NUMERICAL SIMULATIONS REGARDING AIR CIRCULATION IN URBAN SPACES

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Summary

Knowing the trajectories of air currents in urban spaces of high density is important in order to insure pedestrian comfort, the rational exploitation of buildings, the position of the building in the urban ensemble and in relation to the direction of the dominant winds - which directly influence heat losses through infiltrations, the potential for natural ventilation and the valorization of solar energy, and the circulation of pollutants.

The paper presents the results of a study in which we have analyzed the way in which a new building, built in an existing urban ensemble modifies the field of pressure and speed of the air, altering the aspects mentioned above.

The numerical simulations made with the FLUENT software have allowed us to make a qualitative analysis and to evaluate some characteristic parameters corresponding to the various climatic conditions.

Keywords: urban, ventilation, sunlight.

1 Introduction. Research content.

Within the general framework of climatic changes at a global level, urban growth and the excessive development of certain parts of the world are determining serious changes in the microclimate, which have direct consequences on the urban comfort and the energy consumption needed for building exploitation. Concretely, the factors determining these phenomena are:

a. uncontrolled urbanization;
b. the vertical development of urban dwellings and the increasing urban density.

The consequences of these phenomena require for the relationships between build and natural environment to be restored, because it is an imperative for insuring the urban comfort and the reduction of energy consumption, as an integrative part of the sustainable development strategies.

These aspects are also visible in the Romanian cities, especially in the collective apartment building ensembles, but also in the developing administrative and financial centers.

The relationship between the urban configuration and the amount of energy needed represents the object of numerous studies, sometimes contradictory in relation to the urban model considered (compact – dispersed), but unanimously in agreement regarding the importance of this relationship for the functioning of urban mechanisms and the necessity

for an optimization effort. Different urban densities and configurations, paths, intensities, air currents speed and sunlight are determining factors of the urban microclimates.

A significant number of specialized papers on the topic have appeared in magazines and conference books of prestigious international events, and have addressed the issue on various degrees of complexity. Modern technologies and simulation instruments allow for the problems and the phenomena to be pointed out, while promoting the results contributes to the optimization of the urban comfort and the energy consumption. In the last few years in Romania, the research on the subject has been focused more on singular buildings, rather than on urban ensembles.

The present paper, being a part of a larger research, extends the topic of sunlight and air circulation from the singular object to the urban level, as part of the urban comfort and energy saving problems. Building new structures with diverse functions in existing, relatively dense urban settings, as well as rehabilitation activities, with their consequences on urban and dwelling comfort, are calling for specific building regulations based on adequate research. The preliminary research in these situations becomes mandatory, in order to evaluate the potential of saving energy by using the climatic factors and to configure design recommendations. In the research stage we are presenting here, we have use the FLUENT software in order to simulate various conditions. This option was chosen due to the possibility of visualizing the phenomena and obtaining qualitative results regarding air circulation and the sunlight potential. The chosen configuration is presented in Fig.1, 2, 3 and Tab. 1.

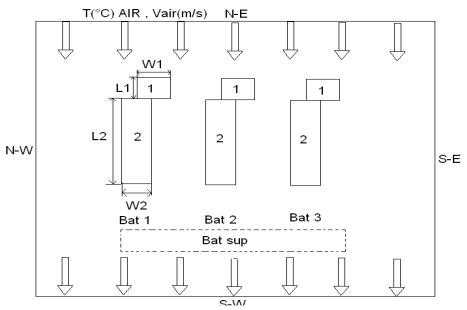


Fig.1 Configuration of the urban ensemble

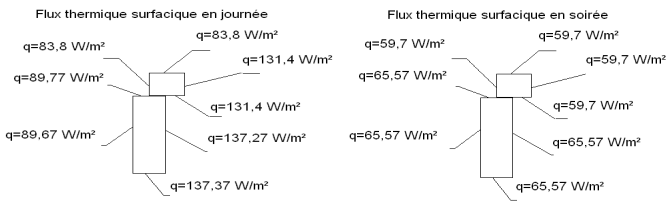


Fig. 2 Thermal flux

Tab. 1 Conditions of simulation

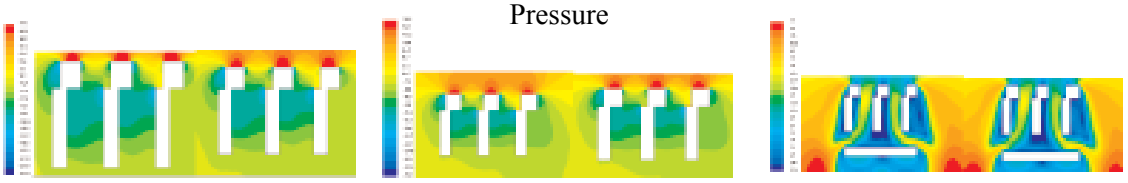
cas	T (°C)	V (m/s)
1	-12	12
2	-10	4
3	12	10
4	12	4
5	20	4
6	-4	4
7	30	4

Building 1: Height H1 = 11,2 m
Width W1 = 14,5 m
Lenght L1 = 14,5 m
Building 2: Height H2 = 14 m
Width W2 = 10m
Lenght L2 = 42,3 m
Characteristics of the material (concrete):
- Density: 2200 $kg.m^{-3}$
- Specific temperature: 1000 $J.kg^{-1} K^{-1}$
- Thermal conductivity: 1,65 $W.m^{-1} K^{-1}$

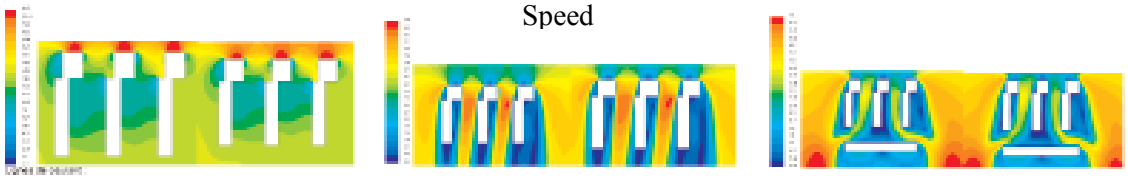
Fig. 3 Characteristics of the buildings

Case 1 Case 5 Case 7

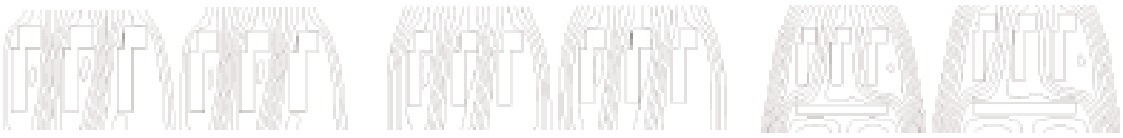
Pressure



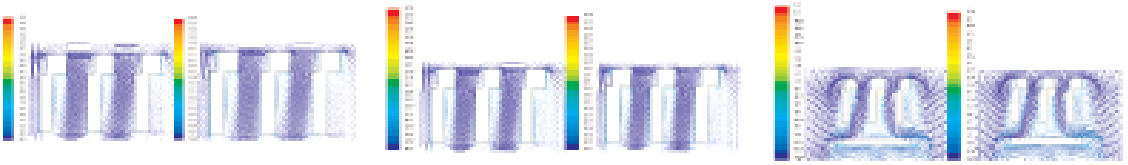
Speed



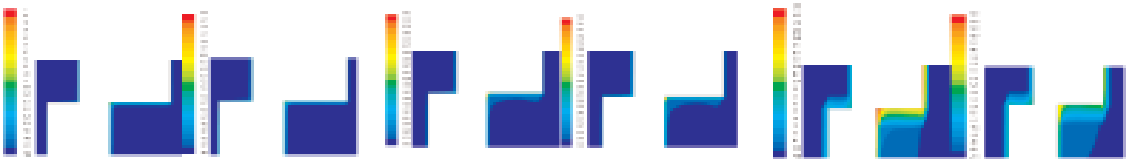
Air current lines



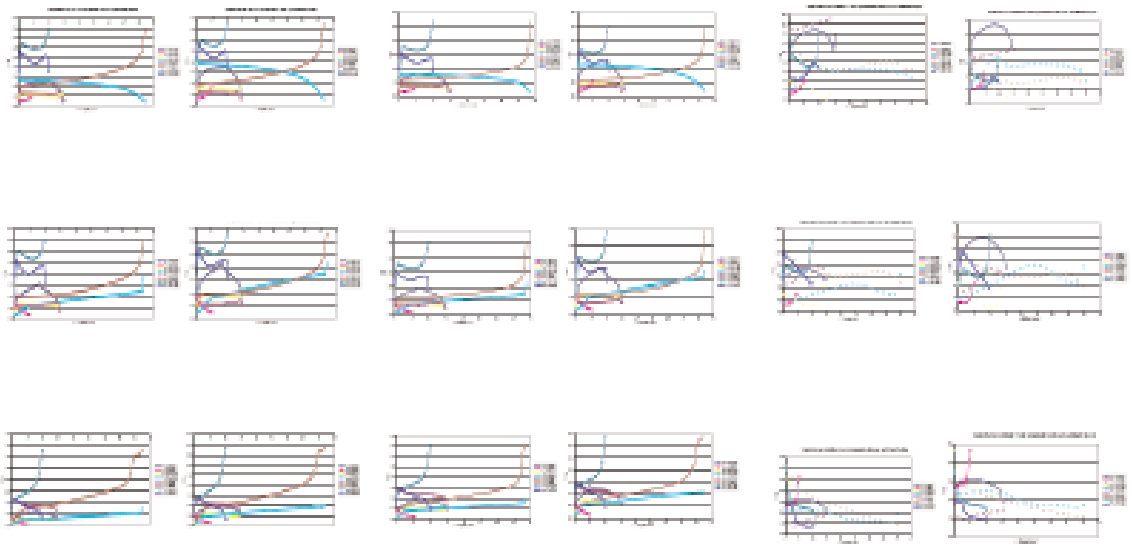
Speed vector according to air temperature



Isothermal



Walls temperature



2 Conclusions of the simulation

Analyzing the field of pressure and speed of the air, as well as the speed vector and the current lines and the temperature fields for all the combinations of exterior parameters and for the planimetric configuration analyzed, the result is the following (on each building):

- For winter conditions:

-the speed of wind and the pressure on the façade on the longer side of the building are much lower compared to the calculation parameters, which means that there is no possible natural, wind-driven transversal ventilation for the principal section; on the shorter side, the pressure levels are superior to the initial value, and the speed levels are slightly modified; therefore, for this section the ventilation determined by the difference in temperature is wind-activated; in the same time, the heat loss determined by the infiltrations is very low on the long side of buildings and has significant values on the short one; in the spaces between buildings, the speed of the wind is highly reduced, with areas of absolute calm (zero speed); the presence of such areas is favourable for the street comfort and is a good spot for placing playgrounds for children.

- For summer conditions:

-the pressure on all the facades of the buildings remains unmodified compared to the initial parameters, which means that, for the given situation, the cooling potential through ventilation is highly reduced; in between buildings there are intensifications of the wind at values superior to the initial ones and areas of absolute calm on the facades of the buildings, including on the short side, a situation that is favourable for street comfort.

Placing a bar-shaped building on the direction of the wind and on the long side of the analyzed buildings (wind speed – 4m/sec, temperature – 4°C) shows that:

-for the initial buildings, the modifications are: raised pressure on the frontal facades and between the buildings, speed less important between buildings, but stronger on the facades parallel to the new building, with the effect of heating the air next to the walls, modifications of the thermal exchanges of the buildings, lowering the transfer coefficient due to the modification of the wind (a 4°C difference for minims and 30°C for maxims); the building number 2 has the highest index of wall temperature; the building added later has a very low ventilation potential; the situation is radically modified for the building added later when the wind's direction of action changes.

The research has allowed us to outline a methodology of analysis - to be used in the design phase - regarding the impact of the urban context on the new and existing buildings from the point of view of sunlight exposure and air circulation, based on the following criteria and levels of performance:

a. Criteria referring to the air circulation - the potential for natural ventilation;
b. Criteria referring to the valorization of the solar potential at the level of urban unit (taking into consideration reciprocal shading);
c. Criteria at the level of the building (passive heating potential, potential for using solar energy through photovoltaic effect, natural illumination potential).

The results of the research, completed in parallel with applications of the URBVNET and CASANOVA programs, have allowed us to set up design recommendations in order to ensure optimal solar exposure and air circulation in densely built urban spaces

References

[1] Allard F., Ghiaus C. - Natural Ventilation in the Urban Environment. Assessement and Design. Building, Energy and Solar Technology Series (BEST), Stylus Publishing ,LLC, 2005