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Thermal and Wind Environment of Adobe Vernacular Architecture in Morocco -Analysis by means of Simulations-

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This paper deals with the analysis by means of simulations of thermal and wind environment of adobe vernacular architecture called "Kasbah" in Morocco. Kasbah has a square courtyard and watch towers in corners. Most of them were built in desert area with a wide range of temperature. It is thought that the indoor environment is protected against solar radiation and high temperature by great thermal capacity of adobe. Simulation of thermal and wind environment in Kasbah were done by CFD, and the evaluations by SET* were compared to the observed data.

Key Words : *Kasbah, Dry region, Vernacular, adobe, CFD*

1. INTRODUCTION

In hot arid region, there are adobe architectures what are called "Kasbah". They have a square courtyard, four watchtowers and thick walls made of adobe. To clarify influence of wind and solar radiation on the courtyard, the simulations were carried out based on the data measured in 2009. [1)]

2. OUTLINE OF KASBAH

(1)Climates

Ait-Ben-Haddou, the measured region in 2009, is located at the Sahara, in Morocco. From morning till night, outdoor air temperature has a wide range what records 15℃ or more through the year. The annual rainfall in 2009 is 113mm, It can be said that the small rain region there.

(2)Residence

Kasbah, adobe vernacular architecture, originally plays the role as the fortress, and generally has watchtowers in the rooftop. In addition, it also owns a square courtyard has a peculiar meaning to Islam. In the viewpoint of lighting, the courtyard possesses an advantage.

Geographical features in the surrounding, where Kasbah exists is a median center in a desert and an oasis. The fort and Palm garden exist in outer of village in Kasbah.

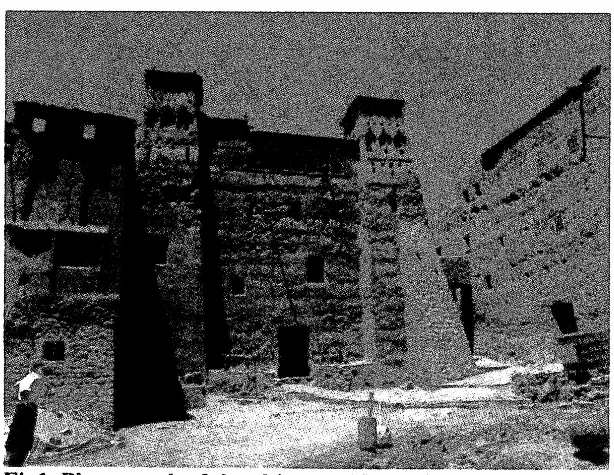


Fig1. Photograph of the object residence facade

(3)Targeted residence

The house is four-story residence. There is no equipment such as the gas, water service, and rest rooms. The first floor is used for domestic animal's food place and barn, because the window is few, and it is few to usually open the window. As for the second floor, there is a hall, and skylight has been installed from the ceiling. There is a courtyard in the center of the third floor, and it is half outdoor space. The fourth floor rooftop has watchtowers used to watch surroundings before takes a stance in four corners.

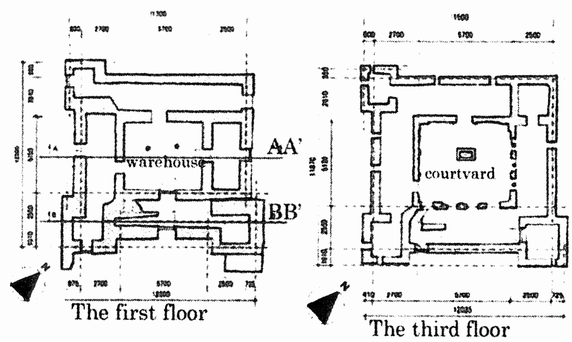
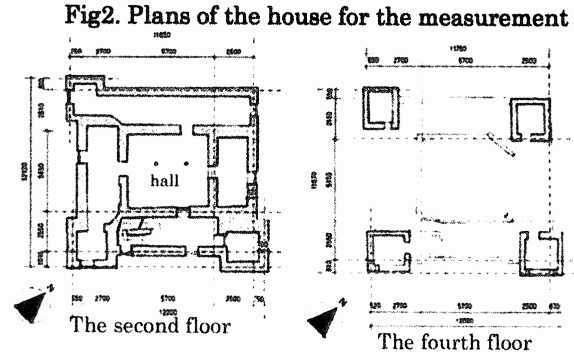


Fig2. Plans of the house for the measurement



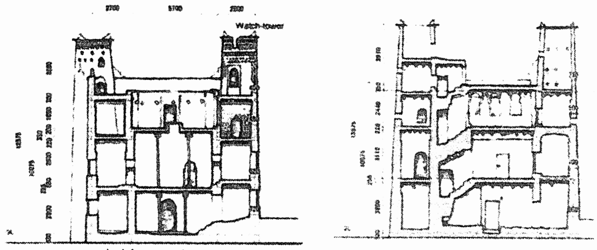


Fig3.Section of the house for the measurement

(4)Survey in 2009

It was measured from August 13th to 15th. The measured item is temperature, globe thermometer, humidity, flux of solar radiation, heat flow of adobe, wind direction, velocity of the wind, and illuminance. For the wind direction, the velocity of the wind, and the illuminance, it was measured every hour. To investigate the influence that the courtyard exerts on the indoor condition, the reading point is emphatically set up on the third floor with courtyard.

3. OUTLINE OF SIMULATION

(1)Purpose

The influence of solar radiation and wind to courtyard in residence in hot arid region is clarified, and the comfort of the indoor condition is verified. It is simulated by using the result of the survey in 2009. Therefore, August 14, 2009 when the survey was done is assumed and analyzed.

(2)Method

The simulation software of "STRRAM for WINDOWS Ver.8" was used to verify in the flow of the air indoor in the residence. In this case, it was made two Simple models from original complex shape to analyze it smoothly. Then, to consider the influence of solar radiation and wind on the day, one is an existing model, and another one is a model the courtyard is blockaded in vinyl seat. This seat almost passes neither solar radiation nor the wind on the day.

In the condition of the wind environment, the northeaster of 2.55m/s blows in the point of 15,700mm from the ground. This is quoted from the result of the survey in 2009. The wind from northeast was a most frequent wind direction August 14, 2009.

For the thermal environment, the outdoor air temperature set measurements every one hour from 8:00 to 19:00. And the measurement value of each point at 8:00 was set to two models and the simulation began.

These make the result of the survey in 2009.

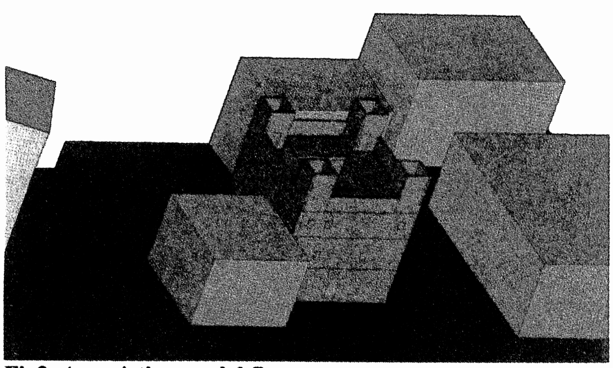


Fig2. An existing model figure

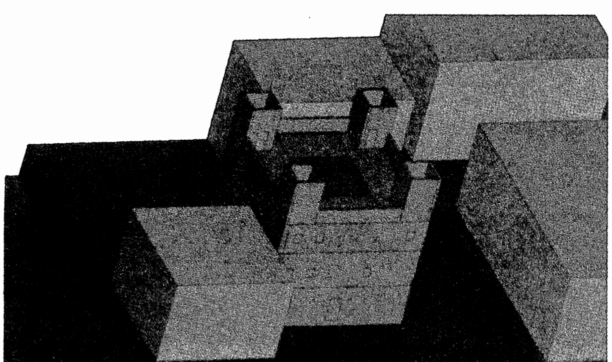


Fig3. A model the courtyard is blockaded figure

4. VALIDITY OF SIMULATION

In the indoor thermal environment and the wind environment, whether it can be said the environment that the value obtained in last year's measurement survey and the simulation value are compared and this simulation result resembles the real environment closely is verified.

The simulation value indicated a value close to the actual measurement value by room, courtyard, and outside environment as a result of comparing it.

Therefore, it is judged that the simulation model in the present study is appropriate.

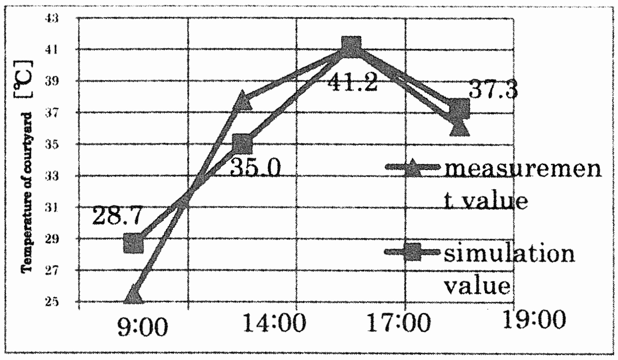


Fig4. Comparison of the courtyard temperature

5. VERIFICATION IN COURTYARD

(1) Wind environment

It was guessed that the courtyard mostly plays the role of ventilation in residence, and closing the courtyard, it becomes impossible to take ventilation indoors. In this analysis, the problem was not caused in ventilation. The wind of almost same velocity as an existing model blew in the velocity of the wind in the room. However, a lot of winds in the vertical direction came to be shown.

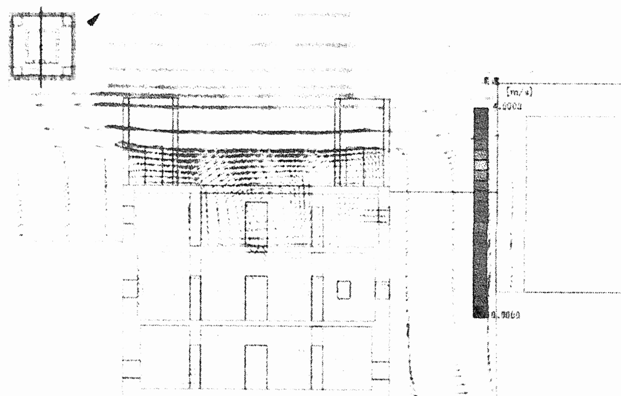


Fig5.The wind in an existing model in section

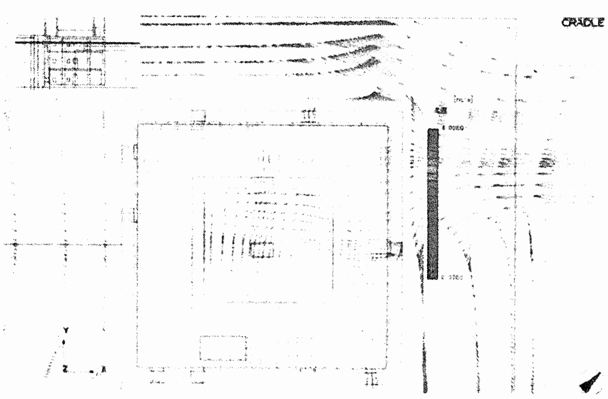


Fig6.The wind in an existing model in plan

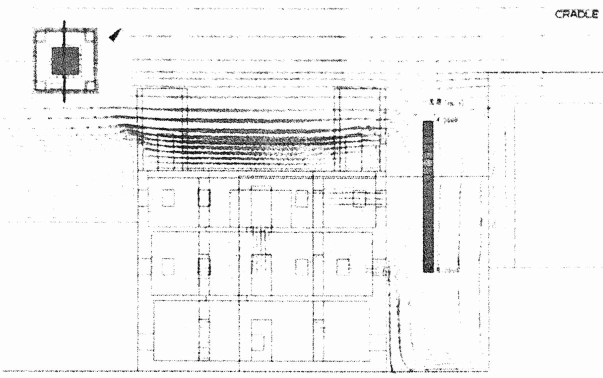


Fig7.The wind in a model the courtyard is blockaded in section

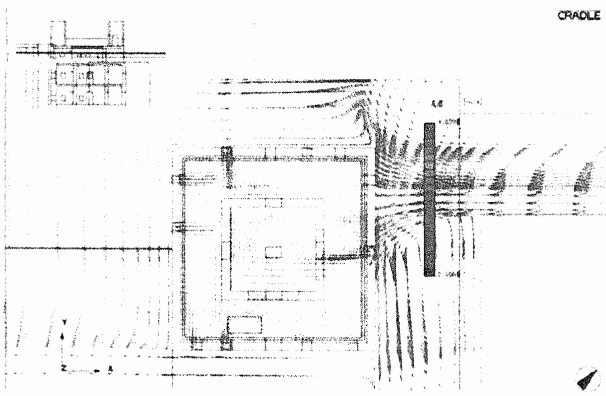


Fig8.The wind in a model the courtyard is blocked in plan

(2) THERMAL ENVIRONMENT

The indoor temperature in daytime(14:00,17:00) had fallen from 2.5 to 7.4℃ on a model the courtyard is blockaded, compared with an existing model. At 9:00 and 19:00, a big difference was not seen by two models.

From these things, it is understood that blocking the solar radiation in daytime prevents the temperature of courtyard from rising.

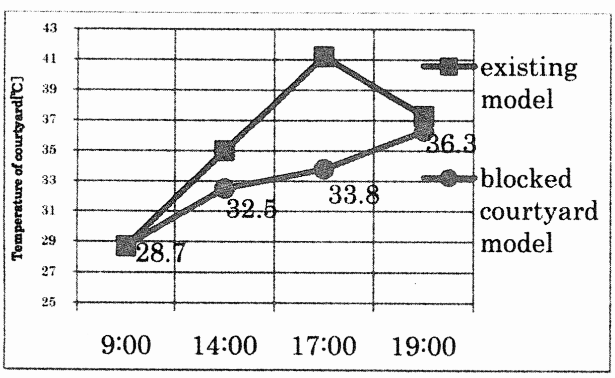


Fig9.Comparison of the courtyard temperature

6. EVALUATION BY SET*

(1) An existing model

In the morning (9:00), all rooms are kept comfortable. The influence of solar radiation begins to appear at daytime (14:00). It comes to be felt that the third floor room is warm. While the third floor room is felt that it is hot at 17:00 after the highest temperature on the day is recorded, the first floor is kept comfortable. This is thought to be the one by the effect of adobe. However, the heat remains in the third floor room even at 19:00 after the sunset.

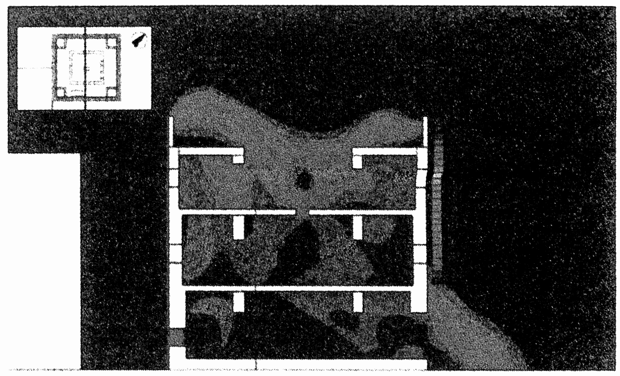


Fig10. 9:00

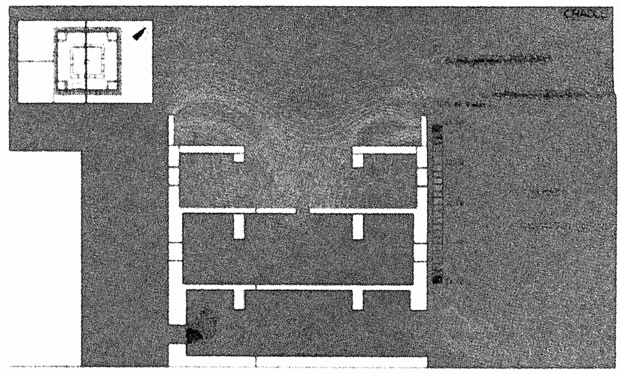


Fig11. 14:00

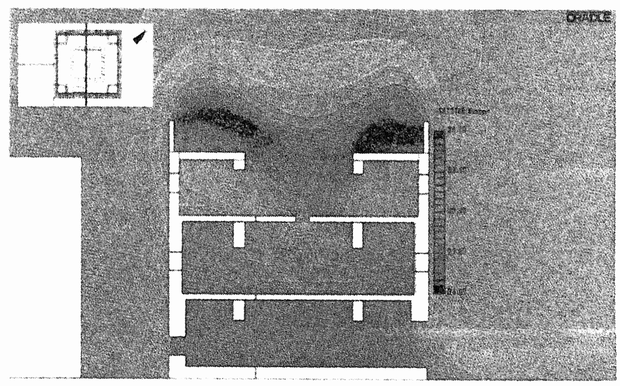


Fig12. 17:00

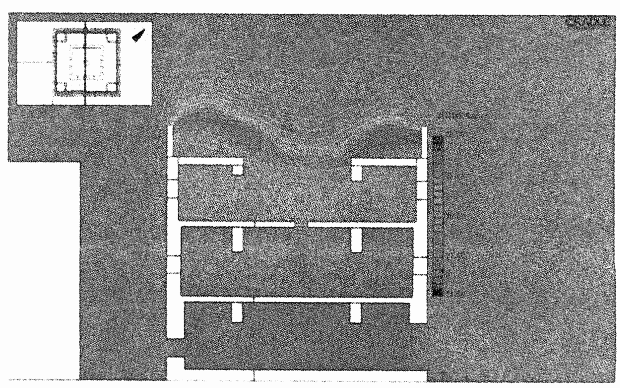


Fig13. 19:00

A lower floor is comfortable thanks to adobe through a day. The heat is severe with the third floor room with a large influence of solar radiation.

(2) A MODEL THE COURTYARD IS BLOCKADED

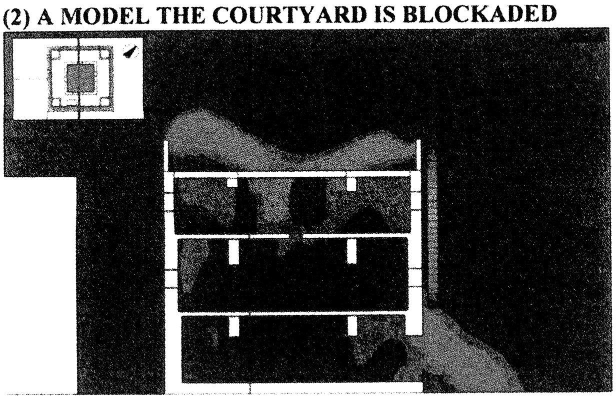


Fig14. 9:00

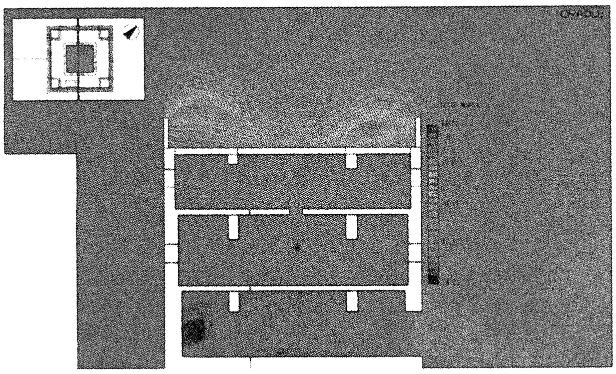


Fig15. 14:00

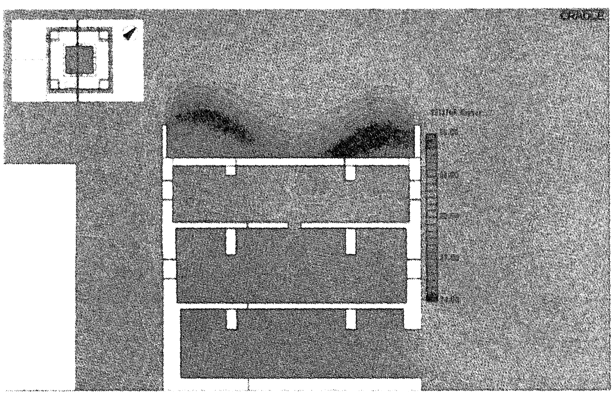


Fig16. 17:00

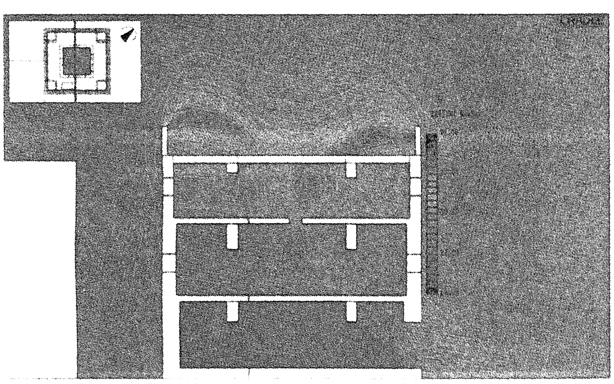


Fig17. 19:00

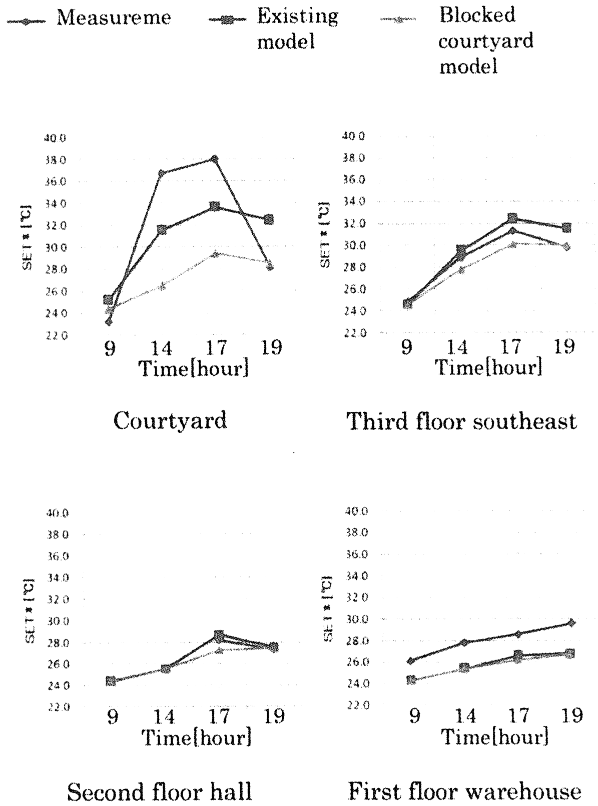


Fig18. Change of SET* according to passage of time

The evaluation of comfort has gone out as well as an existing model, in the morning (9:00). At daytime (14:00), SET* has fallen at about 2℃ though it is felt that it is warm as well as an existing model in the third floor room. It stayed in the evaluation that it was warm in a model the courtyard is blockaded, while it was evaluated that it was hot in an existing model in the third floor room.

Therefore, it is thought that there is heat in the third floor room because of solar radiation to the courtyard.

7. CONCLUSION

It has been understood that in the object residence in the present study, the ventilation trouble doesn't occur by blockading the courtyard, and preventing solar radiation on the day to the courtyard improves the comfort of Kasbah. Though it is thought that it is preferable to reduce the influence of solar radiation on the day if the comfort is pursued, the courtyard is especially important in the sphere of Islam, and do not let the existence of the courtyard negative. Therefore, it is thought that looking for the best plan based on these things is a problem.

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