ANNEX 35 HYBVENT

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MEASUREMENTS IN SITU OF FLUIDODYNAMIC PARAMETERS IN THE BUILDINGS WITH NATURAL AND HYBRID VENTILATION

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1. INTRODUCTION

The careful management of energy, in terms of ecological sustainability, in particular solar and wind energy, have a central role in the design and realization of bioclimatic buildings. The growing demand for comfort and quality of life is proportional to the consumption of resources. The reduction of the cost of investment, of energy consumption and of building maintenance is a goal to achieve together with improvement of working conditions, avoiding further depletion of energy resources already over utilized.
The new building that Mario Cucinella Architects (MCA Paris) have designed for headquarters I Guzzini Illuminazione, company in Recanati, is an example of an innovative office building where reduction of energy consumption and environmental quality have been considered throughout the design process.

2. TEST ROOM

The aim of design of the controlled ventilation room has been as concept the minimum building cost and an high flexibility of preparation to realize the more varied configurations of diffusion and retaking airflow and then to study the distributions of airflow in the controlled volume. The test room has been realized in the laboratories of the Department of Energetic of Ancona University.
Fig. 1 shows the test room. It is a parallelepiped measuring 2450 mm x 2650 mm x 3830 mm and consists of a frame of iron profiles with a section 100 x 100 square mm.
At present a first modulo of this type has been completed with an area that measures about 10 m^2, and such one of identical frame is under preparation, to obtain a double test volume. The test room is pannelled on three sides, a part of four side and the roof, with laminated wood panels with a thickness of 1.5 cm. They have been fixed to the frame and completely closed on the edges of attack of the same structure. The fourth side has a wooden part and a plexiglas formel to allow the video and photographic equipment to visualize the airflow in the test room.

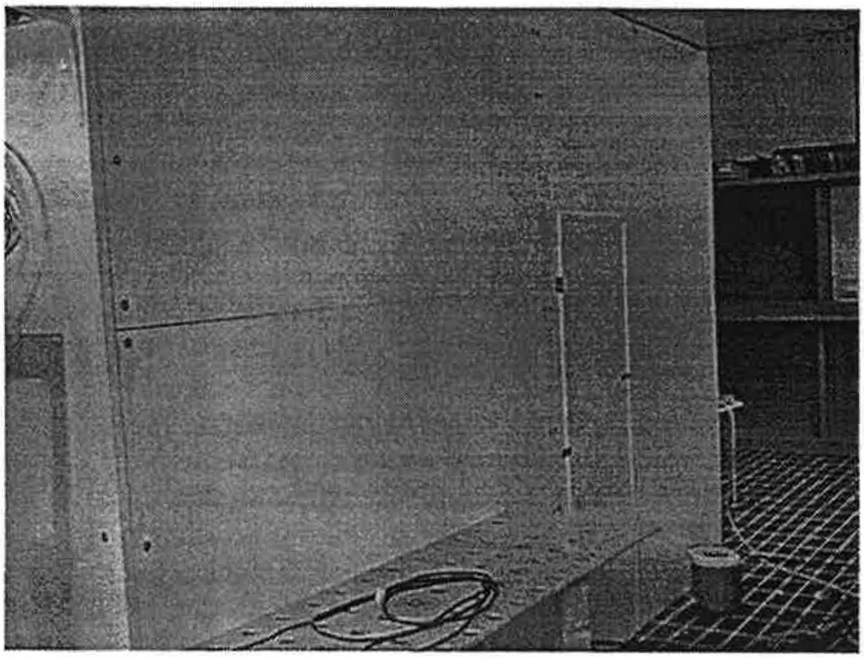

Fig. 1

The small sides of the room have at the top and on the bottom some panels high 40 cm, to install varies grids and to have different configurations and positions.
The test room is fed from a aeraulic circuit constituted by pipes of plastic materials, at circle section, of rigid and flexible type, where are located some equipments such as:

- a centrifugal coupled fan with an electric tree-phase motor, with the power of 0.75 kW, characterized by a maximum of 3.400 round/minute and a maximum rate of flow of 3.000 m3/h;
- a tainted and dimensioned flange, according to the normative CNR – UNI 10023, with static –pressure tube obtained on the two clamping flanges;
- an air aspiration and throw plenum realize with galvanized sheet-metal and dimensioned to install the grids and to distribute uniformly the airflow on the outlet section.

3. BUILDING DESIGN

The building is a new energy efficient office recently built in Italy (Fig. 2). The building is rectangular in plan, with overall dimensions of 40m x 19.3m and a volume of 10.000m^3. It provides office accommodation on four floors, located around a central atrium with circulation and service facilities incorporated with a link to an adjacent existing building. The first three floors house administration offices while the company's direction is located on the fourth floor.
The central atrium brings natural light into the center of the building and allows the office to be naturally ventilated. The building, with the atrium included, meets the market standards for office buildings, and the useful surface area represents the 83% of

the total surface area. On the top of the atrium, that contains also an internal garden, there are positioned twelve skylights designed in view of a natural ventilation system and a daylighting strategy. Each skylight is rectangular in plan and is 2.8 m high, but presents adjustable grills that open and close depending on the air flow required. The total area of openings on the skylights is equivalent to half the total opening area of office windows.

The south facade is entirely glazed. It is set forward 780 mm from the concrete structure and passes in front of it. The east and west facades are opaque. To avoid overheating and glare due to such a large glazing area, a shading roof was designed to protect the south facade.

The building is equipped with a number of solar systems, both passive and active to respond to a variety of conditions resulting from internal and external circumstances.

Natural ventilation is used to offset internal heat gains using cool ambient air. The rate of the mass flow air needed to maintain comfortable internal temperatures depends on the difference temperature between the desired internal conditions and the environmental air, and the quantity of the gains of internal heat. If this system is not sufficient to provide due benefits from natural ventilation, a fan coil system has been installed to provide comfort in cooling the air, thus reducing the internal temperature. The fan coil units provide winter heating and summer peak cooling.

The thermal mass inside the office space allows the use of night – time ventilation to cool the structure of the building and extends the period when mechanical cooling is not required.

The influence of thermal mass on the internal environment depends on the ratio surface area/volume and the dominance of solar gain and air movement within the space.

Both the concrete ceiling and the internal and external concrete brick walls are exposed to the main office spaces. This thermal mass works together with the natural ventilation scheme, allowing ventilation during unoccupied periods to store cool inside the mass and helps to reduce the maximum temperatures produced during working hours.

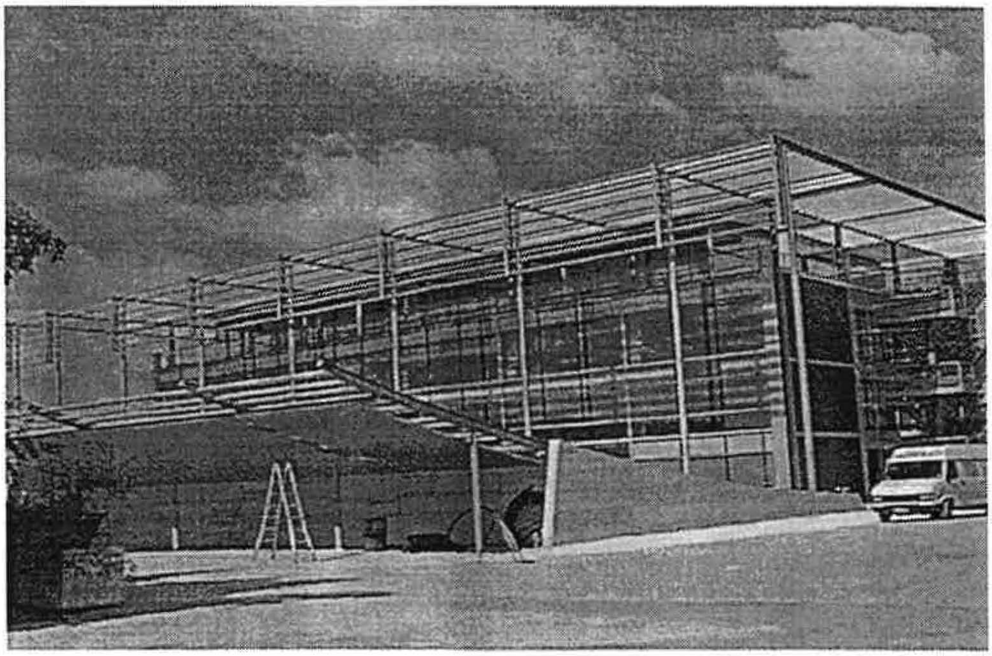

Fig. 2

4. NATURAL VENTILATION

The use of natural cross – ventilation relies on the free – flow of air across a space. On the south facade each bay 6.6 m x 3.2 m of glazing is divided into nine sections of glass. Four of these are hinged opening panels, two at high level and two at low level. These panels combine with the high level openings in the atrium to provide natural ventilation across the perimeter of the area. The air flows across the opening of the connection between the offices and the atrium.
In the absence of wind, the cross ventilation of the offices to the atrium relies on the stack effect generated by the stratification of air within the height of the atrium (13.8 m). A control system has been installed to ensure the correct functioning of the ventilation system.
The building is submitted to natural ventilation if the following conditions are verified:

- rain or high wind aren't present
- the building is occupied
- $t_o < (t_i\text{-}2°C)$ with $t_o>20°$

being: t_o - ambient air temperature, t_i- internal temperature .

A time schedule shall be provided to define when the building is occupied.
During the occupied period , the building shall operate in either *mechanical or natural ventilation mode* depending upon the internal and external temperatures .
Natural ventilation should provide the internal temperature (t_i) above 20° and below 25°C otherwise the building shall operate in *mechanical mode.*
During the unoccupied mode the building shall operate in Night-time mode.
Summary:
the panel windows are opened if $t_o>20°C$ and $20°< t_i< 25°C$ with $t_o <(t_i\text{-}2°C)$
Natural Ventilation is provided by low and high level louvres in the offices and roof louvres in the atrium.
Each low level louvres shall have three positions :

- fully open
- minimum open
- closed

The louvres shall initially be set to the minimum open position.
On rising internal temperature :
- if t_i is higher than 22° C , the low level louvres shall open fully ,and shall remain open until Ti is higher than 25°C,
-if $t_i>25°C$,then the low level louvres will be set to the minimum open position, and the building will operate in Mechanical mode.
On falling internal temperature:
-the louvres will remain open until the temperature is lower below 20°C, when the low level louvres will be set to the minimum open position , and the plant shall operate in a mechanical mode.
The high level louvres have only two position:

- open
- closed

The louvres will initially be set to the closed position .
On rising internal temperature:
-with $t_i> 24°C$ the high level louvres will open and shall remain open until
$t_i>25°C$

-with t_i> 25°C the high level louvres will close, and the building will operate in *mechanical*
mode.
On falling internal temperature :
- the louvres will remain open until t_i <22°C
- when t_i<22°C then the high level louvres will close , and the building will operate in *mechanical mode*. The building is subdivided into some zones for every level-floors. In every zone a local adjustment panel will be provided in the office space to control the movement of the panel window.
Every zone has three points of temperature .
The aritmetic media of the three sensors would be the t_i for that zone.
The atrium has 48 louvres, one on each side of roof turrets, which are controlled in 4 groups of 12 louvres. Each louvres will have two positions: open and close
The louvres will initially be closed.
On rising internal temperature:
-if t_i> 21°C, the first group of louvres (the nearest to the old office building) will open and will remain open until t_i >22°C
-When t_i>22°C , the second group of louvres shall open .
-The other louvre groups will be sequentially opened in a similar manner.
On falling internal temperature ,the louvres will be closed sequentially in reverse order.

5. MONITORING SYSTEM

The research program started with the first experiments since the beginning of January, when already the new office building was occupied, therefore it was useful to design an unwieldy monitoring system, but it can to answer the qualitative and quantitative necessity of scientific program.
Actually we are realising a monitoring system that will be able to take the environmental parameters in different points located in a pre-defined ideal and bidimensional grid, fixed on the vertical section and supported by thermal and fluid-dynamic studies with calculating codes.
The equipment consists in an automatic measurement sensor's movement on the two axes; one of these is 2.300 mm long and the other is 2.600 mm. The transfer is obtained with some carriages fixed on the guides. These are jogged from servomotors and are controlled from retroaction from position transducers, connected at the guides epicyclic reduction gear.
The servomotors are controlled by means of drive cards and are connected to a portable computer through a digital analogyc card PCMCIA (A/D).
By means of this card it is possible to program the position on every co-ordinate cartesian plane.
The sensor's measurement are the recorded input data with a Data Acquisition /Switch Unit HP (Multiplixer module to 20 channel, while sounds are constituted by temperature sensors, differential pressure, hot-wire anemometer, psicrometer and luximeter.
All the system is controlled by the National Instruments Lab View program which by means of a proper program allows a completely automatic measurement in the

individual points. Therefore, during the whole day the system, located in a section of the studied environment, can record the measurement parameters.

6. SUMMER TESTS RESULTS

It has been to monitor comfort conditions in different sections of the building. The results of these measurements will be compared with the data recorded by the building control system and the results of the occupant surveys in order to establish a clear picture of the comfort condition in the headquarters building. The control system records external condition as temperature, relative humidity, wind speed, internal ambient temperature and internal air velocity.

A series of air velocity and temperature measurements of the open space part selected are conducted using the automated apparatus for measurement of environmental parameters detailed described in other paper. The test sector is a part of first floor plane office areas of the building. The experimentation plan layout , set up and experimental equipment are shown in Fig 3 and Fig. 4.

The test equipment was start up in three periods of an hour each in the planned three days 6, 8 and 9 of august 1999, to have a complete sight of nighttime and daytime ventilation.

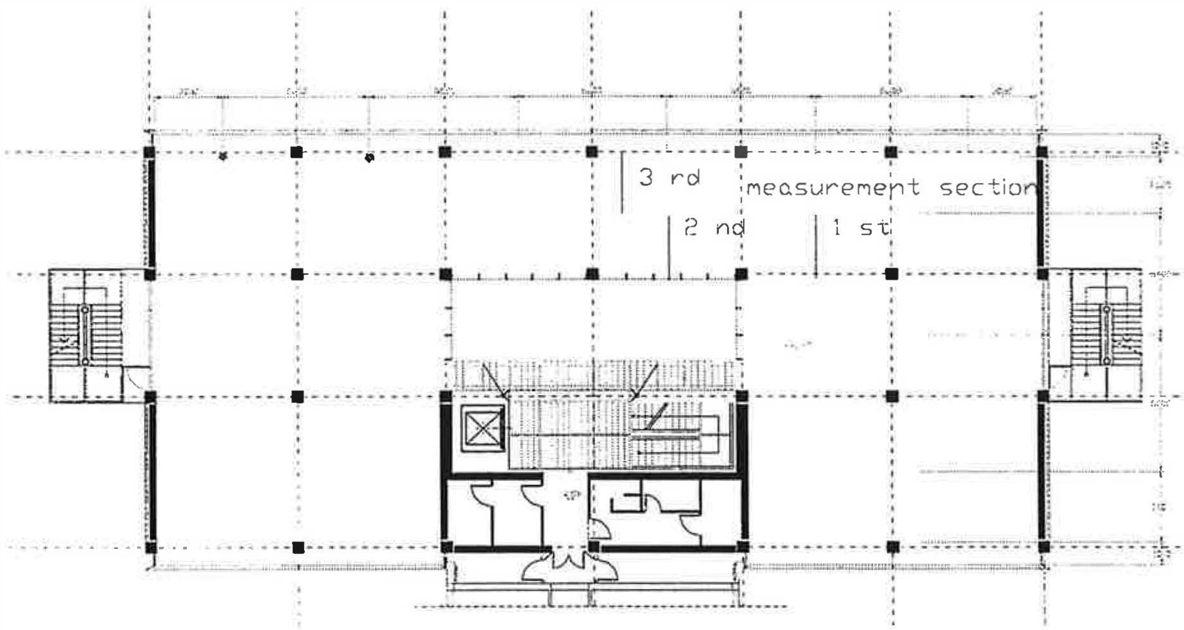

Fig. 3

The environmental parameters has been measured in three different vertical sections

- the first position in the center of the space between the windows and internal room.
- the second position in the proximity of the ventilation cpenings and the fan coil
- finally the third position near the atrium opening.

The results obtain are presented graphically in Figures 5 to 22. It should be noted that during the first day test period, the member of the office staff were present, while in the following days the offices were empty.

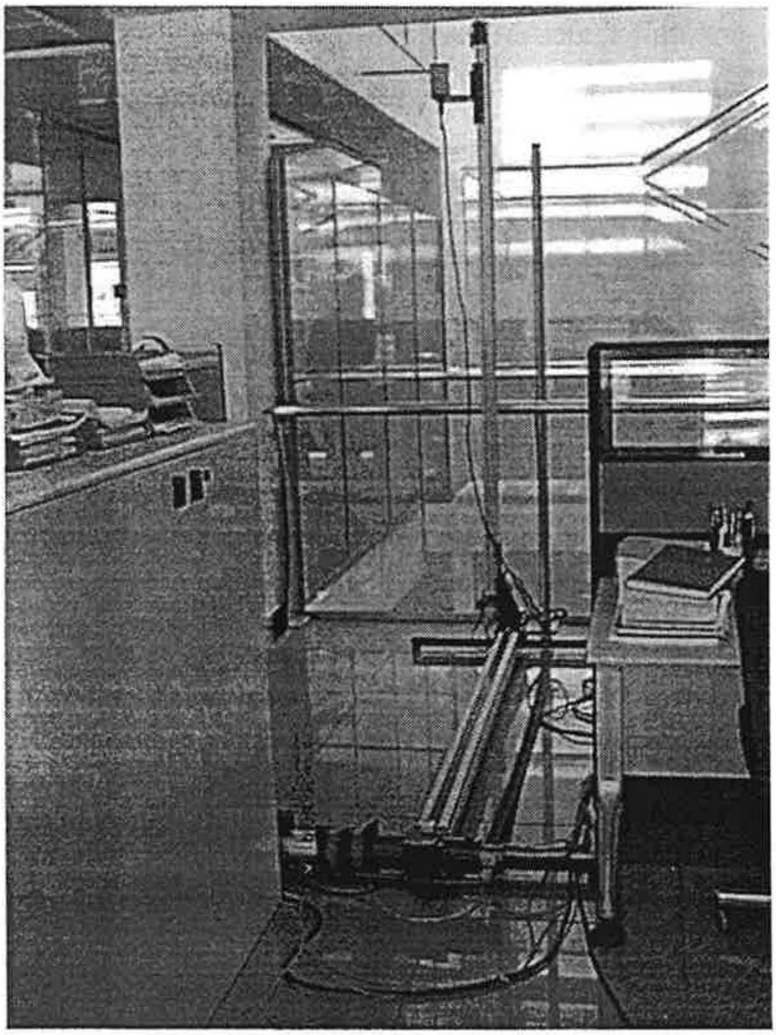

Fig. 4

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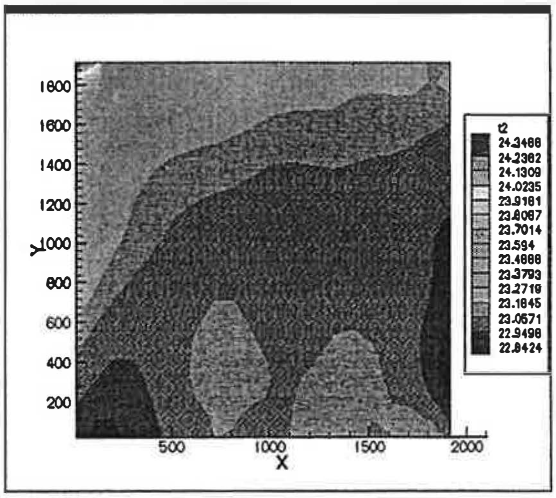


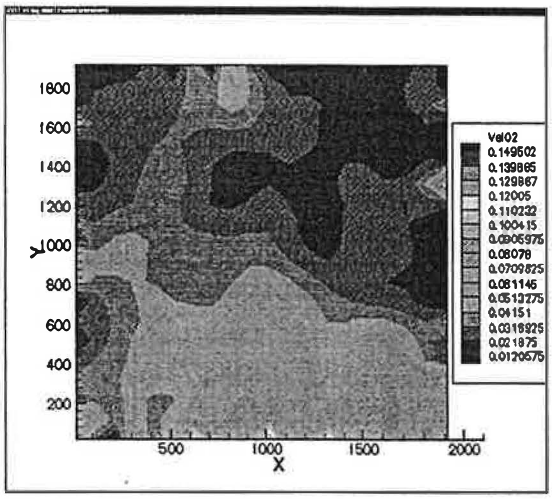
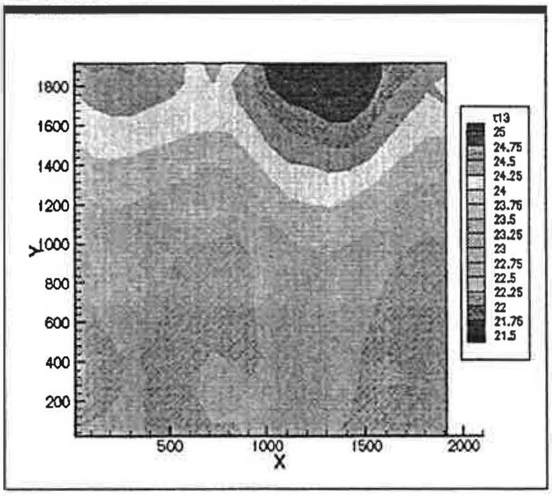


Fig. 5 – Temperature °C at 2 a.m. – Fig.6 – Velocity distribution m/s



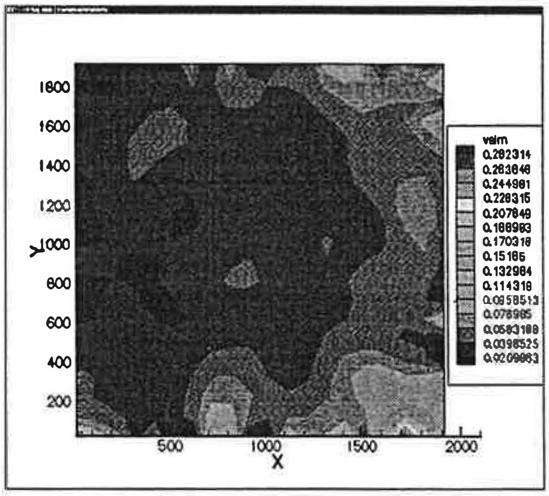
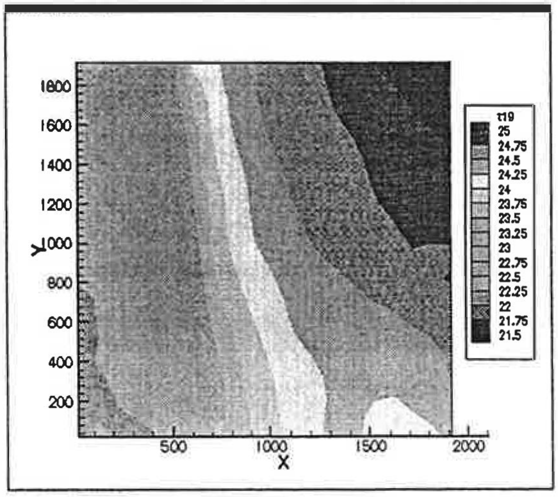


Fig. 7 – Temperature at 1 p.m. – Fig.8 – Velocity distribution



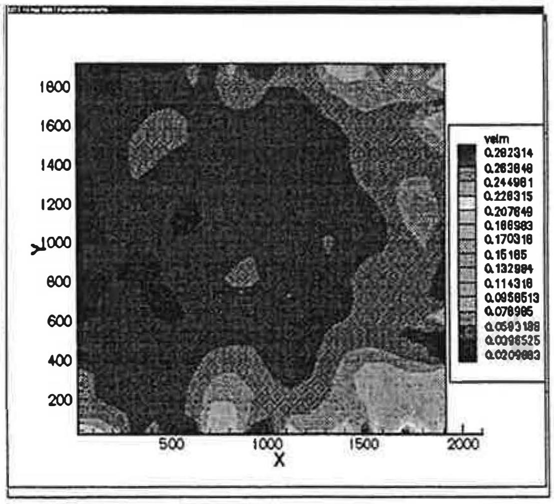


Fig. 9 – Temperature at 8 p.m. Fig.10 – Velocity distribution

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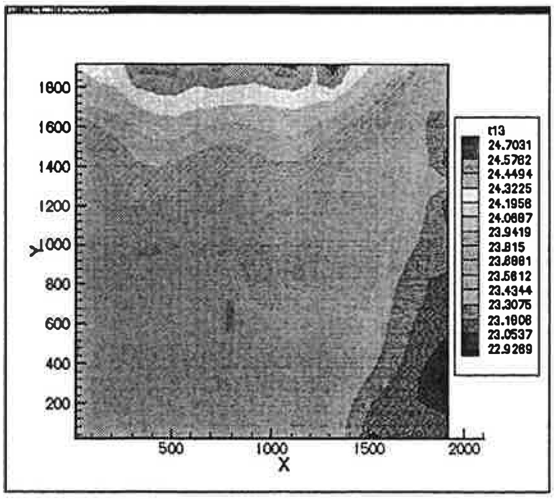
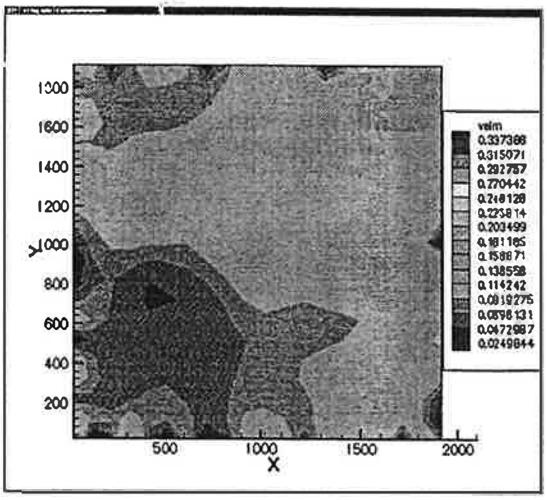


Fig. 17 – Temperature °C at noon



–Fig.18 – Velocity distribution m/s

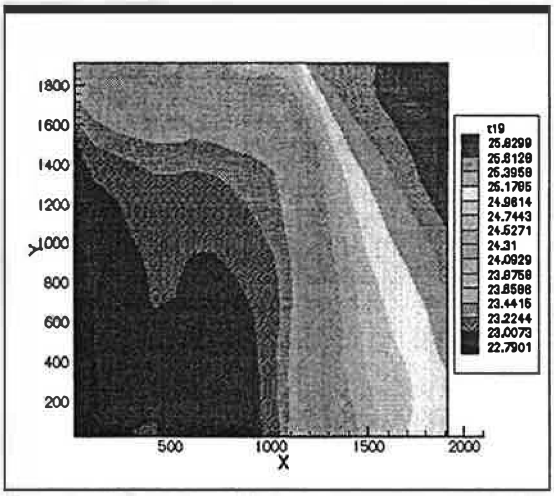


Fig. 19 – Temperature at 6 p.m.

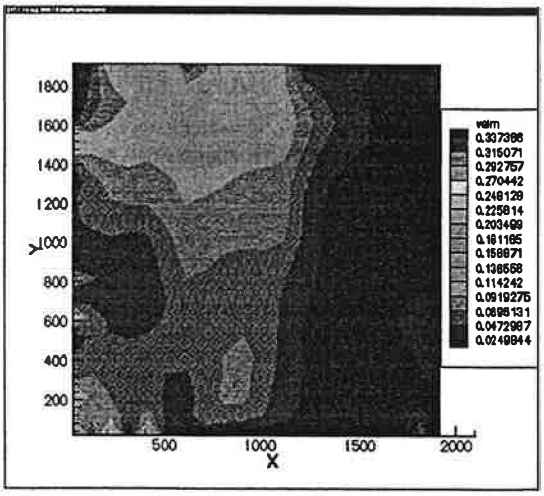


Fig.20 – Velocity distribution

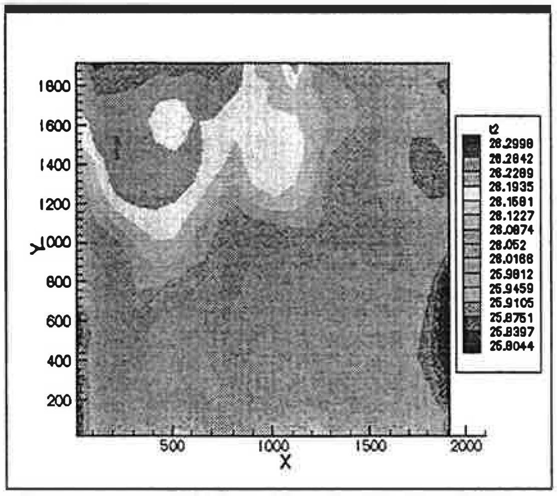


Fig. 21 – Temperature at 12 p.m.

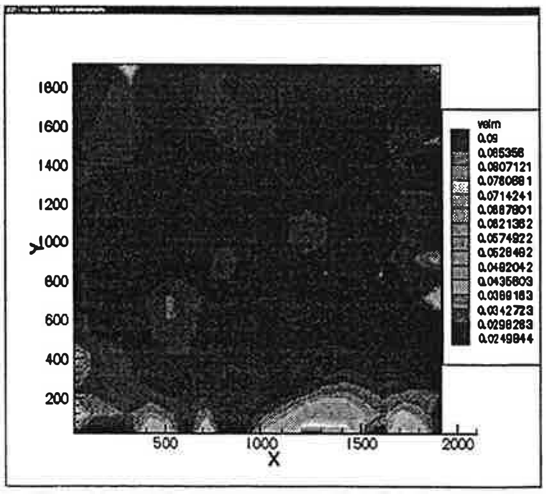


Fig.22 – Velocity distribution

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