

## **Analytical study of the moveable architecture elements in the internal architecture of Al-Haram Al Nabawi**

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### **Introduction:**

Prophet's Mosque is the core of forming mosques in the whole world. As Prophet Peace be upon him built it fourteen centuries ago, it flourished throughout history, and passed through many stages. Architects have used countless ideas to make it easier for its visitors and to provide comfort for them.

We can define Technology as the Greek word that has two syllables, the first syllable **Techno** which means a craft, a skill, or an art, the second **logy** which means science or study.<sup>(1)</sup> Hence, along with the technological development, and the evolution of exploration and invention, the movement of technology had its impact on mosques and it has greatly developed in the last period of time, this expansion is considered of the most important projects in the modern era for its religious importance also because of the modern techniques used in this expansion. The project has won the award of the best technical creativity from the International Building Technology Authority, Houston, USA 1993. <sup>(2)</sup> Therefore the researcher has focused on the most important elements that could have been affected by the new modern technology in the Prophet's Mosque (the subject of the study) which is the movable architecture represented in the automatic movement of awnings also the movements of sliding domes. Here, the researcher will show some types of technological techniques that are recently used in the Prophet's Mosque in the 21<sup>st</sup> century.

### **Statement of the problem:**

The problem of the research is represented in the following question: What is the nature of the movable architecture elements and their impact on the interior architecture of the Prophet's Mosque and what are the material used for building and shaping them?

### **Study significance:**

The importance of the research lies in the following

- A counting and an accurate description of the elements of movable architecture in the interior space of the Prophet's Mosque represented in sliding domes and movable awnings.
- To support the Arabic library with a documented reference of the successive development process of the interior architecture of the Prophet's Mosque in the 21<sup>st</sup> century.

### **Study Objective:**

To count and describe the elements of movable architecture within the interior of the Prophet's Mosque which hold Islamic ideological and artistic features and historical values

### **Delimitations:**

- 1- **Place delimitation:** Prophet's Mosque, Medina, Saudi Arabia.
- 2- **Time delimitation:** twenty first century.

**Research Approach:**

**1-Scientific Analysis Methodology\ Scientific Approach:** Through field visits to the place to find out the details related to the elements of the internal movable architecture and the technology used in it to adopt its contents and fundamentals in the interior design.

**2-Documentary approach \ Theoretical Approach:** Through description, ways of using materials, and modern technology used in the movable architecture to highlight the Islamic identity in the place without detracting from its features.

**1- Technological Elements Used in the Prophet's Mosque in The Twenty First Century:****1-1 First: Movable Architecture:**

We can find a great development of movable architecture systems that were presented and largely appeared at the end of the twenty century and the beginning of twenty first century. As a result of the development of both computers technologies and building materials and the spread of technologies of sensor systems. Architectural projects have emerged which have a distinct identity derived from the presence of kinematic systems that have a clear impact on functional and formational nature of buildings, and that what has appeared in the Prophet's Mosque through mechanical awnings opening and closing, with the movement of sliding domes. The architect **Bodo Rash 1943<sup>(\*)</sup>** was the owner of those beginnings. He had plenty of work in Saudi Arabia, including the design of mechanical awnings and sliding domes, also the design of the City of Pilgrims in Saudi Arabia. He is one of the owners and pioneers of the idea of movable architecture <sup>(3)</sup>.

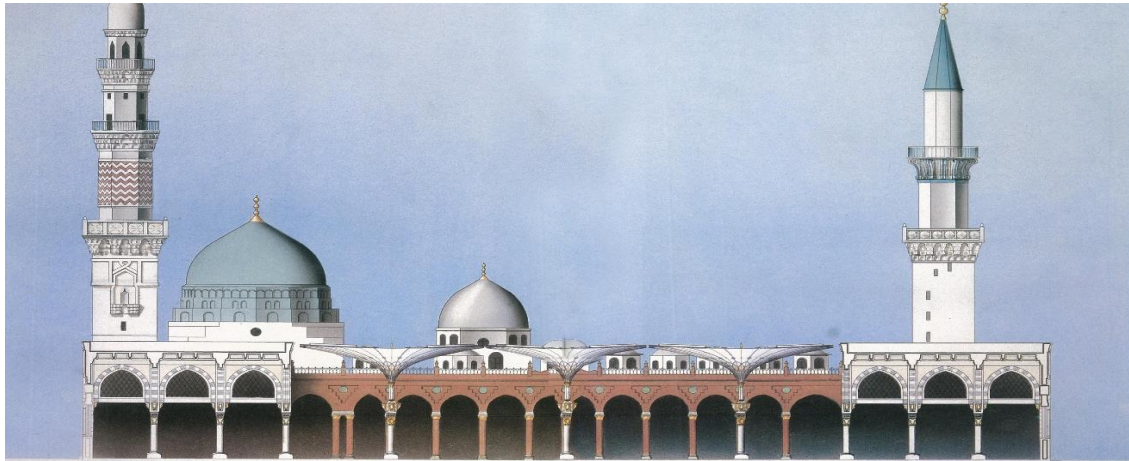
**1-1-1 First: The Mechanical Awnings:**


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Mahmoud Bodo Rash 1943: The designer of movable domes and mechanical awnings. He obtained his PhD in 1980 from the University of Stuttgart on the topic of tent cities for pilgrims. In 1991 he founded his own office SL. Bodo Rash has participated with the architect Frei Ato in a wide range of his works, such as movable roof studies for stadiums and tensile facilities in a number of projects.

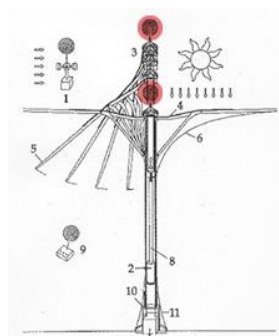
### 1-1-1-1 Idea and General Description:

King Abdullah Bin Abdulaziz during the expansion of the Prophet's Mosque has ordered to add the awnings to the inner and the outer courtyards of the Prophet's Mosque. The project was ended in August 2010. The project at the beginning included 182 awnings in the outer courtyards and 12 in the two inner courtyards, then 68 more awnings were added to the eastern courtyards so the total number became 250 awnings. Dimensions of the awning 25.5m width and length. One awning provides shades for an area of about 57m<sup>2</sup>. The total shaded area is about 104,000 m<sup>2</sup> that can accommodate about 209,000 prayers. Height of the texture lateral tip of the awning is about 15m when it is opened and 21.3m when closed. The awning



**Figure (01) a cross section of the old Haswa (inner courtyard) covered with awnings. Where awnings appear opened and closed. It is clear that despite they are different in personality, awnings integrate with the interior architectural features of the inner courtyard of the Prophet's Mosque in clear harmony.** <sup>(6)</sup>

opens and closes automatically. The movable awning is located in the inner courtyards of the Prophet's Mosque which are called **Haswa** (The stone), it was decided to close the inner courtyards with movable awnings until it was decided to air-condition the mosque and to keep their primary shape that goes back to the origin of the mosque when it was built at the time of the Prophet peace be upon him. On each courtyard there are 6 big awnings that were specially designed for the Prophet's Mosque. Their height matches the height of the mosque 14m. and their dimensions 17x18m, diameter 24m, Surface area 306m<sup>2</sup>. As illustrated in **figure 01** of the awning opened and closed and the ratio with the general surroundings of the place and how they fit the coatings and colors of the place.



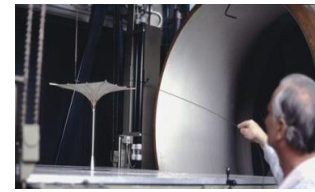
**Figure (02) Analytical drawing illustrates the location of the telescope in red and the operating unit inside the structure of the awning** <sup>(5)</sup>

### 1-1-1-2 Design and Building of the movable awnings:

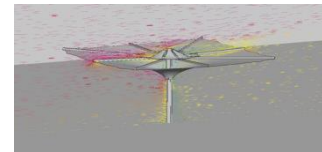
Courtyards of the Prophet's Mosque were equipped with 250 awnings and the two internal courtyards were equipped with 12 mechanical awnings opened and closed. The awnings are above each other to achieve overlapping. This overlapping among the awnings is perfectly achieved when an awning is on top of the other. There are two types of awnings in terms of height; one type is 14.4m and the other is 15.3m while they all are of the same height when

closed 21.7m. The metal structure of the awning consists of a top cylinder that has the telescope and an operating unit as **in figure (02)**. There are 8 upper supporters, 8 internal arms, 8 lower supporters, 4 diagonal arms, 8 arms that support the diagonal arms, 4 middle arms and 8 arms supporting the middle arms. There is a crown and a spear forming the end of the awning from the top made of polished copper coated with gold (electroplated). The structure of the awning consists of a metal bar fixed to a concrete pillar covered with white marble. This bar is supported by a mechanical frame that can be moved by a hydraulic cylinder that works with oil which is pumped into it to move the arm that opens and closes the awning. This process is controlled via the main computer of the building that is connected to each awning. The status of the awning appears on a control board whether it is closed, opened or disabled. Besides that, we can find that the process of opening and closing is done quietly without any noise despite the large size of the awnings.

A lot of tests were performed on miniature figures of movable awnings such as wind tunnel where air currents are used to simulate the reality using computers to measure the rates and measures of their durability as illustrated in **figure (03-A)** that helped to determine the thicknesses and dimensions of the elements and the units of the awning as illustrated in computer applications in **figure (03-B)** these awnings were designed to withstand wind speed that can reach up to 97mph in both opened and closed cases. To prevent tearing of the movable awnings during the process of opening and closing, the system was provided with a device that monitors wind speed and it is connected to the central control room that ensures stopping it when wind speed reaches 22.5 mph.



**Figure (03-A) An image of wind tunnel during performing a simulation study<sup>(7)</sup>**



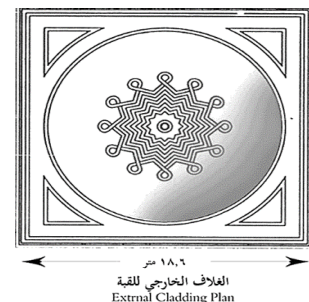
**Figure (03-B) A computer application image that studies the effect of wind on the awning<sup>(7)</sup>**

### 1-1-1-3 Awards:

The project of the Prophet's Mosque awnings that covers all the courtyards of the Prophet's Mosque and is supervised by The General Presidency of the Affairs of the Grand Mosque and The Prophet's Mosque was awarded with Abdul Latif Al-Fawzan Award for Mosque Architecture in its first session held in 1435 AH, 2014 AD.<sup>(7)</sup>

### 1-1-2 Second: The Movable Domes or Sliding Domes:

Domes are elements of architectural engineering constructions. They are arched (curved) in shape with no geometric ends or angles, and it covers large area without the need for supporting columns. Despite their small thickness, they are considered of the strong structural elements of our time. This design allows sunlight to pass through the spaces between arches and illuminates the dome without weakening its construction.



**Figure (04) A general vertical projection dimensions of a movable dome in the Prophet's Mosque in the expansion of King Fahd in the twenty first century.<sup>(8)</sup>**

### 1-2-1-1 Description of Movable Domes of the Prophet's Mosque in The 21<sup>st</sup> Century:

Prophet's Mosque Expansion project in the 21<sup>st</sup> century (the subject of the study) contained 27 movable domes that provide the interior space of the Prophet's Mosque with natural lighting and ventilation through opening and closing them during the day.

It has an area of 18x18m as in **figure (04)**. It is partially and fully opened to allow light and fresh air inside. The length of the square base of the dome is 18.6m and its area is 346m<sup>2</sup>, the inner radius is 7.35m, the height over the floor of the mosque is 16.65m and the height over the roof of the mosque is 3.55m and its full weight is 80 tons.

### 1-1-2-2 Design and construction:

**The body of the dome consists of the following elements:**

**1- (The outer casing):** the outer casing consists of an iron structure covered with ceramic tiles that has some Islamic decoration on it, and it is based from the highest point on the dome then it is repeated.

**2- The steel construction:** it is the main construction that forms the body of the dome

**3- The inner casing:** or the internal cladding that consists of interior decorated wood.

**4- Thermal/moisture insulation materials** of a thickness of 20cm.

**5- Automatic sliding system** on iron bars.

The outer casing also consists of 32 curved isometric slides. Each slide consists of hexagonal ceramic tile from the outside and fixed with epoxy glue over a layer of carbon fibers that is assembled on the metal structure of the body of the dome <sup>(2)</sup>.

The dome is carried by a steel construction consists of 24 supporters halving the circle, plus three rings of steel bridges. The construction of the dome gives a full coverage of the area and also carries all the inner and the outer casing and the insulation layers. It weighs 40 tons <sup>(3)</sup>.

The element of the sliding domes is considered of the richest interior elements of the Prophet's Mosque in decoration, where its full interior surface is covered. These decorations can be described as it starts with a belt that extends over the sides of the square base and it consists of intersecting geometric lines that is a well-known Islamic decoration pattern.

### 1-1-2-3 Planning and Designing the Movement of the Sliding Domes:

Of what is the most important things that were considered in the interior and exterior architecture of the Prophet's Mosque, that manual craft was merged with the use of the latest technology. Also modern industrial manufacturing processes were associated with traditional or manual manufacturing in some interior architecture elements. Designers were interested in developing and using modern applications and achieving various advantages that contribute to the service of the design and architecture <sup>(6)</sup>.

From this point, these ideas became clearer during the processing of the ideas of designing and building the movable domes. Where design and implementation approaches were adopted through modern technology that contributed to the design and gave the designer the ability to suggest and make complex designs and deal with design lines, that help the designer in structural analysis and to verify the required advantages in the field of engineering and appropriate architectural and interior solutions.

Through our study, the 27 movable domes that provide natural lighting and ventilation which represent a breakthrough in the field of architecture and solutions for the interior space

solutions in architecture in general and in mosques in particular like the case of the Prophet's Mosque (Subject of the study) that allows light and air in by partially and fully opening for the entire area of the courtyard to perform the process of renewing the air inside the mosque and to add this renewed spirit inside the place.

### **Results:**

- 1.It was taken into consideration that the materials used in architecture and the interior design of the sliding domes not to be affected by weather fluctuation so that their colors or properties are unaffected by using natural materials and original colors.
2. The latest types of technologies were used in the interior architecture of the Prophet's Mosque, which serve the interior space and the most modern techniques used in forming of building materials and finishing which played an important and enormous role in changing the determinants of constant and variable in the concept of contemporary mosque architecture.
- 3.In designing or expanding of mosques, variables shouldn't be converted into constants. This mistake is made by many of those who are interested in designing mosque architecture. They make patterns, pillars, shapes, techniques, building materials, climate and environmental treatments adapted from different regions they treat some of them as variables and some as constants which narrowed the concept of practicing the profession.

### **Recommendations:**

- 1.To focus on the constants of mosque architecture and to go along with the spirit of the time so that we keep the continuity of values emerging from faith and leaving the space for creativity of the new developments that do not touch the constants.
- 2.To consider the Prophet's Mosque of the first valuable extensions in which the latest technological means were used in processing environmental control systems when designing mosques which didn't conflict with the concept of constants.
- 3.To support the educational track and pay attention to organizing local and international competitions to create modern means and technology that contribute to raising the efficiency of the internal architecture of mosques - in general - and the internal architecture of the Two Holy Mosques in particular.

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