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IMPROVING HAJJ PILGRIMS HEALTH CONDITIONS THROUGH PRODUCT DESIGN

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Keywords: tent design, design research, natural ventilation, climate adapted design, design development

1. Introduction

Hajj is the great pilgrimage for Muslims that is a combination of rituals happening once a lunar year, between the 8th and 13th day of Dhu al-Hijjah, the 12th month of the Islamic calendar. This event is happening in specific locations in and around Mecca city Saudi Arabia [Tabatabaei Yazdi 1996]. All Muslims are generally expected to do Hajj at least once in their life time when some circumstances is happened to them [Quran]. The gathering during Hajj is considered the largest annual gathering of people in the world [Mosher 2005]. Two million and one hundred thousand pilgrims participated to Hajj in 2015 [The Guardian 2015]. Hajj pilgrims Health is a critical issue regarding the extreme density of people which is estimated to reach as high as seven people per square metre crowd density [Ahmed et al. 2009], and extreme climate [Ahmed et al. 2006]. Population density, climate conditions, diet change, change of life style habits pattern, high level of physical activities in defined time ranges, and homesickness are the major reason causing pilgrims being in health risks [Razavi et al. 2005]. These can be categorized into three areas; body thermal comfort and tiredness including population density issues, climate condition, high level of physical activities and lifestyle changes; biological area including nutrition and transmitting diseases; mental health including homesickness and some lifestyle changes causes.

In this study, the aim is to focus on body thermal comfort and tiredness area, which is chosen for higher relativity and tending to have design opportunities to improve industrial and product design functions as optimizing function, value and appearance to benefit users [IDSA 2016]. This paper is directed to identify a critical design question to solve that results in a notable improvement in Hajj health conditions by product design.

2. Brief development methodology

The current body thermal comfort and tiredness situation is analysed from design prospective to identify critical areas as design questions. For this purpose, thermal comfort factors and activity level during different Hajj rites is compared. This leads to clearly identify a right design question to solve.

2.1 Current situation analysis

Hajj has different rites that should be done in defined time and order (Figure 1). The first Hajj step is named Ihram. Done in the first day of Hajj, 8th of Dhu al-Hijjah, by Ihram people put off their regular clothes and put on coverings named Ihram, which contains two separate large white square un-sewed fabric that can just be tied around upper and lower body for men, one wrapped around the waist reaching below the knee and the other draped over shoulders, and simple clear white Islamic typical public dresses

for women, allowing to uncover face, hands and feet. Ihram covers are to be used in later steps as well [Ibn Zuhra 1996] After Ihram and in the same day, pilgrims proceed to Mina to stay until the next day morning. Pilgrims are free to do their concentrations and praying [Mohamed 1996]. The stay is in permanent housing provided as white air condition facilitated tents (Figure 2).

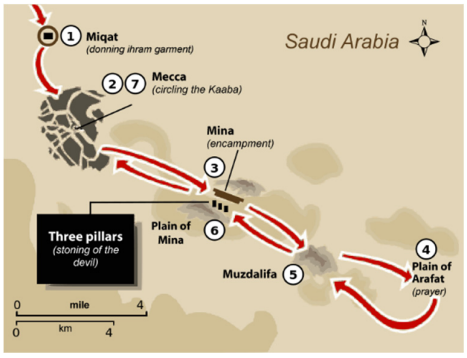


Figure 1. Order and location of Hajj rites diagram [Wikipedia 2016]

Figure 2. Mena air conditioned tents [Pain 2011]

Next day morning, 9th of Dhu al-Hijjah, is left for people to depart Mina and arrive at Arafat for Woqouf which is staying from noon to sunset of the second day of Hajj in Arafat [Mohamed 1996] (Figure 3).

Figure 3. Arafat tents

Figure 4. Muzdalifa site in use [Keepingithalal]

Pilgrims should carry on to Muzdalifa since the second day sunset and stay there till next dawn. In the meanwhile they are expected to pick 49 pebbles for later steps do their pray and are free to sleep in open air [Mohamed 1996] (Figure 4).

The third day's rites starts with proceeding to Mina on sunrise to throw stones to a symbolic devil wall, called Ramy al-Jamarat. Then they or their representatives do sacrifice an animal. The sacrifice which is called Qurbani is not necessarily done by themselves or in the same location, but it is to be assumed done for the next rite which is shaving or trimming hair, called Halq aw Taqsir. From this step onward it is allowed to take Ihram off and to wear common clothes. The next rite is Tawaf which means circumambulation seven times around Kaaba in Mecca in open air (Figure 5). The next rite in the third

day is Sa'ay that means walking or running the distance of two mountains of Safa and Marva near Kaaba [Tabatabaei Yazdi 1996], [Mohamed 1996] which is nowadays done through air conditioned corridors. The length of Tawaf walk can be 1.4 to 4.1 kilometres depending on the distance from Kaaba around where people turn and Sa'ay requires approximately 2.8 kilometres walk [Sridhar et al. 2015]. The following night is spent back to Mina.

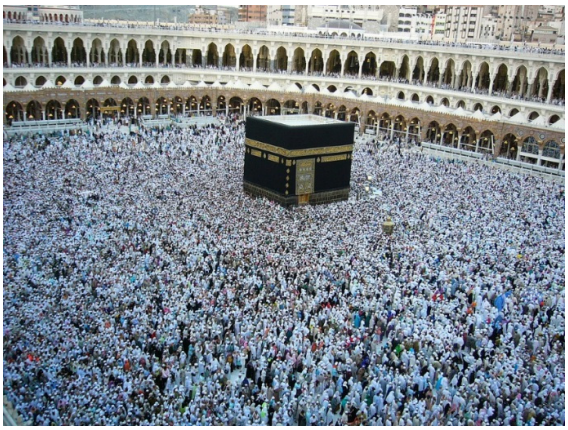


Figure 5. Tawaf around Kaaba, Mecca

For the fourth and fifth Hajj days, 11th and 12th Dhu al-Hijjah, the special rite is to throw stones to each three symbolic devil walls, located close to Mina, between noon and sunset. Hajj ends with leaving Mina to Mecca and doing the last or farewell Tawaf and leaving Mecca before 12th sunset [Mohamed 1996]. Adding the fact that the distance between locations is walked and the distance to walk depends on each person's tent location, an average of 5 to 15 kilometres are walked per day by each pilgrim [Sridhar et al. 2015].
Knowing the activities, order and conditions, Table 1 summarizes activities during Hajj and their activity rate, air ventilation, exposure to direct sun and affection to sleeping habits.

Table 1. Analysis of Hajj activities

Day	Rite step	Body activity	Time of the day	Air ventilation	Direct Sun exposure	Sleep habit affected
First	Ihram	Normal	Morning	Yes	Yes	No
First	Going to Mina	High	Noon	Yes	Yes	No
First	Mina stay	Normal	Noon to tomorrow morning	Yes	No	No
Second	Arafat stay	High	Noon to sunset	No	No	No
Second	Muzdalifa stay	High	All night	Yes	N/A	Yes
Third	Ramy al-Jamarat	High	Sunrise to noon	No	No	No
Third	Halq aw Taqsir	Normal	Around noon	Yes	Yes	No
Third	Tawaf	High	Afternoon	Yes	Yes	No
Third	Sa'ay	High	Afternoon	Yes	No	No
Third	Mina stay	Normal	Whole night to tomorrow noon	Yes	No	No
Fourth	Ramy al-Jamarat	High	Afternoon	No	No	No
Fourth	Mina stay	Normal	Whole night to tomorrow noon	Yes	No	No
Fifth	Ramy al-Jamarat	High	Afternoon	No	No	No
Fifth	Farewell Tawaf and leave	High	Before sunset	Yes	Yes	No

According to Table 1, the first day's most significant body activity is to proceed from Mecca to Mina that is requiring walking or long waiting on transportation vehicles including busses and cars. This is followed by a half day and complete night to rest and recover. The second day starts from proceeding to Arafat in the same condition to stay for a couple of hours from noon until sunset and then moving to Muzdalifa to pray and collect pebbles for further steps. As Muzdalifa stay is not facilitated with tents or housing alternatives, people tend to have a rest on their own mattresses or on the ground. The third day is the most intense day since requiring mostly high activity level steps covering all the day from dawn to sunset. The third night can be spent resting in Mina until tomorrow noon. The fourth day is relatively a quiet day having body activities from noon to sunset for Ramy al-Jamarat in Mina and followed by staying in Mina until tomorrow noon when the fifth day activities as doing Ramy al-Jamarat and Tawaf ends with leaving Mecca before sunset and Hajj rites ends this day.
The third day has the most body activities amongst all. The intense defined activities in defined timing, location and order in the third day requires providing good body fit before, and enough resting to keep body condition well enough to consume high amount of energy and do activities without being affected. Unless the second night, all the other nights are spent in the permanent housings in Mina. The second night when is the night before the most active day, is being spent in Muzdalifa without housing facilities in which pilgrims tend to have a rest on their own carried mattress or on the ground if not provided, and some others prefer to stay awake all the night till morning as sleeping habits are affected. On the other hand, the second day starts with walking or being transported in Arafat and then staying in Arafat tents with no ventilation provided and high population density and then going to Muzdalifa. The second day requires relatively a high amount of activities with poor resting condition at the following night, which is back to back with the third heavy duty day. Consequently, since the second day is done in a poor condition, the third day's pilgrims body fit and activities quality may be affected, as well as their health and endurance. This makes their health at the risks of new diseases or experiencing serious difficulties with some former minor health weaknesses, in the pressure of activities and high population intensity conditions. Therefore, revising the second day's conditions is concluded as the area needing improvement to result in improving pilgrims' health condition.
By providing a higher staying quality in Arafat and Muzdalifa a better readiness for the next day could be resulted.

2.2 Arafat and Muzdalifa current conditions

Arafat is a plain with 12 kilometres in length and 6.2 kilometres in width in south-east of Mecca city, Saudi Arabia. The "Arafat area is considered to have a desert climate. The average annual temperature is 30.2 °C in Arafat and precipitation level is averages 72 mm in average" [Climate-data.org]. People who travel from other countries are usually managed and organized by agencies from the country of origin and having managers and crew during all the journey. Therefore, groups of people tend to remain together during the different steps of the Hajj.
Hajj time, is the only time span that the whole area of Arafat is occupied, as a ritual requirement to stay within that precise area in Hajj. The challenge for the named area is having a suitable accommodation, both to maximise the efficient use of space to accommodate all pilgrims, and to improve the quality of the stay in Arafat for pilgrims to reduce their tiredness and damage risk in further activities during Hajj. While Arafat is being used from noon to sunset of the 9th Dhu al-Hijjah, Muzdalifa is to be occupied from sunset to tomorrow dawn. Pilgrims should do their prayers there, collect pebbles and use their time for their own or have a rest. There is not a housing facility and the crowd tend to remain awake and keep praying until morning. The average temperature for all day hours is 24 to 36 degree depending on seasons and the average high temperature of the day is 30 to 44 centigrade. Arafat is occupied daily in this temperature range with housings described in following. The average low temperature of the area, which is the time range that pilgrims stay in Muzdalifa at night with no housing facilities, changes between 18 and 30 centigrade through different seasons.
Currently used tents in Arafat are established by erecting four rims on four corners of a square shape sheet, as well as another rim at the middle for more stability. In addition, Horizontal bars are attached to the vertical bars and curtains are hanged down from the horizontal bar in the ceiling of the tent. The current tents has not a flooring built in and separate woven are used on the sandy ground as covering.

Figure 6. The current Arafat housing solution

The current solution benefits are clarity of the establishing process for labourers who may establish them once a year, rims can be used for other purposes for the rest of the year; limited storage space required when deconstructed for the rest of the year; and the ability to attach more than one tent together. In contrast, the drawbacks of the current tents are that they are not appropriate for the climate they are being used in; the lack of ability to add facilities inside them; that they are not adapted appropriately for the sandy ground; they are not designed to the personal needs of users; a lot of time is required to build and deconstruct the tents; and the poor ventilation exacerbated by the limited energy supply available.
The fact that this area is used only for about one day during the year might explain why the costs of construction are kept low. In addition, the lack of regular energy supply is another factor to be considered in this context.
Muzdalifa night stay is without housing facilities provided.

2.2.1 Initial design brief

There is a need for design a new housing solution for using in Arafat in the second Hajj day and in the second Hajj night in Muzdalifa in order to improve physical comfort, provide suitable intellectual concentration context for the special aim of Hajj and to make appropriate solutions toward the climate issues and ventilation.

3. Research methodology

Research undertaken focuses on three main areas: the intellectual environment demanded; users' physical and personal needs; and the environmental and architectural aspects.

3.1 Intellectual requirements

As the situation is about a special context related to religious and symbolic activities. Therefore, it is needed to analyse intellectual and mental situations for related context. Research focused on gathering information on some fundamentals of the Hajj act and its symbolism from respected references and written materials. In addition, interviews were conducted with people who have been to Hajj to understand the realistic atmosphere and mental orientations.
They are different hints toward naming that area Arafat. One is naming it as a land with elevated area, stemmed from The Arabic word of "Arifah" as it is near a mountain and also contains a hill within. Another name meaning comes from the Arabic word of "Irfan" which stems from mysticism and self-knowledge. Another perception of the Arafat naming is historical in which it is told that Eve and Adam had met in that desert after a long breakaway, or Another belief is that Ibrahim, the prophet, had being messaged and became deep in knowing himself, pointing to self-knowledge meaning [Motahari 2005]. According to former Hajj pilgrims, current intellectual atmosphere in Arafat is focusing on pilgrimage

and pray, to think and feel about the area and Hajj in simple and mono style clothing, feeling simple, pure and equal.

3.2 Users' needs

The main body of research in this area was primary research to have access to people's right feeling and concerning during stay in Arafat and Muzadalifa. Observation and ethnography was the main qualitative method to analyse and investigate problems and design issues. As Hajj happens once a year, high demand resulted in special rules and in some circumstances years of waiting to get allowance to participate in Hajj in its right time. Therefore, the qualitative research was conducted based on photos and videos chosen among a large number of materials from realistic context observant and participants. In addition interviews has been done with five Hajj group leaders who were engaged in many reported and unreported problem and issues during the journeys.

3.2.1 Observation and ethnography

Ethnographic observation is a qualitative method used for deep insight towards target group members and being more related to the topic in context [Griffin 2005]. Due to the time limitation for Hajj which is happening once a lunar year and specific requirement to travel to Saudi Arabia in Hajj time for high international demands, it was decided to undertake video observation and photo observation based on realistic videos and photos captured and documented by people who have been there.

Figures 7, 8, 9 and 10. Current situation in Arafat

Some of the most important issues investigated in the ethnographic observation were that people tend to make their staying situation more pleasant by increasing opening for more ventilation and using shadows of privacy to pray and concentration; spaces being covered in dust; fabrics getting easily torn; and a lack of a special architecture and aesthetic theme related to religious usage.

In contrast with Arafat and Muzdalifa, Mina has well sophisticated temporary housing facilities including air conditioning, energy supply, permanent service buildings and even recently accommodation blocks to house pilgrims for Hajj season. The reason for poor housing facility in Arafat and Muzdalifa in comparison to Mina is that Arafat and Muzdalifa stays are short, each not more than several hours, and this seems not reasonable for investors to establish facilities on two separate locations to serve a relatively large number of people in two different areas each for a couple of hours, aside from urban planning issues and limitations. That is while Mina stay is for at least three complete night from sunset until tomorrow morning or noon, convincing necessity of established facilities in place.

Figure 11. Inside a tent in Mina

3.2.2 Interview

Interviews are a useful method for gathering information from participants on their experiences and viewpoints [Klein 2012]. Interviews conducted with the group leaders who are responsible for bringing people since departure from the country of origin until finishing Hajj and returning back home, because they have been in contact with a large number of people in Hajj often over many years and with many different situations, issues and personal matters. This makes them aware of frequently occurring problems in different steps of Hajj as well as knowing other issues in managing scale. Five semi-structured interviews were undertaken with five group managers in three different Iranian cities of Shiraz, Tabriz and Tehran. Semi-structured interviews were chosen because this approach helps the interviewees having the feeling to go deeper in some topics and indicates importance of issues they observed from in their opinion. Eleven other structured interviews were also undertaken with Hajj participants in the named cities to investigated deeper into pilgrims needs and feelings toward different problems found in observation and know more about some issues hidden from management but existing from a user's perspective. The reason for Hajj participants' interviews were to have a practical understanding and comparing between what managers see from above point and what participants feel in context as the real users and to make realistic understanding of the outcome of group managers opinions.

The most important and frequent points understood in this research are as following. The tents are established and managed by contractors rather than each tour leader or the government. Therefore, a cumulative solution for all settled people is demanded at the same time, rather than solutions for special needs for small groups. More privacy is needed. Pilgrims found the environment hard for focusing on pray and concentrating on the reason of their journey. Some people became ill due to the harsh hot climate adjunct with dehydration and had to give up for the rest of the journey due to health problems.

3.3 Climate issues and traditional architecture solutions

Climate is defined by sunshine, temperature, moisture, wind and precipitation and influences the level of an individual's thermal comfort, which includes physiological and psychological results of heat influence on the body. Thermal comfort minimally includes the following factors: Temperature should ideally be between 16 and 30 centigrade, moisture between 20% and 90% [Koch-Nielsen 2002], and air movement ideally between 0.25 and 1 metres per second [Kasmaei 1983].

Another research was investigation into solutions to adapt with hot and dry climate in traditional architecture. Benefits of traditional solutions is that the solutions are being tested and evaluated for unlimited times until achieving the best results in relevant, facilities and circumstances and using context. Some developed solutions were based on the best usage of shadows like dome shape roofs, ice houses, ice making walls and towers, and some others were based on effects of negative and air pressure and evaporation such as some of Persian traditional wind towers [Taghizadegan 1991]. Following figures illustrates some solutions achieved traditionally.

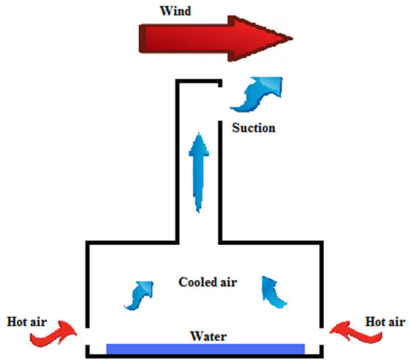
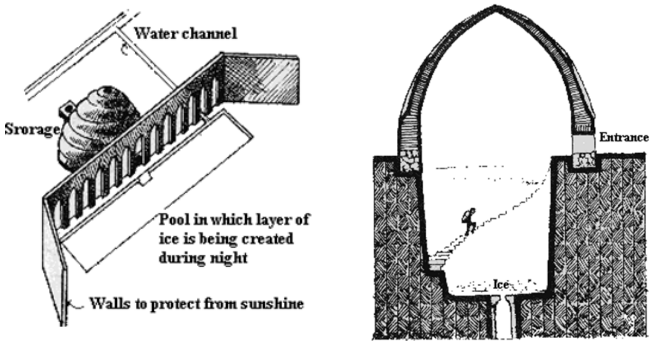


Figure 12. Wind tower mechanism

Figure 13. A wind tower set in Ardakan, Iran

Figure 14. Employing cooling effect of shadow by dome shape roofs, Seestan Masooleh, Iran



Figures 15 and 16. Employing cooling effect of shadow to make and storage ice in Persian deserts

Figure 17. An ice house in Meybod, Iran

4. Design brief

Following the related researches phase, developing a good design question through the design brief outlines the concept design and development phase within prospective improvements to achieve. Design brief narrows the range of ideas and solution generated in the design and development phase to the fulfil target points efficiently rather than leaving that phase broad but at the same time inefficient to achieve related improvements. Based on researches, the following brief is developed for the design development phase.

The aim of the design phase was to design a tent to be used in the dry and hot climate of Arafat and Muzdalifa for the purpose of sheltering Hajj pilgrims in the second Hajj day, happening once a lunar year, to suggest solution for:

- Preparing suitable intellectual space for the Hajj pilgrims
- Natural ventilation
- Efficient usage of area to establish tents
- Flexibility of instalment on the site
- Protection against direct sun
- Preventing dust and sand entering the tent

- Predicting convenience and operation to establish and take down again
- Suitability to carry and storage regarding yearly usage
- Production feasibility
- Having privacy in use

5. Design development

The design development started by using mind-mapping method, which is a graphical way to help thinking and organize different aspects to be considered for a subject, and provides the ability to take a look at many aspects as a whole as well as details at the same time [Buzan 2006]. By this, many ideas for the general body and structure and many detailed ideas for openings and mechanisms were generated. Another tools in this step was TRIZ or Theory of Inventive Problem Solving, which is a method for understanding, facing problems from different aspects and solving them [Proctor 2010]. This method is based on the problem and the obstacles faced, and suggests general solutions that can be converted to solutions by experts, especially when facing two contradictory elements or problems to solve, this system suggests solution to solve to facets of the problem at a same time [Moseley 2007] The whole method is finding two contradictions through analysis and to find general solution for that contradictions using TRIZ matrix [Moseley 2007]. The reason for using this method was facing contradictory problems to be solved in the design development phase. An instances is requiring large space to shelter pilgrims and at the same ability to carry and store after usage. TRIZ matrix suggests the following solutions: The other way round, dynamics, segmentation, and mechanics substitution, which by these general solutions ideas and concepts is developed to reach fulfilling results [Gadd 2011]. TRIZ is used for diversion and generating different solution for different aspects of the problem. Ideas were converged to 13 final concepts that cover requirements, each by a different extent, for the evaluation phase to choose a concept to match with design brief requirements better than others.

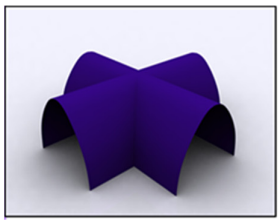


Figure 18. Concept 1

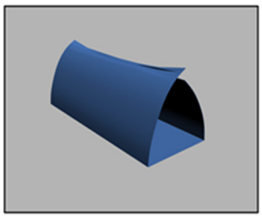


Figure 19. Concept 2

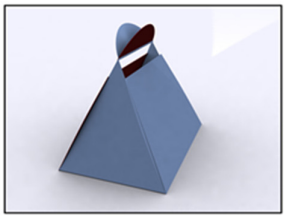


Figure 20. Concept 3

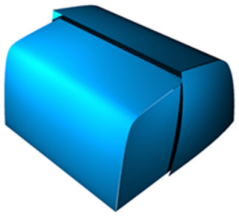


Figure 21. Concept 4

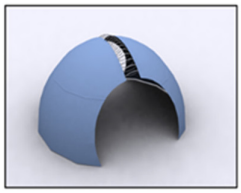


Figure 22. Concept 5

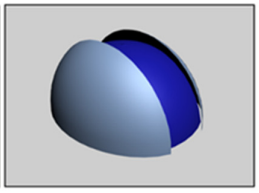


Figure 23. Concept 6

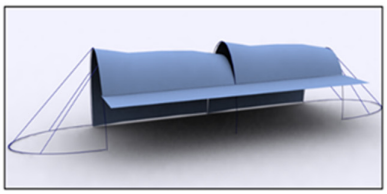


Figure 24. Concept 7

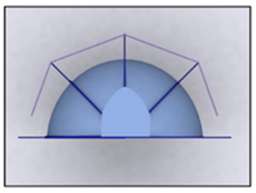
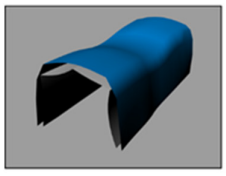
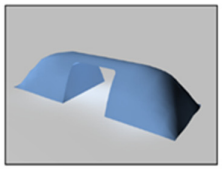
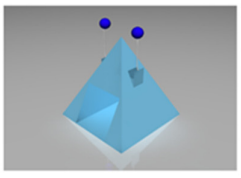
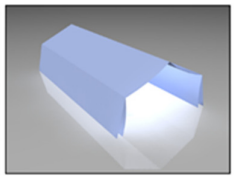


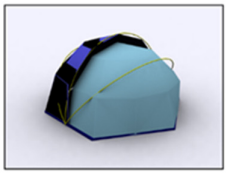
Figure 25. Concept 8











Figures 26, 27, 28, 29 and 30. Concepts 9-13

6. Evaluation

The concepts are to be compared with the design brief factors to conclude the level that each concept is fulfilling each factor and to choose the overall most efficient design in solving aimed questions. Because

of the influence of different factors on choosing and evaluation and initial ambiguity of dominance of each factor over another to choose, AHP evaluation method has been conducted in evaluation. AHP or Analytical Hierarchy Process is based on comparing pairs of factors by experts to assign predominance between pairs and conclude them as ratios for each factor followed by evaluating each design aspect in the same way to conclude the cumulative score for each concept that makes able to compare qualitative factors and elements quantitatively [Bhushan and Kanwal 2004]. The following tables are comparison of evaluation factors and assigned score to the different concepts. The outcome is a conclusion to choose the final best concept.

Table 2. Evaluation factors with ratios

No	Factor	Ratio
1	Natural ventilation	16.43%
2	Preparing suitable related intellectual space	36.83%
3	Preventing dust and sand to come in	9.33%
4	Efficient use of area and space	16.59%
5	Easy and fast to establish and wrap again	3.11%
6	Production feasibility	2.07%
7	Suitability to carry and storage for yearly usage	3.70%
8	Easy to repair and maintain	1.47%
9	Flexibility of instalment in relation with hindrances	10.47%

Table 2 indicates a numeric ratio of different factors in design brief. These factors are achieved by comparison between pairs of factors, assigning priority to one of each pair, adding factors scores and scale them to 100 percent overall score.

The following table indicates comparative scores for each concept on factors viewpoint. To achieve comparative scores, each pair of concepts have been compared separately from defined factors viewpoint and their scores were added up and scaled to 1.0 overall score. For example for factor 1, concept 1 and 2 were compared from the viewpoint of preparing better natural ventilation; since concept 1 is identified more providing natural ventilation, one point is assigned to concept 2, with no point to concept 2. This was done for each pair of concepts separately, then the scores were added up for each concept and then were scaled to 1.0 summation. This way, the comparative scores for all concepts in factor 1 column is defined. The same process was conducted for all factor to achieve score points for all concepts against all factors.

To understand the overall score for each concept to compare, the concept final score for each factor was calculated by multiplying factors score with the related factor ratios and adding them up. The outcome is concepts overall comparable scores with influence of each factor dominance.

Table 3. Evaluation factors with ratios

	F 1	F 2	F 3	F 4	F 5	F 6	F 7	F 8	F 9	**Final Score**
	16.43%	36.84%	9.33%	16.59%	3.11%	2.07%	3.70%	1.47%	10.47%	100%
Concept 1	0.01	0.05	0.02	0.05	0.02	0.05	0.03	0.10	0.10	0.0345
Concept 2	0.11	0.07	0.13	0.08	0.17	0.24	0.18	0.17	0.05	0.0887
Concept 3	0.04	0.03	0.12	0.07	0.12	0.07	0.09	0.10	0.06	0.0504
Concept 4	0.05	0.11	0.05	0.06	0.07	0.05	0.06	0.14	0.03	0.0708
Concept 5	0.05	0.04	0.03	0.01	0.12	0.07	0.07	0.11	0.03	0.0368
Concept 6	0.09	0.16	0.01	0.01	0.04	0.03	0.01	0.05	0.04	0.0793
Concept 7	0.09	0.06	0.01	0.02	0.05	0.03	0.02	0.03	0.12	0.0445
Concept 8	0.07	0.08	0.05	0.14	0.11	0.10	0.11	0.03	0.21	0.0789
Concept 9	0.16	0.10	0.05	0.09	0.04	0.08	0.03	0.01	0.03	0.0869

Concept 10	0.01	0.03	0.17	0.10	0.02	0.02	0.04	0.04	0.07	0.0483
Concept 11	0.05	0.01	0.10	0.06	0.01	0.08	0.04	0.09	0.02	0.0360
Concept 12	0.22	0.15	0.06	0.09	0.09	0.10	0.20	0.08	0.04	0.1254
Concept 13	0.05	0.11	0.20	0.24	0.12	0.08	0.11	0.05	0.21	0.1174

Concepts 12 and 13 have similarly higher overall scores than other concepts. The potential strong points of Concept 12 compared to number 13 are natural ventilation and potential suitability for storage and carrying. In reverse, strong points of concept 13 are preventing dust and sand to come into the tent, efficiency is using areas and space, and flexibility in installation. The other factors score difference for these two concepts are slight. As one of the problem faced for the named context is using limited are for a large number of people, efficient usage of areas and spaces and flexibility in installation t to overcome the area installation inconveniences for concept 13 are dominant to the potential strong points of concept 12. Consequently, the chosen concept for further steps is concept 13, with further improvements desired in ventilation and carrying and storage.

7. Final concept design

The final concept is to have an opening in a direction regarding local winds that makes a suitable low pressure to evacuate heat from upper part of the tent.

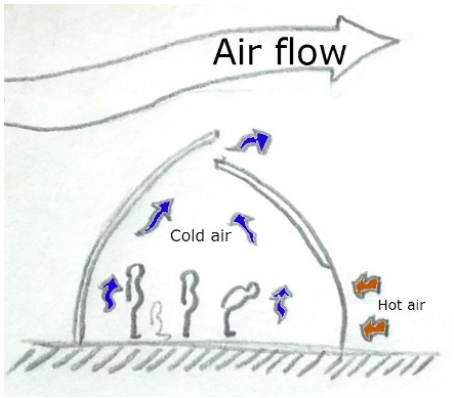


Figure 31. Ventilation diagram

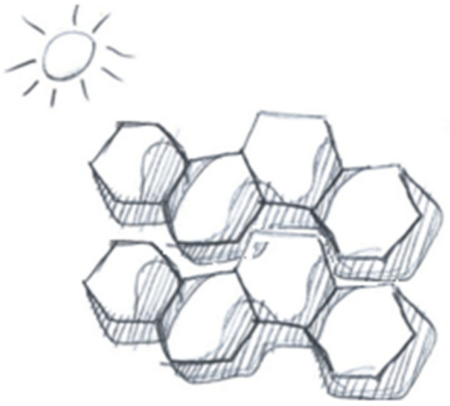


Figure 32. Using tents shadows

Another aspect included is by natural cooling through evaporation. The effect in wind tower based on loss of energy for evaporation is projected here by using body moisture absorbed by tents inner body as moisture resource. By having air flow in contact with body moisture absorbed by tents inner walls, the air becomes cooler since tents to absorb moisture and reduce temperature.

Another aspect of the cooling solution is that the tent is designed dome shaped and therefore a part of it will have shadow all the time, resulting in loss of heat from that points. As illustrated in Figure 32, tents shadow also prevents direct sun towards other tents. In addition, the corridor space between tents can be kept shadowed by tents body and gain less heat.

Another reason the whole tent is designed dome shaped is that it resembles the architecture of domes used in mosques and therefore provides a positive feeling for pilgrims to help them focus better on praying and to provide a positive atmosphere for the Hajj and the Arafat stay.

The hexagonal basement of tents makes it possible to use space efficiently in composition and the modularity also makes it more adaptable in the environment by providing the ability to change the order, number and direction of established tents in desired areas. Other considerations in development of the final design was anthropometry and mechanism design. The needed space for people to be able to pray and sit on the floor is a 125 centimetre by 60 centimetre area [Neufert 2000]. Based on that, the outer diameter of tents is around 4 metres to prepare enough space for 9 people in stable conditions. The structure is designed as rounded shaped pins attached at two ends. The aim for this type of mechanism

was to provide the ability of rapid installation and to collapse into compact shape for transportation and storage.

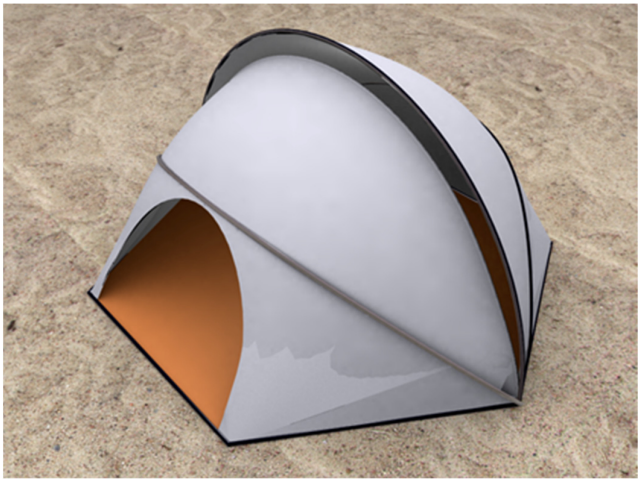


Figure 33. The Final tent design

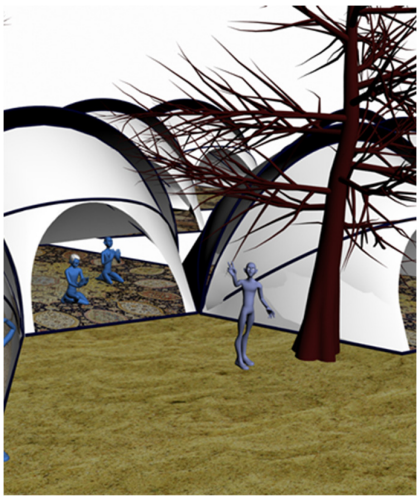


Figure 34. Usage image in context

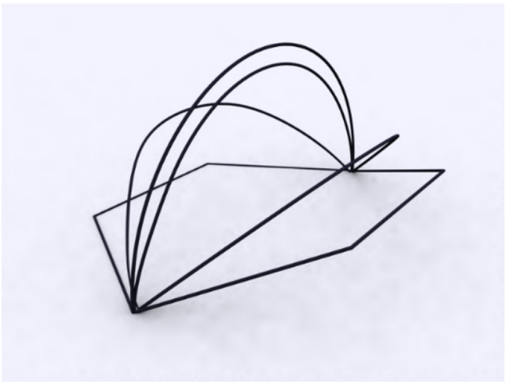


Figure 35. Mechanism opening view

Figure 36. Mechanism closing view

8. Analysing

After completion of the design development, a low-fidelity user testing was conducted in order to evaluate the product from users' prospective [Jordan 1998], [Hare et al. 2013]. A questionnaire was responded by 12 users, including 7 male and 5 female, who all had participated in Hajj. The questionnaire included questions about their expectations of a tent and among questions were indirect feedback of the characteristics of the designed tent. For example it was asked do they prefer to pray in a housing with a dome shape roof or a flat roof, and architectural non-ornamented interior samples of each was provided. The same was done to understand the preferred height of tents, area, shared spaces from users' prospective. Eight participant have opinions conveying that the new design can improve intellectual conditions for the aimed purpose. The height of the tent could be concluded desirable in seven participants' opinion and six people were optimistic that the new installation of tents together tends to make better environment than their former experience in the context. Overall, it can be concluded that the new solution addresses several existing and focused issues with current solutions form users prospective.

9. Conclusion

Improving Hajj level of health through design was started with analysing different steps to identify a focus area and consequently a complete design methodology have been developed to suggest a

cumulative design solutions to result in improvements in context and consequently in health level. The whole research and design was combination of product design, architecture, with considerations to cultural special needs. After analysing steps and rites and body condition it was decided to focus on the second day of Hajj mainly due to its poor conditions and the fact that the following day is the most intense day requiring good preparation. By leading the design and development phase to improve the Hajj second day's quality, this project aimed to improve health by product design.
The limitations for this project was firstly the special travelling rule to go to Saudi Arabia for context researches and in field activities, requiring waiting on years long ques due to high demand. This may cause more investment in simulates tests in simulates lab settlements or testing the product in similar climate conditions, while forcing to replace another ethnographic and data gathering methods.
The findings of this paper indicates that product design can make improvements in terms of desirability, body comfort and intellectual conditions related to religious and cultural purpose of Hajj. This results in a better body fit for the later steps requiring high energy consumption in later steps and Hajj health level improvement.

10. Future works

A medium fidelity user testing, using real scale mock up that makes people feel the environment can make more detailed improvement point to the concept design.
In addition, a high fidelity and experimental prototype testing, using fully working material and scale prototypes to test In the real context will be improving, especially when including later steps in the third and fourth Hajj days, with monitoring body's physical health factors by medical devices and compare it to similar data from other participants using old facilities. This shows the efficiency of the changes made to the second day of Hajj to increase body health conditions.

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