Passive cooling in the works of A.N. Tombazis and associates

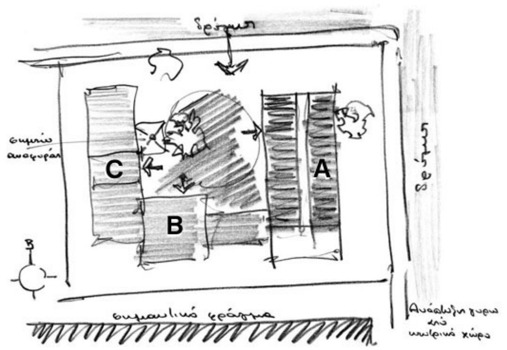
A.N. Tombazis
Meletitiki – Alexandros N. Tombazis and Associates Architects Ltd, Athens, Greece

The main design strategies when dealing with cooling are well known by now. The paper will not present options one by one, but will show how each one has been used as a starting point of design in recent projects.

1. OFFICE BUILDING COMPLEX, POLYDROSO, ATHENS, GREECE

Three office buildings have been designed (and constructed during 1990 and 1994-95) to form a group around a central entrance courtyard, which is dominated by a pond, wooden decks, a piece of sculpture by G. Zongolopoulos and the mature olive trees that have been saved or transplanted. Building A and B house different engineering companies, while the approximately 1,100m^2 building C the offices of Meletitiki – A.N. Tombazis and Associates Architects with about 50-60 work stations.

The building is comprised of a basement with parking and ancillary spaces, archives etc. and three above ground levels, which are all developed on half levels with substantial voids between them. The interior space is entirely open so that from any point one can perceive the rest of the space.



The building for reasons of bioclimatic design is narrow and long, approximately 8.0m x 35.0m. Thus all workstations are adequately daylit by the side windows and furthermore by light reflected from fabric panels below the skylights of the roof. All apertures of the east and west elevations are shaded by individual exterior vertical electric motor awnings. Artificial task lighting is provided only as a back-up system and is seldom used.

The building has increased 10cm insulation provided within the ventilated facades which are clad with fair-faced cement bricks.

Natural ventilation and cooling is achieved by cross-ventilation, when appropriate, and by automatically controlled ceiling fans which extend the comfort range from 25°C to 29°C. When temperatures exceed 29°C a zoned A/C system turns on (air heat pump). Cooling is further enhanced by the mechanical night ventilation provided through two extraction fans on the roof (25 ACH), which use the lower night time exterior temperatures and provide a temperature drop of about 3°C the next day.

All systems are controlled and consumption is recorded by a central BMS.

Rain water is collected and used for irrigation and flushing of the double mode toilets.

2. AVAX S.A. HEADQUARTERS, ATHENS, GREECE

This building was designed (1992-93) and built (1993-98) to house the headquarters of "AVAX" S.A., one of the major Greek contracting companies. It is situated in the centre of Athens on the east-facing slope of Lycabettus hill.

It comprises of three basement levels, ground floor and five levels above ground with a total area of 2,950m^2. The main aim of the design was to apply bioclimatic design features, in order to cover the energy demands of the building and to create a comfortable environment for its users.

The following bioclimatic design features were applied:

- Special vertical glass panels shade the east facade. They cosist of double laminated glass panels with a silk screen-printed surface providing a shading coefficient of 70%. The blinds rotate automatically in response to solar radiation.
- Openings are foreseen on both sides of the building with access to an underfloor plenum to provide fan-assisted night ventilation.
- Ceiling fans with individual demand are provided throughout the building, extending the comfort temperature from 25°C to 29°C.
- Lighting control systems measure the outdoor lighting levels, turn off/on interior lighting at specific times of the year and working hours and check space occupancy.
- The thermal insulation is increased to 10cm.
- An ice bank is provided in the basement to make use of off-peak electricity.
- A Building Management System (BMS) controls ventilation, shading, lighting and the back-up A/C system.

3. GREEK REFINERY HEADQUARTERS, ASPROPYRGOS, ATTICA, GREECE

Competition by invitation, 1st prize

The site is situated along the highway leading from Athens to Corinth in Aspropyrgos, a very polluted industrial area.

The 9,800m^2 (and 3,800m^2 basement) building (which was constructed in 1996-99) is a right-angled triangle in plan, which makes the best possible use of the available space, but also distinguishes the building from the neighbouring volumes. Large external open and internal enclosed atria divide the volume while the glazed parts of the roof create openings in the building shell providing for natural lighting of the interiors.

The metal structures that shade the vertical openings (east and west windows) and the skylights are positioned above the building and connect the building morphologically (together with the watch tower to the east) to the industrial character of the area.

The main design intentions were:

- provision of maximum possible flexibility so that the interior layout corresponds to changing functional needs,
- maximisation of the use of daylight through the appropriate shallow shaped office wings,

- demonstration – through the design of elevations, entrance, open and enclosed spaces and selection of building materials – of the company's identity,
- provision of the possibility for future extension and
- creation, through the building's bioclimatic design, of an appropriate microclimate both inside and around the building.

The building's exterior triangular shape is internally interrupted by subtracting trapezoidal prismatic volumes, which organise the building's functional development along an east-west axis. This axis forms the basic corridor along which the wings that incorporate the various departments are placed.

Positioned between the wings are large open atria 9.90m wide, while the wings themselves each have an enclosed atrium 5.40m wide. All office spaces thus have access to natural light. The planting of both the open and enclosed atria provides for green areas that intensify the building's intentional introvert character.

4. ELECTRICITY AUTHORITY OF CYPRUS ADMINISTRATION BUILDING, NICOSIA, CYPRUS

National competition, 2nd prize

In collaboration with A. Gabrielides, architect, Nicosia

The building houses the main administration offices of the Electric Company of Cyprus. Construction was recently completed. The total surface is 14,000m² excluding basements where parking space and other ancillary functions are placed.

The building is composed of two long and narrow (14m wide) office wings developed along an east-west axis for reasons of better bioclimatic design. Between the two wings a multi-storey enclosed atrium is provided, which enables daylighting and natural ventilation of

the offices from the side.

The main entrance and public areas are via the atrium on ground floor level. The south wing on ground floor level is a void volume allowing for open views towards south-east. The atrium is covered by a curved metal roof that is constructed in such a way in order to enable the installation of photovoltaic cells in the future.

Office spaces are flexible, either enclosed or open. The reinforced concrete structural slabs are exposed and, instead of a false ceiling, a raised floor is provided throughout the building.

The south and north elevations are designed in accordance with the bioclimatic needs of the building. The south elevation consists of a double façade and light shelves are provided for control of the solar penetration.

The main bioclimatic element of the building is the atrium because:

- it reduces contact of the exterior shell and the windows with the external environment resulting in reduced heat gains during summer and heat losses during winter,
- the lighting levels are controllable,
- the cooling load of the building is reduced through the chimney effect,
- night cooling is achieved through special design openings.

5. SANCTUARY OF FATIMA, CHURCH OF THE MOST HOLY TRINITY, FATIMA, PORTUGAL

International competition by invitation, 1st prize

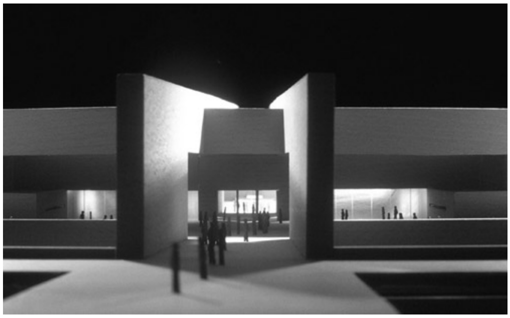
Execution of design in collaboration with P. Santos, architect, Porto

The aim of this project (under construction) is to create a large covered space to protect 9,000 pilgrims from rain and bad weather during the winter months and to accommodate other, non religious activities, while not distrurbing the continuity of the historical place.

In a building of this type and size the roof acts as the main climatic modifier. Consequently it employs the main passive bioclimatic features. Two complementary sawtooth structures and a skylight above the altar area were designed in order to optimise the daylighting performance of this hall and at the same time accommodate for its special needs. The main area of the hall is covered by a north-facing sawtooth roof, which optimises daylight access and distribution while excluding unwanted solar gains. Above the central axis however, a south-facing sawtooth structure has been incorporated, which allows a variety of lighting scenarios for different uses through the variability of the shading system. This feature adds grandeur and translates the dimension of the light from above into an actual experience.

The rooflights incorporate double glazing and are obstructed by the roof at 30°. In order to increase the amount of daylight entering through the glazing a highly reflective material was chosen as cladding.

Under the north oriented sawtooth apertures



covering the two hemispheres of the main hall the shading system consists of stretched fabric pieces supported by steel cables. This solution was employed in order to further increase the uniformity of daylight distribution.

For the south oriented apertures of the main axis, a different shading strategy was used. These apertures define the space, creating a “light path” from the entrance at the north side of the building to the altar, which is well daylit. By adjusting the shading of these apertures (which can incorporate coloured transmissive fabrics), the lighting situation can be set in a variety of ‘dynamic’ modes depending on the desired effect. The artificial lighting system is designed so as to complement the daylighting modes in glare-free ways.

6. NEW CONCERT HALL, STAVANGER, NORWAY

International competition, honorary mention.

In collaboration with H. Rostvik, architect, Stavanger

The Competition was held by the Municipality of Stavanger, the «oil capital» of Norway and a city of substantial musical tradition. The building programme consisted of a 1,600 seat concert hall, a 1,400 seat multi-purpose hall, rehearsal and resting spaces, administration, parking space, public facilities, cafeterias and a restaurant in a complex with a total area of 13,000m^2.

The aim was to design a building as a continuation of the landscape with planted roofs extending the existing park and creating a public network for walking and biking. The only apparent building volume are the two halls and the tower with the restaurant elevated high above the quay serving both as a landmark and as a duct for the natural ventilation of the halls. Main

requirements were the creation of a landmark for the whole harbour, the use of elements of bioclimatic design and the rehabilitation and public use of the, nowadays derelict, dockside.

The two halls are not daylit, due to the requirements of the brief. However, all the other functions are not clustered around the halls but instead form wings with linear courtyards between them, which, like fissures in the landscape, introduce ample daylight to all spaces. Additional skylights provide daylight to the large foyer spaces. During hot weather control of solar gains, night time ventilation and adequate thermal mass help to maintain a comfortable temperature throughout the building. Additionally cooling is achieved by the air drought created in the ducts incorporated in the observation tower. Another important feature for exploiting solar energy is the use of transparent photovoltaic panels, hanging like stardust over the complex that will produce a significant amount of electric energy. The largest part of the roofs are planted.