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Double-shell dome in terms of thermal behavior in Kashan desert climate*

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Abstract

Since a large part of Iran is located in hot-dry climate, also the maximum amount of radiation absorbed is done from the roof in low-lying buildings among other facades in summer. And also the maximum area of the outer shell of the building is dedicated to the ceiling. Further, the most energy consumption is devoted to the building, and there is high cost of cooling in the summer in Iran. Hence the implication of the roof's shape in providing comfort conditions couldn't br ignored. On the other hand, the vernacular architecture of Iran, like many other ancient civilizations has provided comfort conditions for many years with lower energy consumption. The double-dome roof is one of the indigenous architecture in hot-dry climate of Iran. Suitable double-dome is considered to provide comfort conditions in public buildings. By this aim, Kashan, a city of seven thousand years old and a vernacular architecture is chosen. The dome of the Chehel Dokhtaran tomb, that followes the general form of Kashan domes and has certain circumstances of this research, was considered the base. Afterwards the following tests were tried respectively and there were some changes on the geometry of the double-dome of the tomb by computer simulations such as Ecotect, Design Builder and Fluent softwares.

A-conduction: the reduction of heat transfer of the roof the better thermal performance on hot and cool days;

Test 1. Single shell dome is considered by removing the inner shell.

Test 2. The distance between two shells was decreased.

Test 3. The distance between two shells was increased.

B-radiation: the more radiation absorbed is reduced, the better thermal performance of the roof on hot days;

Test 4. The outer surface of the dome is deformed into hemisphere shape.

Test 5. Covering the outer shell of the dome by traditional tile.

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C-Convection: the warmer air is less dense than the cold air and always move upward, therefore the more remove the hot air accumulated inside the more comfort conditions provide in summer;
Test 6. Creating windowes in outer shell of the dome.
Test 7. Creating wind-catcher on the top of the dome.
The results of conduction, radiation and convection tests were compared with each other:
Considering the dome with two shells regardless shells distance from each other is significantly effective to provide comfort conditions in hot and cold days, due to reducing heat conduction from outside to inside and vice versa.
In the case of double shell dome with thin air layer like 5cm thikness between shells, the air layer acts as thermal insulation and the heat transfers only by conduction in such a way that the convection heat transfer isn't done. Compared with the main dome, the heat was crossed from the outer shell of the main dome during the day, and is collected at the top of the space between two shells; pass out while the weather temperature decreased at night, in test2 the heat transferred later to the outside. So, indoor air will experience higher temperature. And on winter, the heat will be transferred faster to the outside. So, the inside temperature will be hotter in summer and colder in winter.
In test3 the distance between two shells is increased to 3m and be filled by air. The heat will be collect under the top of the outer shell and will be far from the surface of the inner shell, although the interior vortices are formed completely and faster than the basic form in summer day and night and more time is required to transfer heat from outside to inside and vice versa. But on winter night the heat was gathered under the inner-dome will transfer to the air between tow shells. Compared to the main dome the heat will be transferred faster to the outside because of the stronger vortices. So in the winter inside air will be colder.
Comparision Nari dome form and the hemesphire dome with similar area, Nari dome is more suitable, thanks to the more surface area of it that is placed in shade and less direct and indirect radiation absorbed on hot days.
If the outer surface of the dome covered by bright tiles, reduces the absorption of radiation and the air temperature will be decrease on summer.
Air conditioning between shells caused evacuation of gathered heat and in summer reduces inside air temperature.
Wind-catcher causes negative pressure of the wind power on the outer dome, and make hot air that was gathered under the inner shell pulling out. And through heat exhaust, inside ventilation is formed, which is desirable on summer.
The general result is: The best geometric configuration to cover the roof of the building in desert climate of Kashan and similar climates, is the double-shell dome with outer-shell in the form of Nari-shaped and the inner-shell in the form of sphere sector, which similar to the dome of the Chehel Dokhtaran tomb of Kashan. Therefore with installing windowes on the outer shell and installing wind-catcher on top of the dome to remove the hot air. Also covering the dome by Iranian tiles, reduces the absorption of radiation. So the air temperature inside the building reduces on summer. Also close windowes and wind-catcher would be desirable, on winter.

Keywords:double dome, hot and dry, Kashan, conduction, radiation, convection.