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AN APPROACH TO NATURAL VENTILATION CONDITIONS IN URBAN APARTMENT BLOCK BUILDINGS IN GREECE BASED ON THEIR ARCHITECTURAL AND CONSTRUCTIONAL CHARACTERISTICS

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ABSTRACT

The multi-storey blocks which constitute the main type of building in Greek urban environments, have certain common characteristics. Those characteristics include the overall building dimensions and geometry, internal room dimensions, the materials used both in building construction and insulation, the size and the arrangement of the openings on the facades, the arrangement of the balconies, the position and dimension of the staircase etc. Some of these characteristics, through their intervention in natural ventilation processes, contribute both qualitatively and quantitatively to the air flow regime of indoor spaces. This means that given specific meteorological conditions, they influence the air change rates and the mixing properties of shifting air masses. The consequent effects of such influences are in some cases favourable and in other cases unfavourable with regard to the resulting ventilation conditions in indoor space. This paper aims to investigate these influences in order to provide a basis for the development of design guidelines for similar buildings.

KEYWORDS

block buildings, residences, offices, ventilation strategies, natural ventilation, indoor air quality, air change rates.

INTRODUCTION

The main factors which affect natural ventilation in multi-storey building interiors are the pressure of the wind (wind effect) and indoor-outdoor temperature variations (stack effect). However, the extent to which these factors are influential is determined by prevailing meteorological conditions. Moreover, the influence of these factors is also determined by processes that occur during air change in the interiors of buildings, which are related to architectural and constructional characteristics. Consequently, under specific meteorological conditions, the greater the similarities that buildings share with regard to the characteristics already mentioned, the greater will be the similarities they share, from both a quali-

tative and quantitative point of view, with regard to their ventilation conditions. Some of the factors that contribute to obvious similarities in the architectural and constructional characteristics of buildings are the climate, the prevailing architectural and constructional traditions and practices, the social and economic background of the region and a series of other parameters, including relevant local laws and building regulations, availability of construction materials etc. Therefore, taking into account that these factors have strong geographical associations, it can be presumed that some of the resulting similarities permit consideration and description with regard to the ventilation conditions of the buildings (or, at least, some aspects of these) on a local base.

According to statistics for the year 1993 in Greece, habitations (approximately 3.7 millions) represent about 73 % of buildings, while the remainder constitute office and trade buildings, public buildings (health-care, education, sport, culture etc.), hotels etc. The Mediterranean-type climate of Greece (Tselepidaki 1994) results in marginal ventilation heat losses that do not justify complex ventilation systems in buildings, based on energy conservation alone (Liddament, 1996). Therefore, natural ventilation systems outnumber corresponding mechanical systems, despite the shortcomings that result from dependence on prevailing meteorological conditions for their effectiveness. The exception concerns buildings in areas with intense pollution or noise, as in big city centres or special categories of buildings with elevated ventilation demands (e.g. hospitals, gathering-places etc.). Most of the residential and commercial (non-industrial) facilities in the urban environment in Greece are accommodated in multi-storey buildings. In these buildings, ventilation is achieved to a large extent through infiltration and when this is not sufficient, the residents arrange to increase it by using the openings in the structure. In specific interior spaces, known as wet (kitchen, bathroom, WC), passive ventilation stacks or extractor fans are frequently installed which, when needed, are activated by the occupants.

This paper examines the characteristics common to urban block buildings in Greece with regard to the natural ventilation processes which take place. Emphasis is given to the contribution of corresponding characteristics and their influence on the ventilation processes which form the indoor environment. The paper, on the base of this analysis, attempts to judge and assess, from both the qualitative and quantitative points of view, the natural ventilation conditions which prevail in buildings of a corresponding nature, which constitute the main type of building in the Greek urban environment. Although limited, all available relevant experimental data was used to contribute to the findings of this study which could ultimately provide a basis for the development of design guidelines for corresponding buildings.

URBAN PLANNING AND THE ARCHITECTURAL CHARACTERISTICS OF APARTMENT BLOCK BUILDINGS IN GREECE

An indication of the intense urbanisation recorded during the last few decades in Greece is the fact that the largest part of the population lives in an urban or semi-urban environment. In addition, multi-storey blocks constitute a key factor in the urban planning system of Greek cities. In densely-populated areas, rows of multi-storey blocks form a continuous line at their perimeter, resulting in a square with a non-constructed area at its centre, which is the cumulative result of the open spaces left for all buildings either opposite or adjacent to each other (Figure 1). The apartments in each building are distributed on the various floors. The largest ones, mainly used as dwellings, are typically oriented transversely and extend from the facade to the open space at the back. The interior space in these habitations is arranged in such a way that next to the more impressive facades can be found the living rooms while kitchens and bathrooms, as well as bedrooms are usually located at the back.

This urban planning and construction model offers certain advantages with regard to the natural ventilation of the apartments, such as:

- the separation and the relative isolation of the places from which different pollutants are emitted. Moreover, the living rooms are separated from the kitchen and the toilets, spaces which usually generate most of the annoying pollutants.
- the possibility of cross-ventilation through openings on the opposite sides of the shell.
- conflicting wind pressures visit different parts of the shell, and are thus oriented towards different (opposite) wings of the building. Thus, the various protective-shielding features that are formed on the opposite sides of the building, favour, in the context of ventilation, a specific flow of air from a wide range of winds. This encourages the air to enter from the openings in the facade (which is usually more exposed to the wind) and to exit from the openings on the rear side.

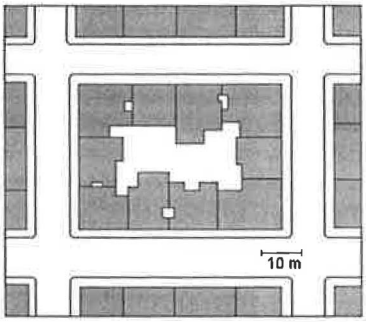

Figure 1: Sectional plan of a conventional block in the centre of Greek cities.
It consists of a continuous line of apartment block buildings along the perimeter with the open spaces of the corresponding building plots congregated in the middle. The ventilation in some of these spaces is achieved through light wells.

The urban apartment block, as the prevailing type of building in Greek towns, has many characteristics connected to the ventilation conditions in the apartments (Figure 2). More specifically:
- it has a prismatic shape, with a more or less square sectional plan and a relatively small volume. The surface of these buildings varies from between 150 to 250 m^2, while their height does not exceed 8 floors, which, given that the height of each floor is about 3 m, reaches about 25m.
- even if the total surface of the apartments varies significantly, they most usually range somewhere between 60 and 100 m^2 in size, particularly in the case of residences. The total surface of the apartments is divided into rooms and their dimensions do not vary much. A representative room in a residential apartment has a surface of about 10 m^2. Each room usually has only one access door.
- there are openings in each room (windows or balcony doors), which may often be more than one. These openings are relatively wide and are distributed around all facades, usually in columns, one on top of the other. When the layout of the apartments does not permit the positioning of all the rooms on one of the facades, then some of them (usually toilets, kitchens or storerooms) have openings into a light well.
- on the sectional plan of the apartments, there is an attempt to arrange the rooms centrally, usually with reference to the entrance. However, due to different restrictive factors this is not always feasible.
- an integral part of every Greek apartment block building is the balcony. Each apartment has access to at least one balcony. Balconies are generally arranged on the facade in columns, and they often extend the full length of the facade.
- every block of flats has a stairwell, usually at its centre (which also includes the elevator well) and access to the apartments is exclusively from the landings.
- the ground floor of the apartment block is rarely used to accommodate apartments. It is sometimes used for shops or purposely remains unbuilt to provide parking spaces between supporting columns.

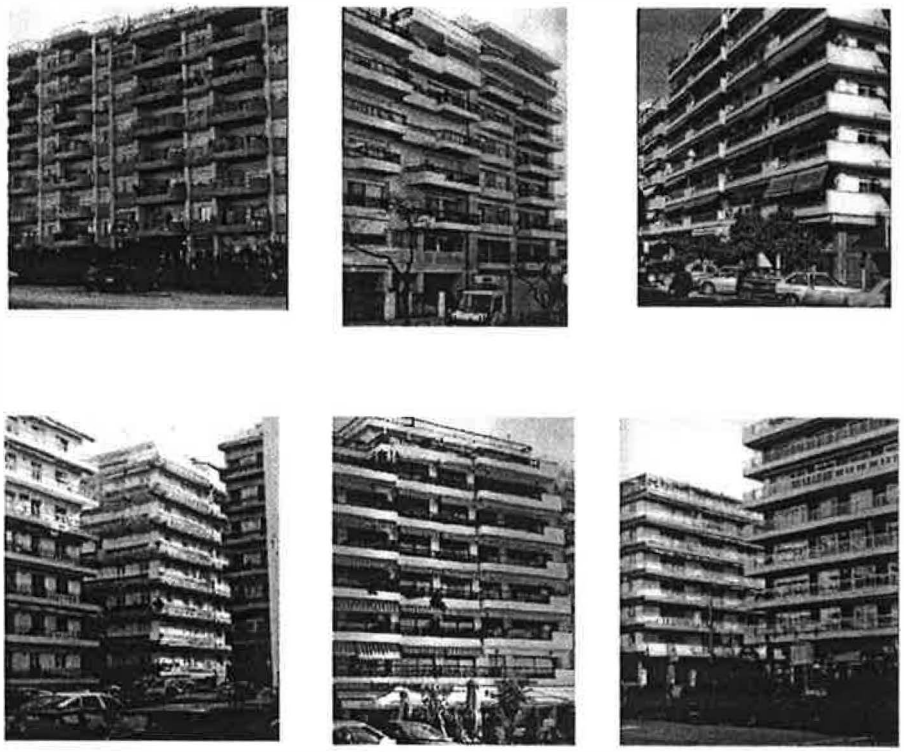

Figure 2: Facades of typical Greek urban apartment block buildings

The above characteristics leave wide margins for intervention, on the design level, in order to achieve satisfactory ventilation. For example:

- some are related to wind pressure distribution on the building shell. Thus, its stereometric characteristics create relatively clear and simple wind pressure fields for various wind conditions, which, in addition, have the advantage of being empirically accessible. Morphological elements, like columns and balconies, modify the wind pressure field to a certain degree, which to some extent is relatively specific (Newberry & Eaton, 1974).Moreover, balconies, like all ledges, create a small-scale vortex in the air stream, which results in an intense wind pressure gradient on the shell.
- in contrast to wind effect, where the general architectural characteristics of the building seem to affect the ventilation of the apartments in a positive and important way, the stack effect, in this specific climate, is a significantly weaker element than the wind and therefore does not seem to be exploited to the same degree. It would appear that the relatively low height of the buildings does not permit, de facto, effective exploitation of the stack effect. It does, however, appear to contribute in a significant way with regard to the amount of ventilation achieved through the stairwell, the passive ventilation stacks and the well (when it exists).
- with regard to ventilation conditions in indoor spaces, the multiple openings in the building shell contribute positively in a qualitative as well as in a quantitative way. Moreover, under specific environmental conditions, increased rates of ventilation and a satisfactory mixing of the alternating air masses

are achieved. In the same way, the centralised sectional plan of the apartments (i.e. when one dimension does not exceed the other excessively) also contributes to this action. On the other hand, the small volume of the rooms and the obstacles to air circulation inside the apartment, due its being separated into rooms, have the opposite effect. Also, the small size of the indoor areas (the rooms as well as the overall apartments themselves) limit their capacity to function as a "fresh air reservoir" in case of the need to place a temporary limitation on ventilation (e.g. due to outdoor pollution).

CONSTRUCTION OF APARTMENT BLOCK BUILDINGS IN GREECE

In Greece, over the last few decades, not only the multi-storey buildings but a substantial number of other buildings, both in urban and rural environments, have been constructed with concrete and bricks. On the contrary, other construction materials with notably different airtightness, like timber or light multi-layer walls, which are widely used abroad, are not used in Greece except for secondary structures, such as storehouses, or indoor construction elements like frames, divider walls etc.. The specific method of construction produces, in general, an airtight shell (Elmroth & Levin, 1983). Relevant studies of different types of building abroad have concluded that the largest amounts of air leaks corresponds with the following openings in the shell (Reinhold & Sonderegger, 1983; ASHRAE, 1993):

- the junction points of prefabricated elements
- the casing (between the moving parts and between the casing and the frame)
- cracks and pores of the shell elements made out of wood and light multi-layer walls
- the roof and attic
- the meeting points of pipes (electric power, water, heating etc.),especially in small buildings e.g. detached houses.
- the fireplace

Of the above types of openings, only the one related to casings seems to apply to buildings in Greece. The rest are either related to elements rarely used, or are not justified by the construction techniques. Considering that the aluminium casings as well as the composite ones that have been used more recently, are in general more airtight than the wooden ones used previously there appears to be an advantage with regard to airtightness in this category for buildings in Greece. Airtightness has also been improved by the development and the extension in the range and application of different insulation materials, as well as by the development of modern construction materials (e.g. plastics) during the last few decades. Apart from the fact that they contribute to reducing the rate of ventilation in the buildings, these materials often aggravate the quality of the air indoors by the emission of pollutants (Namiesnik et al, 1992). Even if relevant available data is limited (e.g. Lagoudi et al, 1996; Papamanolis, 1997), it is possible that such indoor air quality problems also occur in Greece and can be attributed to the high airtightness of the building shell and to a corresponding reduction in air change values.

DISCUSSION AND CONCLUSIONS

In the presentation of the typical architectural and constructional characteristics of urban apartment block buildings in typical urban planning of Greece, many were identified as either directly or indirectly influencing the natural ventilation processes of indoor space. Other important characteristics suggested included the morphology and the stereometry of the building, the organisation and use of indoor space, the distribution and the size of the openings in the shell, the construction materials used etc. Some of them affect the airtightness of the shell and the pattern of the pressure field exerted by the natural forces on it. Accordingly, under given meteorological conditions, they influence the air change rate in the indoor space of buildings. In the same way, other characteristics influence the airflow path within interior space and determine both the model of ventilation (e.g. cross ventilation, single-sided

ventilation) and the corresponding distribution of indoor pollutants. This means that, under given meteorological and environmental conditions, they influence the effectiveness of ventilation. Some of the above characteristics contribute positively, both in terms of quality and quantity, to the ventilation of internal space; thus, under fixed environmental conditions, they contribute to relatively high ventilation values and a satisfactory mixing of the exchanged air masses. On the other hand, the influence of other characteristics counterbalances. Nevertheless, apart from the factors that were examined there are several other factors that contribute to the formation of the qualitative and quantitative characteristics of building ventilation such as, for example, the age of the building, which leads to deterioration in the construction materials, which has a significant effect on the airtightness of the shell.

In Greece, air change rate measurements are limited and insufficient to constitute reliable statistics regarding ventilation conditions in all the buildings of the country. Since 1989, when the first measurements were carried out on a building complex with solar architecture in Attica, until the year 1996, thirty-six (36) ventilation measurements have been recorded, which applied to sixteen (16) buildings of different types (Papamanolis & Koinakis, 1996). These calculations used tracer gas methods under meteorological conditions normal for the region and the season, according to relevant standards. The results, with reference to naturally ventilated commercial and residential buildings, varied between 0.14 and 8.57 ac/h. These values are within the limits of similar measurements carried out in several other countries and in buildings of conventional (according to the standards of each country) construction (Elmroth & Levin 1983).

Taking all of the above into due consideration, the study of all the typical characteristics of apartment block buildings prevailing in the Greek urban environment offers clarification with regard to the natural ventilation conditions in these buildings. Such a study provides information which is quite helpful in both the design and the construction of corresponding buildings. Nevertheless, the significance of these general conclusions, resulted from this analysis, must be judged in light of the lack of more reliable information (e.g. statistical outputs from a robust database).

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