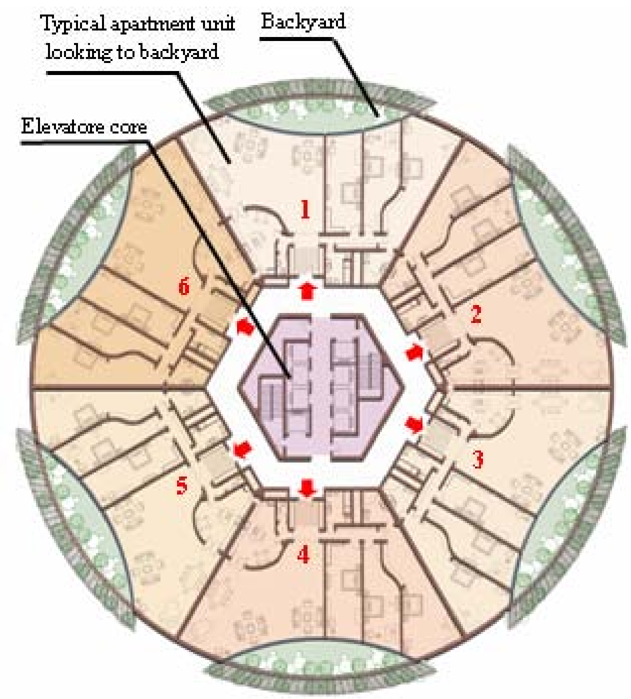


Figure 7. Typical floor plan for residential (up) & typical foor plan for common spaces such as; a woman or man gathering area, fitness center, hammam, pray area, children play ground or daycare (down)

Floor plans with the backyards repeat themselves every 8 floors. The tower has a total 80 floors. Refer to Figure 8. Families that live at the top on the 80th floor still have their yard seven floors down.



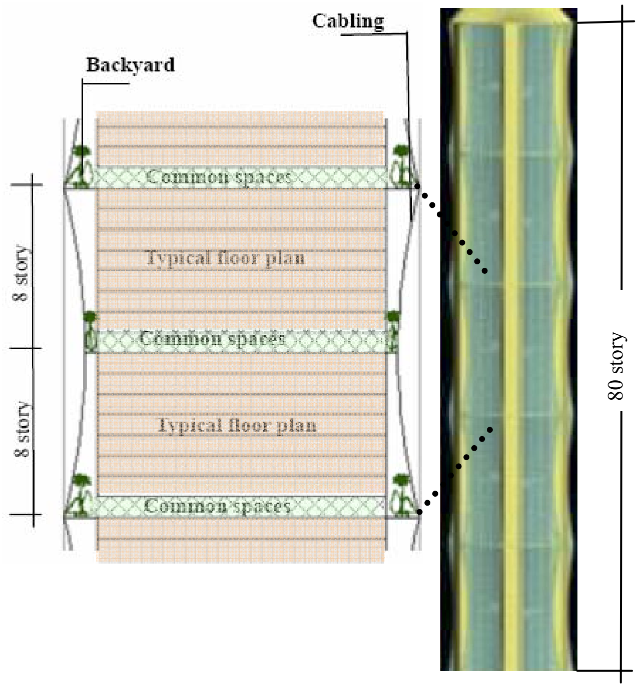


Figure 8. Part of section that shows 16 story of the tower (rihgt) Arial view of 80 story tower (left)

Figure 9. Cabling around the tower

One important strategy that is applied to the plan is, reducing the external surface area of glazing. Two thirds of the building façade area normally glazed was designed as solid wall by caving the façade in where the backyards are located, covered by cabling that have the function of mashrabias. Refer to Figure 9. This means almost 70% of the normally glazed external surface was eliminated by design.

- *cultural adaptation of low-rise living style to high-rise* (8 story low-rise living to high-rise living)

The floor plan that opens to the backyard has common spaces such as a woman or man gathering area, fitness center, hammam, pray area, children play ground or daycare. Refer to Figure 7&8. This also helps them to retain the neighborhood activities, which is very essential part of the culture.

Efficiency of the Design

The efficiency of the form of the tower was analyzed by using eQUEST, an energy simulation program. Comparisons were made with the same square meter floor area and using a glass covered tower as a baseline case. Our form with the caving (case1) and backyard (case2), and adding the cabling shading (case3) were compared to the base case. The performance of building envelope was compared.

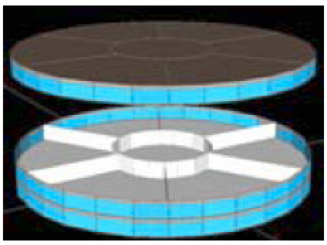


Figure 10. eQUEST model of baseline

Baseline case; Figure 10 represents eQUEST modeling of same square meter glass faced tower.

Figure 11 represents eQUEST modeling of the reduced glass area with caving. The reduction on total cooling load is 35% and on cooling energy is 36%.

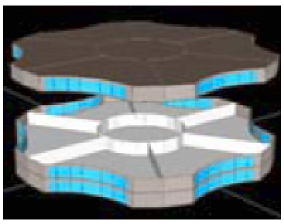


Figure 11. eQUEST model of case 1

Figure 12 represents eQUEST modeling of the reduced glass area with caving and backyards. The reduction on the total cooling load is 38% and on cooling energy is 39%.

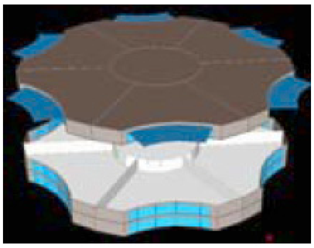


Figure 12. eQUEST model of case 2

Figure 13 represents eQUEST modeling of the reduced glass area with caving and backyards and the application of cables for shading. The reduction on the total cooling load is 55% and on cooling energy is 57%.

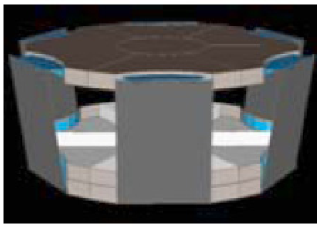
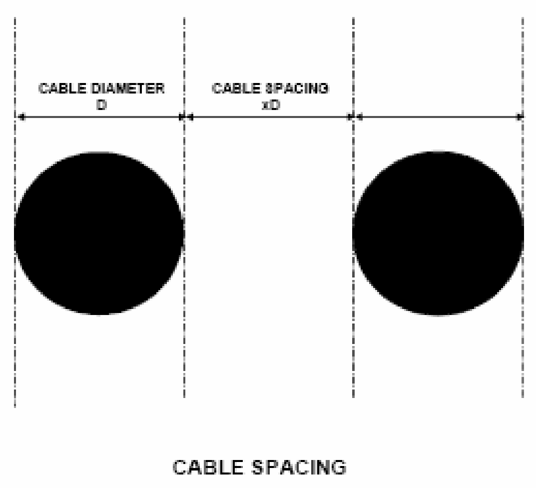


Figure 13. eQUEST model of case3

Further Analysis of the Cables for Shading

Based on the results above a further analysis was performed to study the shading performance of the cables based on the spacing of the cables.

The external cable structure that provides for reduction in cooling load, reduction in cooling energy and a veiling of the windows providing a cultural response of privacy. The cooling load and energy performance of the cable structure specifically were analyzed using DOE 2.1E. The analysis was performed using various cable spacing, based on the diameter of the cable, with the spacing ranging from 1 cable diameter (1D) to 10 cable diameters (10D). Refer to Figure 14.



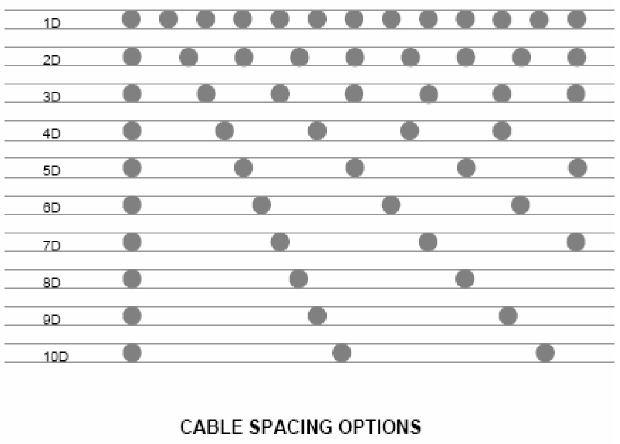


Figure 14. Diagrams showing the spacing between cables based on the cable diameter.

Peak Cooling Load Analysis

Figure 15 represents the reduction in peak cooling load based on the cable spacing and the orientation of the facade. As expected, the closer the spacing of the cables, the greater the reduction in cooling load. As seen in Figure 2, a cable spacing of 1D results in a dramatic reduction in peak cooling load. This most pronounced on the north and south exposures, 58% reduction. The east and west exposures also exhibit significant reductions as well, 50%.

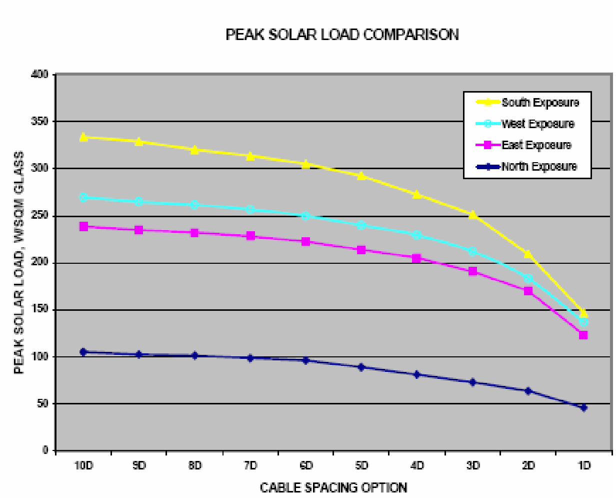


Figure 15. Reduction in peak solar cooling load based on cable spacing and facade orientation.

The cooling load is important as it is directly related to the capacity of the air conditioning systems and equipment that is required to be installed in the building. That includes piping, ductwork, fan coils, chillers etc. , and the electrical supply associated with the equipment. The electrical supply is critical because the rapid growth in Dubai and other middle eastern cities is rapidly outpacing the capability of the existing electrical generating capacities and power grid.

Annual Cooling Energy

Figure 16 represents the reduction in annual cooling energy also based on cable spacing and facade orientation. The reduction in cooling energy is similiar to the reduction in cooling load. Reductions of 50-60% result from changing the spacing from 10D to 1D.

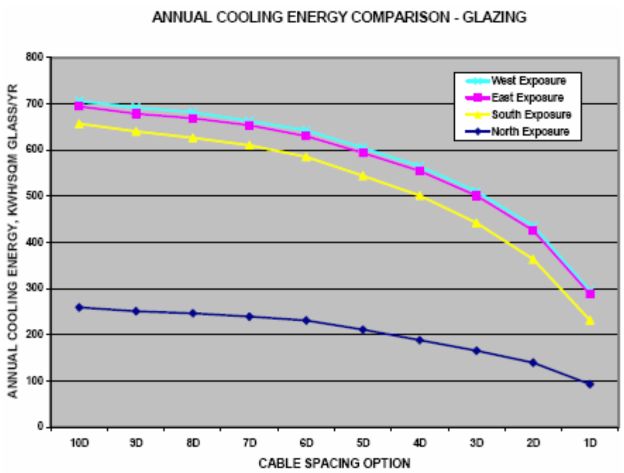


Figure 16 Reduction in peak solar cooling energy based on cable spacing and facade orientation.

In many climates shading of the glass would have an opposite effect on heating energy causing it to increase but in Dubai which is dramatically cooling dominated, shading the glass reduces the overall energy consumption of the building.

Visual Considerations

Using the exterior cable as a sunscreen is very effective in reducing the cooling load and cooling energy as observed in the previous 2 figures. However there is an obstruction to view from the indoor occupants. Traditional middle eastern cultures tend to have a different psychological feeling toward views and day light in a resisence than western cultures. The traditional house did not offer a view of the exterior except through obstructions such as mushrabias. Most views were concentrated inwards toward toward private courtyards primarily due to the heat of the sunlight in the harsh desert environment. Because of this the attitude toward daylight (sunlight) was not positive. Also, in a residence there is an overriding need for privacy. Figure 17 shows a simulated view through the window for various cable spacings.

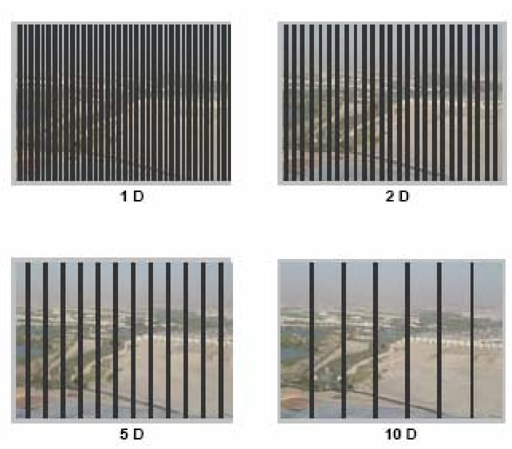


Figure 17. Simulated view through the window for various cable spacings.

The cables spaced at 1D, as reported earlier, offer the best cooling load and energy reduction but also result in the most dramatic obstruction of view. One way to maintain the positive benifits of a dense shade and mitigate the detrimental view aspects is to reduce the cable diameter to a finer cable. This illustrated in Figure 5 where a s pacing of 1D produces a softer visual effect.

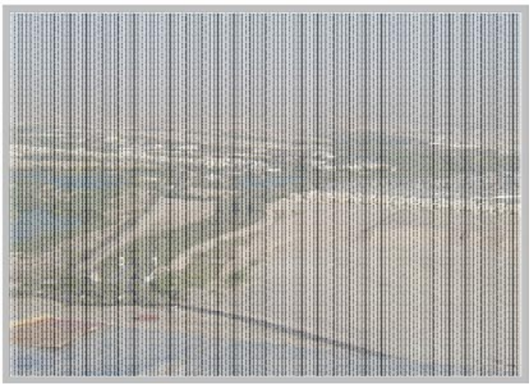


Figure 18. Cable spacing of 1D with a small cable diameter.

This gives more of a screen appearance than the 1D spacing with a larger diameter cable. The screen could be designed with horizontal cables that would further improve the performance or even a pattern to represent the traditional mashrabia screens.

Conclusion

This tower project represents the transformation of Middle Eastern architecture to contemporary architecture for a high-rise building. It attempts to preserve the Islamic character and culture with a strong climatic response and energy efficient design. This is accomplished with the use of frequent common and green spaces, backyards solar protection using cables.

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