Logical use of traditional technologies for housing passive cooling in hot humid Italian climate areas

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ABSTRACT

Climate of the Po Valley, in northern Italy, typically is hot humid during summer and cold during winter.

In such region new house constructions are often defective in dealing, by passive means, with solar radiation and outdoor temperatures, the majority of new buildings is designed with light envelope, and no care is taken over many issues like solar control, albedo of external surfaces, natural ventilation strategies. The negative result is a substantial growth of electrical demand associated to housing cooling, since A/C systems are becoming cheaper and more popular.

The paper is going to describe, through some actual case studies, how a rational use of traditional techniques and technologies, along with a smart design, can contribute to provide acceptable summer comfort with no needs of energy draining cooling systems.

A methodical design procedure is vital to succeed in this aim: starting from site analysis, the continuous checking of design goals and the evaluation of each option through simulation tools can help to outline true primary targets.

1. CASE STUDIES

Design methods and specific strategies mentioned below are illustrated through case studies derived from research and professional design experiences carried out by the authors (general coordination Ph.D. eng. Angelo Mingozzi and environmental-energy control A. Mingozzi e S. Bottiglioni).

Two of the presented projects are related to the construction of a new sustainable residential settlement: in Pieve di Cento (Bologna) and in Villa Fastiggi (Pesaro); a third project regards the enlargement and retrofitting of the National Etruscan museum of Marzabotto (Bologna).

The Project of Pieve di Cento (Fig. 1), covering an area of about 7 ha, is completely designed by Ricerca & Progetto – Galassi Mingozzi e associati, Bologna and includes different building typologies.

The Project of Villa Fastiggi (Fig. 2) describes a sustainable intervention to build a new 300 dwellings complex, located in a 15 ha area in Villa Fastiggi's neighbourhood, Pesaro (general co-ordinator of the cross disciplinary design group Ph.D. eng. Angelo Mingozzi).

Some of the buildings are designed by Ricerca & Progetto – Galassi Mingozzi e asso-

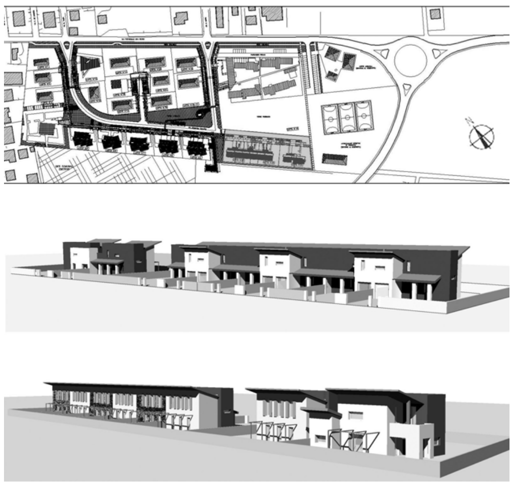

Figure 1: Project of Pieve di Cento (Bologna). General plan of the intervention; north and south façade of new residential buildings, which are going to complete the intervention.

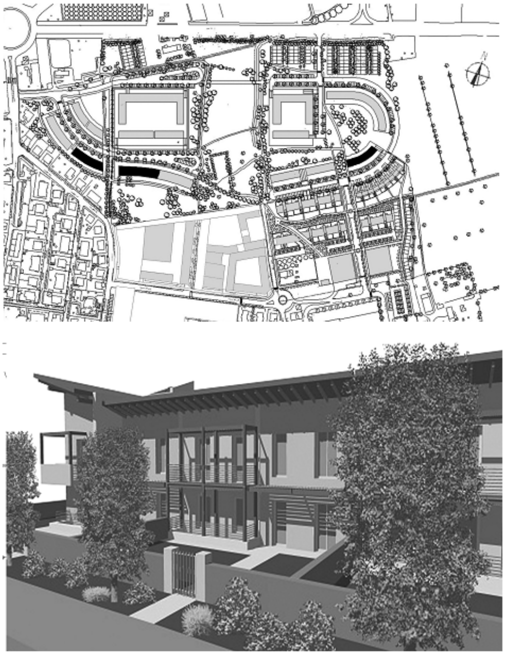

Figure 2: Project of Villa Fastiggi (Pesaro). General plan with reference to the buildings designed by Ricerca & Progetto, Bologna and south façade of one of the buildings included in the EC Project SHE.

ciati, Bologna, belong to COPES cooperatives and are part of a Demonstration Project of the EC Project on Energy, Environment and sustainable development SHE – Sustainable Housing in Europe (2003-07, Coordinator Federabitazione Europe, Italy).

The project of retrofitting and enlargement of the National Etruscan Museum “Pompeo Aria” in Marzabotto Italy (Fig. 3) belongs to the Demonstration Projects “MUSEUMS – Energy and Sustainability in Retrofitted and New Museum Buildings” (2000-2004, coordinator Meletitiki-Tombazis, Greece).

In this project Ph.D. eng. Angelo Mingozzi is the scientific responsible and coordinator of the cross disciplinary design team and leader of the “Horizontal activity” about “indoor climate”.

2. DESIGN METHOD

Two are the global objectives of sustainable design: to preserve the environment and to practice a balanced use of resources. This requires to realize that since a sustainable building process

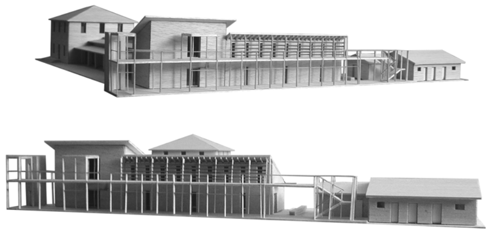

Figure 3: Project of retrofitting and enlargement of the National Etruscan Museum “Pompeo Aria” in Marzabotto (Bologna). South view of the scale model of the new exhibition hall constructed according to sustainable and bioclimatic criteria.

comprehends many different subjects and is made of a complex ensemble: an integrated approach has to be multi-disciplinary and multiscale, and designer needs a precisely defined method to govern it.

Some major issues involved by sustainable design are: awareness about the location; consciousness that the project impact goes beyond formal bounds, spatially as well as through time, till and after the building life; to consistently manage the design at its different scales; interdisciplinary character, which also means that environmental, social and economical aspects have to be considered as a whole; frequent audit of design choices, considering the building lifecycle, as well as general and specific objectives.

Three phases strictly connected are the bases of the method: *site analysis*, which is the study of local environmental and climatic factors; *design targets definition*, in light of the two abovementioned global objectives; *solutions identification*, *design control* and *choices assessment*.

3. SITE ANALYSIS AND RECURRENT CLIMATIC CONDITIONS

Knowledge about the place where each project stands has been acquired through a detailed site analysis; in fact specific targets of sustainable building are strongly influenced by the location, both in terms of opportunities and protection needs. Site analysis represents the first essential step which provides basic information to define project sustainable targets, as it highlights the key influences upon the design process.

The three case studies have common climatic characters: hot and humid summers and cold cloudy winters. During hot season dwellings need to be protected from sunrays, while during winter the sky is often cloudy and solar radiation feeble, so it is necessary to reduce heat losses through shell, and to avoid exposition to cold winds.

All these issues are to be considered in relation with all other environmental characters, as for example noise sources, electromagnetic fields, etc.

Starting from the site analysis, designer has to optimize relations between building and the sol-air impact (due to the combination of solar radiation and air temperature), by means of an appropriate building layout including placement, shape, orientation, and outdoor spaces design.

4. DESIGN STRATEGIES

Passive cooling approach not necessarily have to recur to highly technological devices: there are many strategies that belong to local traditions, and that can be easily and successfully implemented within design process. Their use requires to bring inside the project the awareness and the knowledge about the strong energy relations existing between outdoor climate and building design choices. Solutions require at first to be simple, logical and integrated within the architecture and only in later investigation more specific and technologically advanced solutions should be implemented.

According to the local climate analysis the primary need is to reduce summer heat gains rather than stressing to get the most energy from winter gloomy skies.

This goal should be pursued by a comprehensive set of actions that start at large scale by controlling the relations between buildings and outdoor spaces.

A correct use of vegetation in outdoor layouts can provide radiation reduction by shading and assure cooling through evapotranspiration when temperatures are high; broadleaf plants shade from direct solar rays in summer and naked branches let the light pass through in winter. External horizontal surfaces exposed to south or west should be protected in order to prevent re-irradiation toward the building and overheating.

While defining the settlement layout and buildings position, shape and orientation should be carefully designed. The settlement should be arranged in order that each building have correct solar orientation and full “access to the sun”. Building plan layout requires main spaces and secondary ones to be correctly located: south orientation permits to enhance passive solar gains during the winter and to easily control solar radiation during the summer (Fig. 4).

Kitchens, living rooms and children bedrooms are preferably located towards south and south-east in order to let them grasp as most daylight and sun as possible, while accessory spaces like bathrooms, stairs, corridors, laundry, do not need the same attentions and could take place in more disadvantaged orientations.

At these latitudes (43° - 44° N) roofs and other horizontal surfaces collect a large amount of solar radiation during summer hottest hours.

To overcome this issue suggested solutions are single-pitched roofs tilted towards north, designed to reduce northern wall area and at the same time enlarge southern façade (Fig. 5).

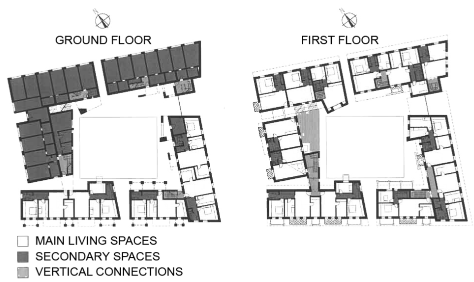

Figure 4: Project of Pieve di Cento (Bologna). Indoor space organization inside a “court” building typology in order to offer best solar exposure to principal living spaces.

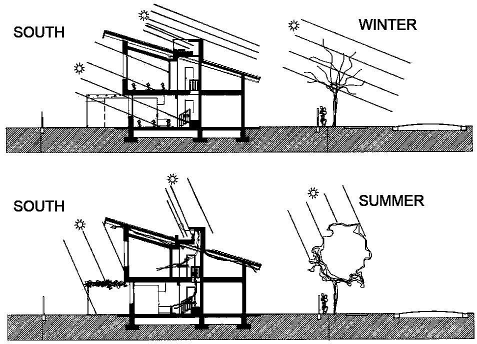

Figure 5: Project of Pieve di Cento (Bologna). Typical section of linear dwellings typology and external sun shading devices to control solar radiation.

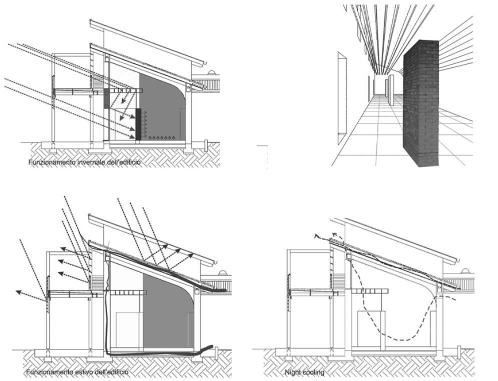

Figure 6: Project of the museum Pompeo Aria. Comprehensive strategies for passive cooling: solar control, heavy structure mass and natural ventilation.

Roofs have strong insulation to avoid thermal losses during winter, and are ventilated in order to reduce summer solar overheating. Different kinds of roof ventilation can be suggested, but in these cases an air gap greater than 6 cm was preferred.

Glazed surfaces should be correctly placed and sized. South oriented surfaces should be maximized, while west oriented ones should be minimal. Northern windows require to be highly insulated.

All the windows facing south and south-west have to be shaded: in the case studies this is done using external screening devices such as roof projection, architectural elements like balconies and dedicated devices on windows (Fig. 6).

Windows should of course be sized taking into account also daylight quantity and quality, to find the correct balance for comfort and daylighting needs of users (Fig. 7).

As concern building envelope, preference is given to environmental friendly materials and technologies, evaluated on a life cycle basis.

In the examples heavy structural bricks walls are used. In order to find good compromises between thermal inertia and insulation, external walls are different according to orientation: south and west walls are massive while northern and east ones are more insulated (Fig. 8).

For passive cooling purposes, thermal mass in floors and walls has to be associated to night ventilation that permits, when external temperatures are favourable, to dissipate heat and cool down the mass. Night ventilation is basically

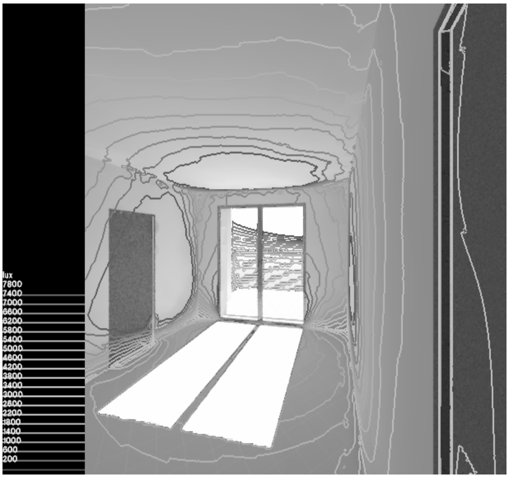

Figure 7: Daylight simulation inside a dwelling of Villa Fastiggi’s Project (LBL Radiance).

operated by inhabitants but dwellings can be equipped with dedicated apertures and ventilation chimneys.

Heavy thermal masses are useful even during winter, providing a more stable climate: this is due to their great inertia, which fits well with the heating system’s one, constituted by low temperature radiant floor and condensation boiler, which uses thermal energy from solar

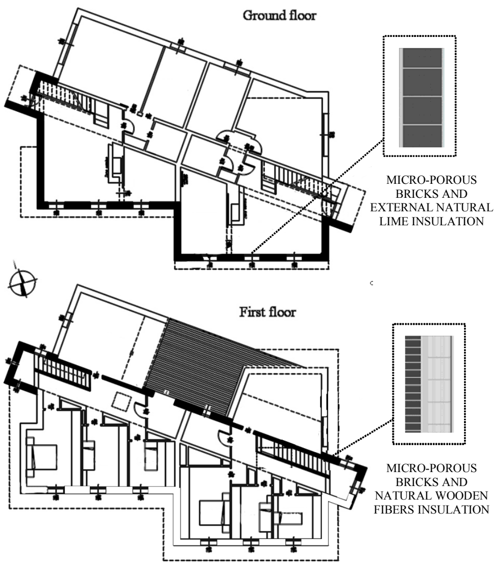

Figure 8: Project of Pieve di Cento (Bologna). Different wall technologies to balance thermal mass and insulation according to solar orientation.

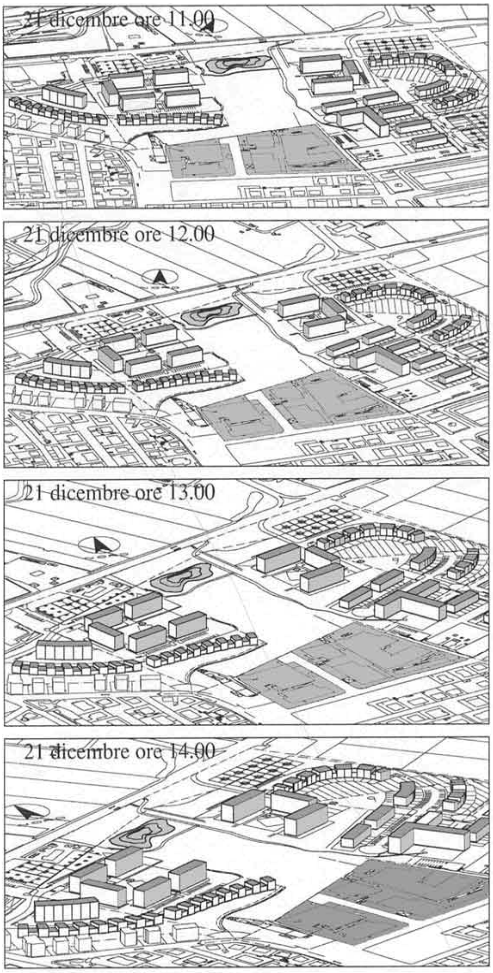

Figure 9: Project of Villa Fastiggi (Pesaro). Winter solar views used at the preliminary design phase to control sun penetration inside the different buildings.

panels, too.

5. DESIGN CONTROL AND CHOICES ASSESSMENT

The use of simulations tools to orient strategies and control design choices is a crucial point when constantly checking target fulfillment. Such design control tools may help to investigate the effect and the importance of a specific parameter, component, system, or a combination of them, as well as to quantify global energy and environmental performances of the final design.

More or less complicated control systems are needed to sustain each design phase according to its character, not exceeding in complexity. During preliminary phases to evaluate the relations between buildings and sun, designer can be aided by a simple instrument: solar views, which are schematic representations of building and its surroundings, viewed from sun position in some representative hours and days of the year, such as noon of winter solstice (Fig. 9).

Other instruments, like dynamic thermal multi-zone simulation tools, can be necessary to get a full evaluation of benefits coming from thermal masses and night ventilation.

6. CONCLUSIONS

Previous examples are probably not the best issues neither solutions to be replicated “as they are”.

The intent of the paper is to show that sustainability and energy saving issues may succeed and encounter large public consensus, when they are proposed in a comprehensive and architecture integrated way (Figs. 10 and 11).

In order to promote passive cooling at these latitudes, solutions have to carefully consider solar radiation control, both at settlement and building scale, in combination with heavy thermal masses and night ventilation.

The lesson to be learned from these experiences is that logical use of traditional technologies, optimized according to information coming from the site, may produce, by passive means, satisfactory comfort conditions during hot humid summers and reduce energy needs during winter.

Figure 10: Project of Pieve di Cento (Bologna). Pictures of the “court” buildings typology.

Figure 11: Project of Pieve di Cento (Bologna). Pictures of the linear dwellings typology buildings.

REFERENCES

Barozzi, A., M. Biolcati, M. Rinaldi and A. Mingozzi, 2002. Criteri di definizione delle caratteristiche di ecocompatibilità nei progetti di edilizia residenziale, Proceedings, International Workshop "Edilizia Residenziale pubblica ecocompatibile (sustainable public housing)", Naples, April 12, pp. 371-380.

Mingozzi, A., 2004. Edilizia per la città: intervento ecosostenibile a Pieve di Cento, Bologna. *Bioarchitettura,* n. 38, pp. 12-17.

Mingozzi, A., 2004. Sustainable architecture, a comprehensive approach: the case study of Villa Fastiggi's neighbourhood, Italy, Proceedings, Conference PLEA - Passive and Low Energy Architecture, Eindhoven, The Netherlands, September 19 – 22.

Mingozzi, A. and S. Bottiglioni, 2004. National Etruscan museum "Pompeo Aria", Marzabotto, Italy: an example of an integrated approach to sustainable museums design, Proceedings, Conference PLEA - Passive and Low Energy Architecture, Eindhoven, The Netherlands, September 19 – 22.

Mingozzi, A. and S. Bottiglioni, 2004. A comprehensive approach for ecological settlements: methodological aspects and an Italian Case study, Proceedings, Conference Sustainability of the Housing Projects, Trento, Italy, September 21-25.