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Thermal Environmental and Cooling Effect of Sea Breeze in Gallipoli Island of South Italy

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This paper deals with investigations about field measurements on thermal and wind environments at Gallipoli, a harbor island city. Measurements about outdoor thermal environments were carried out by moving a thermometer with human power. Indoor environments were also investigated on two houses and an underground facility.

At the survey in the environmental of the island effect of cooling because of the sea-wind appears at the coast of windward, and in the houses and facility we got the effect of insulating because of thickness of the walls by measuring wall temperatures, and the improvement of comfort because of the wind-go-through the houses by evaluation of findings SET*.

Key Words: thermal environment; sea breeze; land breeze; sea breeze; land-wind; heat island phenomenon

1. Introduction

In late years temperature in an urban region rises by a heat island phenomenon. I will turn worse a heat island phenomenon to strengthen air-conditioning to deal with outdoor warm temperature environment. Various measures such as roof tree planting / wall surface tree planting are done in these measures, but the block formation that considered ventilation is put up. It is thought that the wind that is coolness from the sea relaxes a heat island phenomenon in a seaside city, and the city planning which considered sea breeze is considered.

In this study, actual surveys have been carried out in a port town Gallipoli of the south Italy, and cooling effects of hot environments by sea breeze, in August 2006.

2. Characteristics of Climate of Gallipoli Island

Gallipoli is the harbor city of the cape which juts Ionian-sea in Puglia, south Italy. Fig 1 and 2 show the map of Italy and photos of Gallipoli. An old city area of Gallipoli is an island, the size of about 500m x 500m, south, and is

connected by a bridge to the land. The old city area consists of the circumference road and a main road crossing the island to East and West. Both the main road and sub-roads in an island are narrow and two or three story houses have been built closely. And more spread road has commoner's houses and the dead ends. On the other hand, a new city area consists of square typed blocks in land.

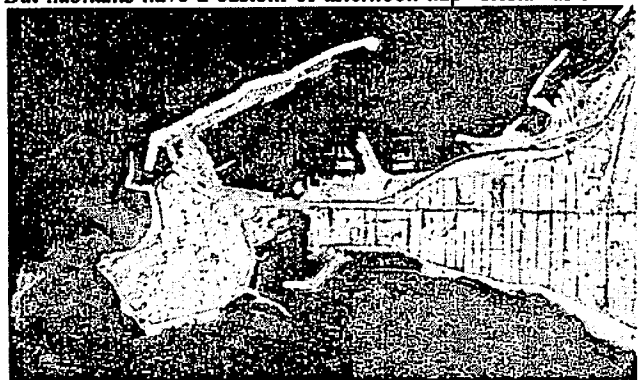
A lot of church and palazzo of the baroque were put up. The palazzo are in the zone of north-east of this island.

Gallipoli was the time when it prospered most, and it was exported olive oils manufactured in the basement of palazzo which named as "frantoio" 18th century from the 17th century.

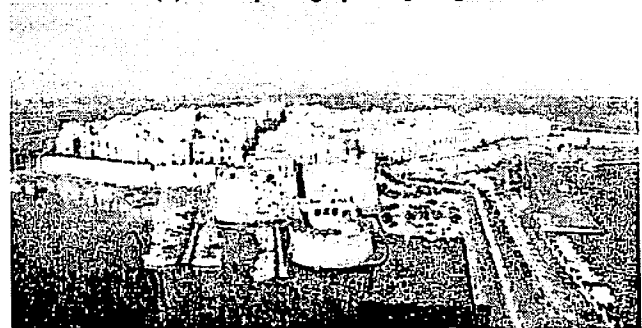
In the summertime, small streets become full of tourists. But habitants have a custom of afternoon nap "siesta" as seen



Fig 1 Map of Italy



(1) Aerial photograph [Google Earth]



(2) Whole view from a landseide
Fig 2 Photographs of Gallipoli

* Department of Architecture

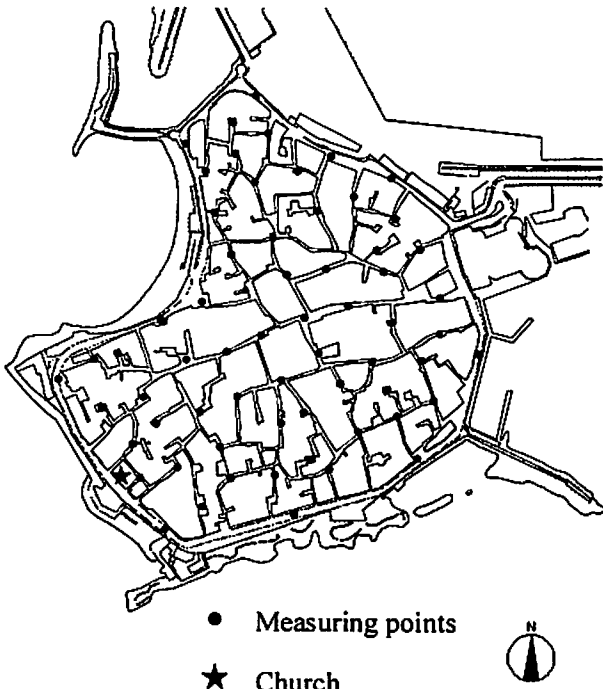


Fig 3 Map of Gallipoli, with measuring points

in Spain (see to Fig. 3 (1) and (2)). Houses have a courtyard "portone". The rooms are face to a patio, and some are built in a cul-de-sac road. It has both public and private zone. Fig. 4 shows an example of cul-de-sac road called "corte", above which three arches were installed reinforcing a wall of both sides.

The climate in summer is warm, and has the Mediterranean Sea characteristics of a dry high temperature in the summertime. It is characteristic in summer to blow a hot wind called "sirocco". A sirocco is a hot wind of high temperature with high humidity from the Sahara Desert to the southern part of Italy. Fig. 5 shows an example that an outer wall is damaged by a sirocco and a strong wind.

The windows have louvers, shown in Fig. 6. Houses of old town do not have an air conditioner, and the louver is very useful to prevent strong sunlight and to secure the ventilation in summer without losing the privacy, and also to break a strong wind. It can adjust to an arbitrary angle by a lever.

3. Outline of the measurements

The actual surveys were performed about thermal environment of tow houses and a basement facility, and about the thermal and wind environment on outdoor streets, from August 23 to 27, 2006.

3-1. Out side Reference Climate

Outside reference climate as a reference was measured on the roof of a church, shown as *mark in Fig. 3, the data were recorded continuously through the period. Outdoor temperature and relative humidity, and wind velocity and direction at height of >>>Lm from the ground were measured.

3-2. Measurement at Plazzo de Granafei

(1) Measurement of thermal environment

Plazzo de Granafei is a residence where placed along the main street, Via Antonietta de Pace, in the middle of the island. Entering through the gate, there is a space called Portone which is the passage shaped like a tunnel that can approach to the courtyard. Granafei is two storey plazzo, where now seven families share it. All families are accessed



(1) Main street with tourists



(2) Nobody as for afternoon nap

Fig 4 Views of old town



Fig. 5 Example of cul-de-sac

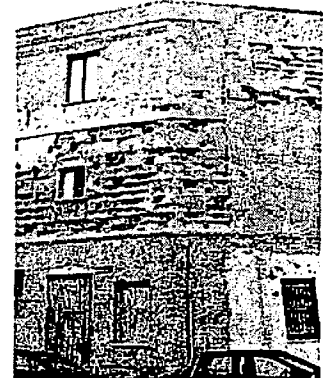
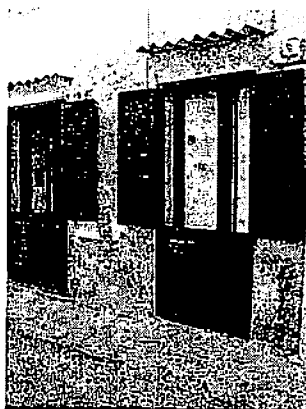
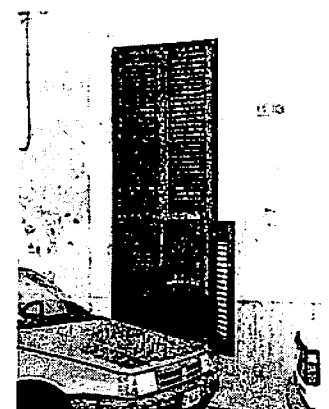


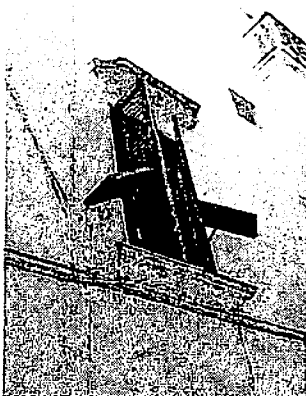
Fig. 6 Outer wall of a house



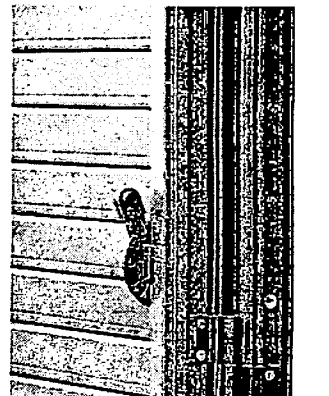
(1) Louver upper half open



(2) Louver lower half open



(3) Louver of upstairs



(4) Angle adjuster

Fig. 7 Various types of the louvers of windows

through the portone or courtyard, regarded as semi-public space. At the court they are enjoying the conversation, hanging out their clothes or reading the newspapers with getting their chairs out (Fig. 8 and Fig. 9). Measurements of temperature, humidity, globe temperature and wall temperature were carried out at the main space of this house shown in Fig. 9, between 19:00 on August 23 to 9:00, August 25.

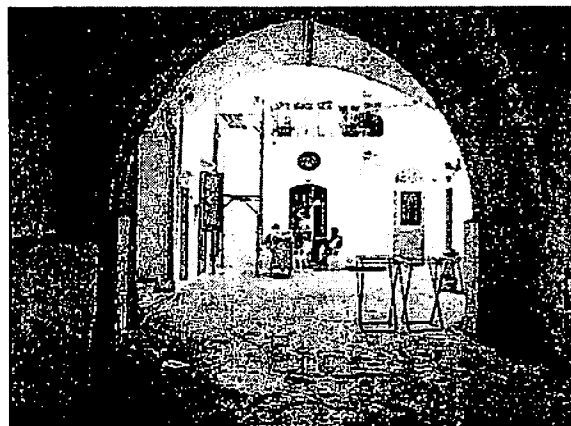
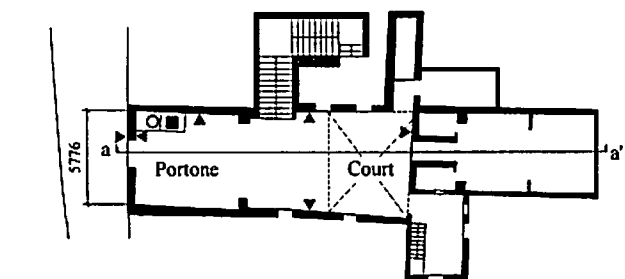
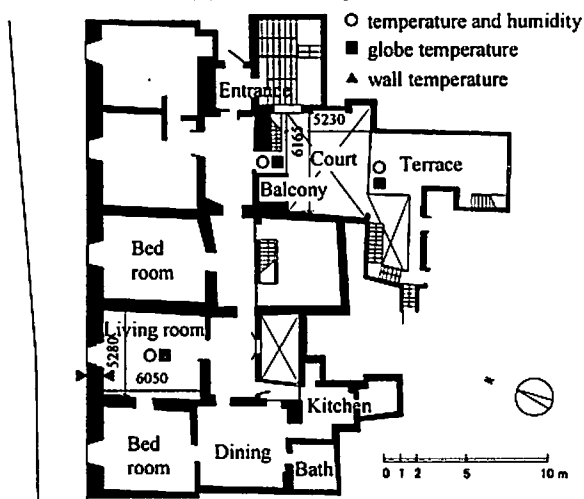


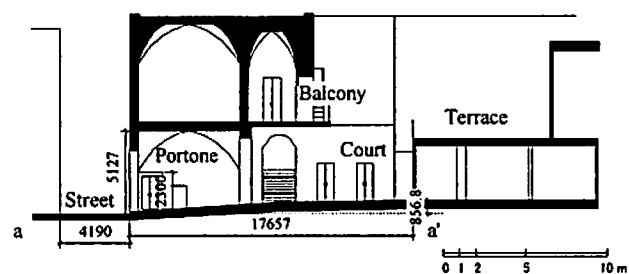
Fig. 8 "Portone" at Palazzo de Granafei



(1) first floor plan



(2) second floor plan



(3) section a-a'
Fig. 9 Plan, measuring points and items

(2) Measurement of wind velocity and direction

Wind velocity and direction at Palazzo de Granafei were measured between 11:45 to 14:00 and 16:30 to 18:00 on August 24, by a anemometer at the points of 12 or 15. Each wind direction was observed in a direction of a tape hanged on the poles.

3-3 Measurement at Palazzo de Tomasi

Palazzo de Tomasi is a residence where placed along the water side at southeast in the island. Fig. 10 shows the plan. The ground floor is for the portone with stairs accessing upstairs. Measurements were carried out in the rooms of second floor and in the courtyard for temperature, humidity, globe temperature and wall temperature, between 20:00 on August 25

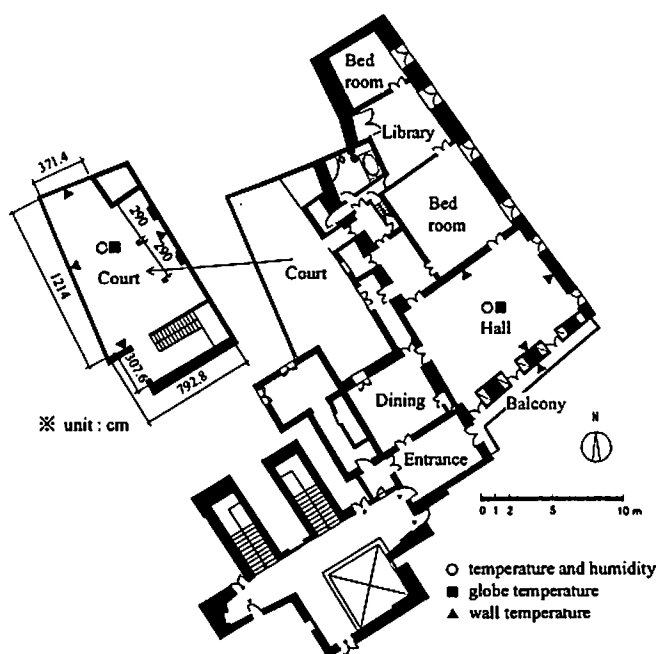


Fig. 10 Second floor plan, measuring points and items

to 17:00 August 26

3-4 Measurement of Underground facility (Frantoio)

"Frantoio" is a underground facility that extracts olive oil for the lamps. The Frantoio for the measurement is just located beside the Palazzo de Granafei. It is no longer working but still remains as a museum. Temperature, humidity, globe temperature, wall surface temperature and floor temperature were measured there, between 19:00 on August 23 to 9:00 August 25.

3-5 Outside thermal and wind environment

Outside temperature and humidity were measured at every two hours between 8:00 to 14:00, 20:00 and 22:00 on August 26, and at 16:00, 18:00 on August 27. It is carried out at the points of 64 (with 15 on the new town area) on the road by moving on foot. The measuring points were shown in Fig. 3. Outside wind velocity and its direction on the street were also measured at several points.

The distribution of temperature based on results are made after time difference corrections.

4. Results of measurements in houses

4-1 Results in Plazzo de Granafei

(1) Measurement of temperature and humidity

A change in the temperature on each space and changes in the outer walls temperature and walls temperature in the living room are shown in Fig.11. The temperature at the balcony and terrace were increased rapidly because of sunrise, maximum temperature was 33 °C at the balcony. The other hand, the temperature in the Portone and living room were increased gently, maximum temperature was 29 °C at the Portone where coolest environment place at the time when the temperature increases most during the day (11-17o'clock). The wall temperature in the living room did not practically change, the maximum difference between outer wall and wall was about 3 °C.

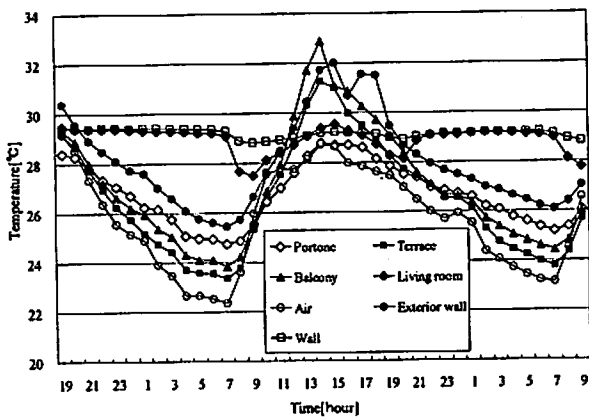


Fig. 11 Variation of Temperature

(2) Measurement of wind velocity and direction

The results of measurement of wind velocity are shown in Fig.12 and 13. The reference wind speed is measured at the balcony on the second floor. The length of the arrow shows the ratio of wind speed to the reference wind.

The averages of wind velocity are 1.7 m/s at 14:00 and 3.3 m/s at 18:00 in the outdoor, and 0.4 m/s at 14:00, 1.1 m/s at 18:00 inside the house. The air flew into all over the house.

(3) Comfort Index of SET*

Thermal comfort can be evaluated with an index of SET*, shown in Fig.14. The value of SET* in Portone was evaluated as "warm", and "hot" in the terrace on the second floor was, and "very hot" in the balcony on the second floor respectively. Portone is the most comfortable space by the reasons of sun break and breeze.

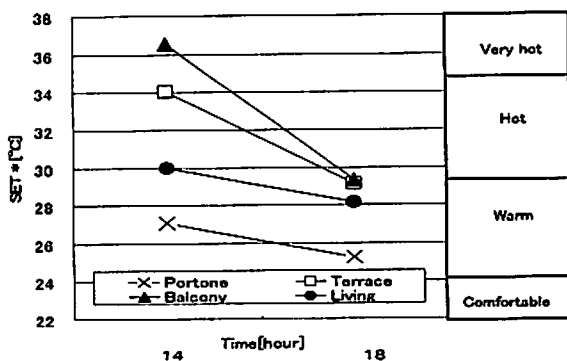


Fig. 14 Evaluation by findings SET*

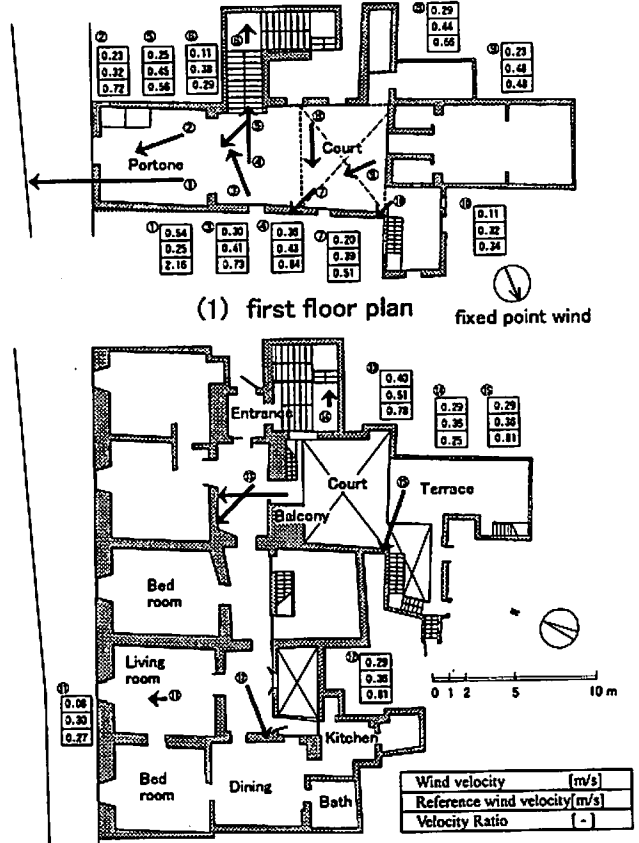


Fig. 12 Wind vector measured at 14:00

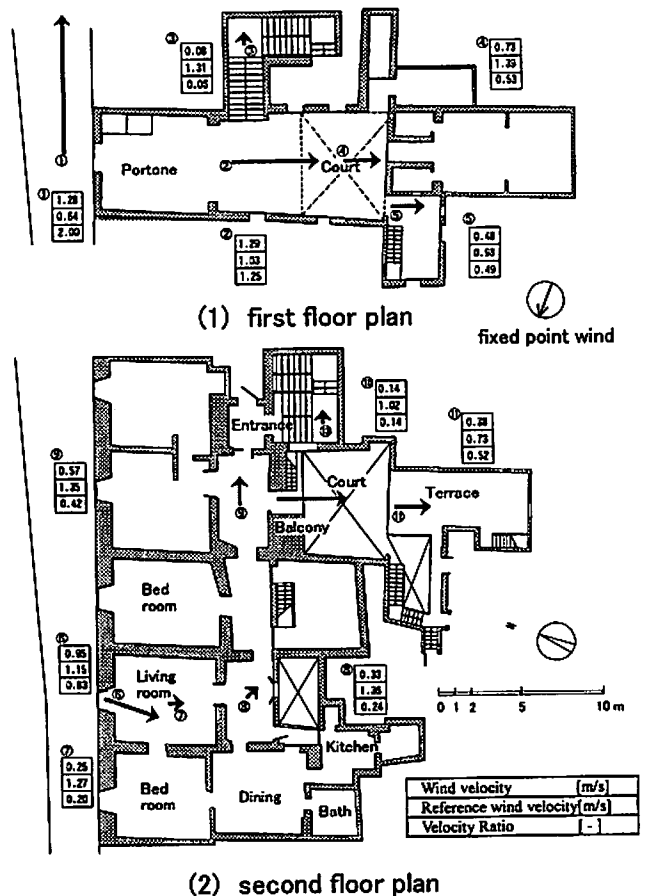


Fig. 12 Wind vector measured at 18:00

4-2. Plazzo de Tomasi

Plazzo de Tomasi is located in southwest of an island and faces the sea. The measurement at the Plazzo de Tomasi was carried out at the courtyard and the mail hall, shown in Fig. 15.

Fig. 16 shows the result of room temperature. The indoor temperature of the mail hall increases quickly after 7:00, because the room is facing to the East and the South. The temperatures at the middle of courtyard increase afternoon.

4-3. Frantoio

Frantoio was a olive oil factory of underground typed in old times, but it is open to the visitors as a museum. Fig. 17 shows it's section.

The changes of the temperature of each measurement point are shown in Fig.18. The temperature, globe temperature, wall, floor and roof temperature were almost constant. Above all, roof temperature was a little bit lower than others, next wall temperature, and floor temperature was a little bit higher than those two points. There is no influenced by radiation because the temperature and globe temperature was almost the same. But, the relative humidity reached almost 100%, some dehumidifiers were put in the room.

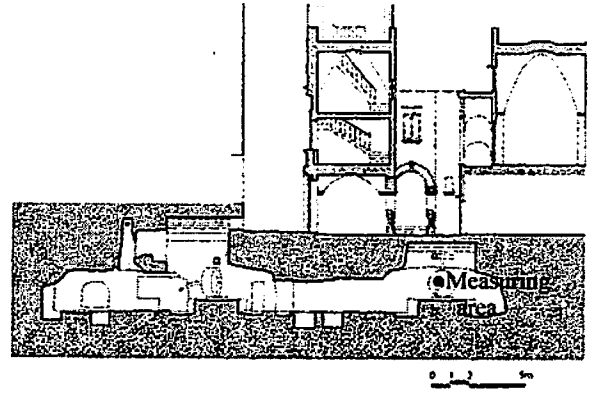


Fig. 17 Section of "Frantoio"

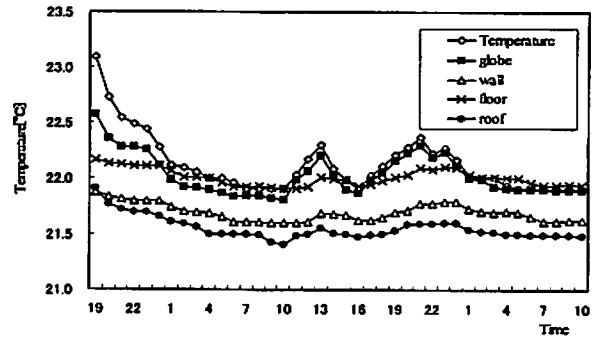


Fig. 18 Temperature in Frantoio

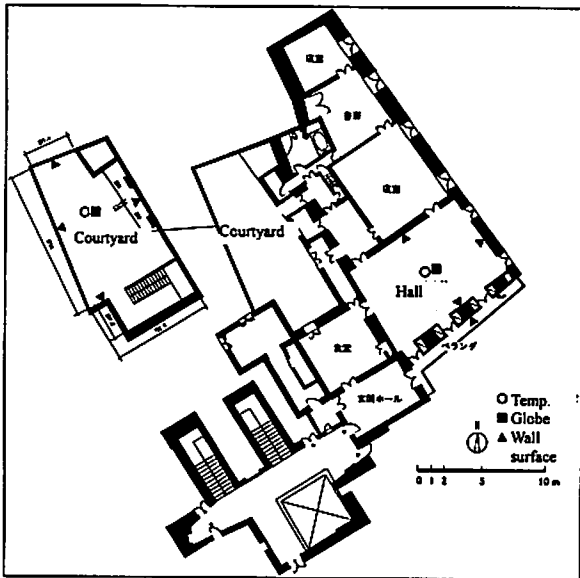


Fig. 15 Plan of Plazzo de Tomasi

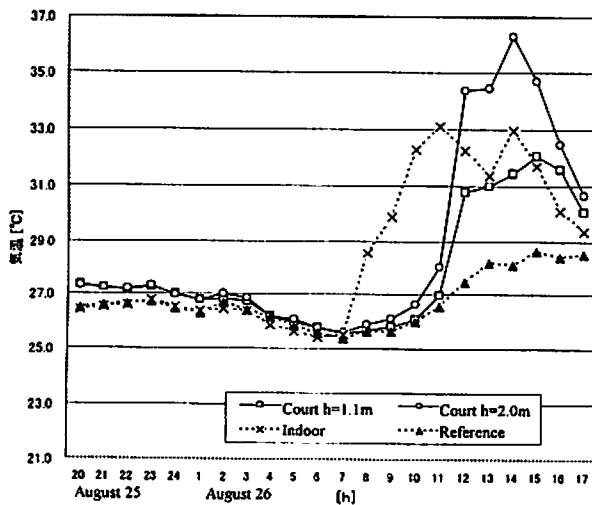


Fig. 16 Temperature at Plazzo de Tomasi

5 Outdoor thermal environment of the island

Distribution of outdoor thermal environment, the measurement of temperature and humidity were carried out at 64 points on the road in Gallipoli island by moving the thermometer on foot. It took about fifty minutes in one tour, the data have been corrected using the trend of the reference value, by the formula as follows:

$$T_i = T_i(t) + (Tr(0) - Tr(t))$$

- where, T_i : corrected value of I point i
- $T_i(t)$: measured value of time t at point i
- $Tr(0)$: regression value of time 0 at the reference
- $Tr(t)$: regression value of time t at the reference

After the corrections, the distributions of outdoor temperature are shown in Fig.19 to Fig. 21. Temperature distributions show the difference from the average over all points.

At the morning of 8:00 August 26 in Fig. 19, the average temperature was 26.3 degrees C, average of wind velocity at the fixed point observation was 5.2 m/s, most wind direction was NNW. Temperature decreased at the windward. The difference between maximum and minimum temperature with all the measurement points was 1.8 °C at this time. The other hand, largest difference was 2.6 degrees C, the highest temperature was at the 14 o'clock. At this time, average wind velocity at the fixed point observation was weak, 1.6 m/s.

At noon of 12:00, the average temperature 28.8 degree and the averaged wind speed is 1.5 m/s. The reference wind directions of WNW and SW were prevailing. The maximum temperature 30.0 degrees is seen in the south-east area of the island, and the minimum 27.4 degrees in the north-west area.

In the evening of the time 20:00, the average temperature was 27.2 degrees C, average of wind velocity at the reference point was observed 4.5 m/s and the prevailing wind direction was SW. The difference between maximum and minimum

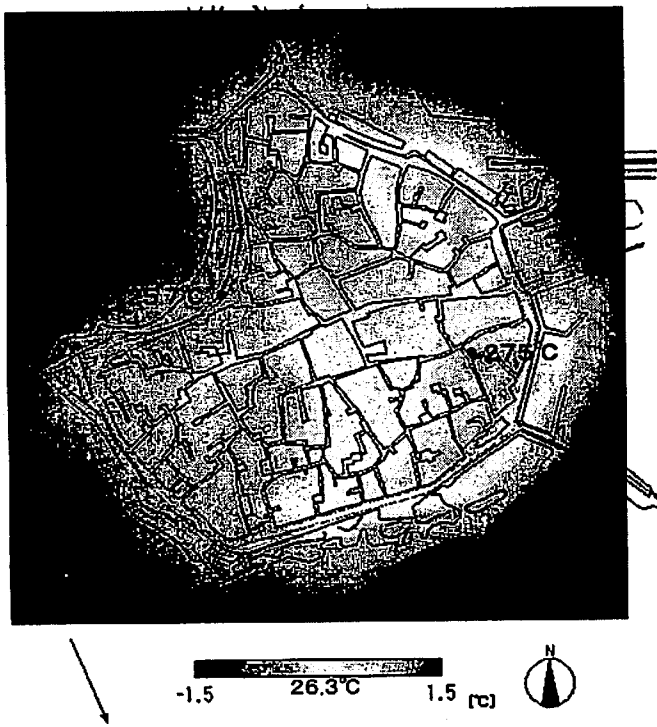


Fig. 19 Temperature Distribution at 8:00 on Aug. 26, 2006

temperature with all the measurement points was 0.8 degree at this time, and there is no difference at the temperature distribution in the island.

6. Conclusions

From the thermal and wind measurements of houses and outdoor one the port town Gallipoli of south Italy, the following knowledge is obtained.

- 1) From the measurements of temperature, humidity and wind velocity about the houses, the wall has sufficient thermal insulation. Thermal comfort SET at 14:00 in the house of Granatafei were 27 degree at the “portone” against 29 in outside and 30 degree in the bedroom. The open common space “portone” is comfort by the breeze and sun break.
- 2) About the environmental of city, temperature difference of each measurement points in temperature distribution in the island was maximum 2.6 degrees C at the daytime, 0.8 degrees at the nighttime. Cooling effect caused by sea breeze is just only influenced to the waterside of windward, does not matter how the wind is big or small, because the streets are too crowded like a maze so that wind can not go through inside of the city, but there were no effects at the nighttime because of the heat radiation from the streets and buildings.

Acknowledgement

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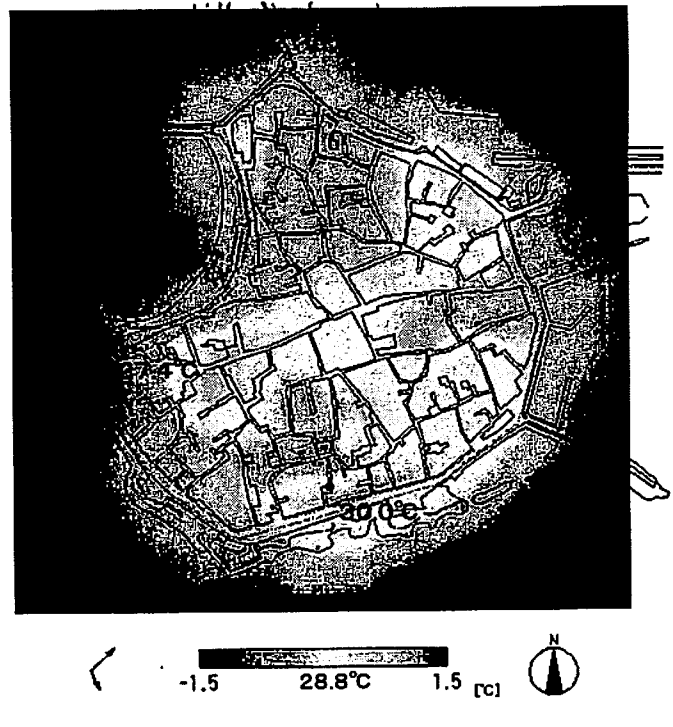


Fig. 20 Temperature distribution at 14:00 on Aug. 26, 2006

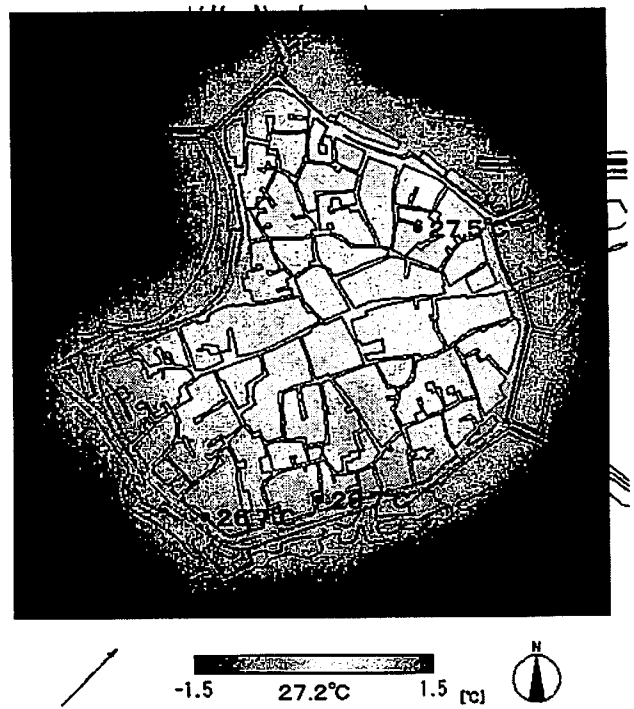


Fig. 21 Temperature distribution at 20:00 on Aug. 26, 2006

Caracciolo, people in Chiesa di S. Maria degli Angeli, people in Museo Frantoio Oleario Ipoeco, and Ms. Aiko Makino, a translator.

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