Evaluation of Environmental Control of Transitional Microclimatic Spaces in Temperate Mediterranean climate

Claudia Poggi, MArch  Alessandro Rogora, Prof  Gianni Scudo, Prof
[Politecnico di Milano]  [Politecnico di Milano]  [Politecnico di Milano]
claudia.poggi@polimi.it

ABSTRACT

Mediterranean architecture is characterised by the presence of transitional spaces in which thermal conditions are intermediate between the inside and the outside ones. It is important to analyse these spaces because they act as climatic moderators with a strong social role at the micro scale level.

This study focuses on a particular type of transitional space that morphologically is located at the border of a building, usually called porch. The geometry of this space influences the effect of solar radiation as a source of heat in the space and for the building facing on it. However, their potential in terms of thermal comfort especially in summer season is in contrast with the need of solar gains in winter, daylighting and visual contact to the outside. The importance of integrating these aspects is generally underestimated by designers.

Aim of this study is to define the potential of environmental control of these transitional spaces and, in particular, how they can balance the requirement of a shaded area and the need of natural lighting inside the building. The effects of a porch orientation and proportions are analysed to compare how different configurations modify the transitional space performances. These evaluations are performed with simple tools, which take into account the impact of direct and diffuse solar radiation.

The analysis is still in progress but the most important finding of this paper is to present a method of evaluation that enables the architect to do early stage considerations according to the user requirements and the external constraints of the context.

INTRODUCTION

Mediterranean architecture is characterized by a great diffusion of transitional spaces (called also intermediate or semi-open spaces) that have intermediate thermal conditions between the indoor and outdoor environment. Historically their role as climatic moderators makes them an extension of living space and a place that favour social relations.

These spaces have always existed in different countries with specific features according to the culture and the climate. The benefits they provide make them interesting to investigate.

Intermediate spaces were largely used in the history of the Mediterranean countries where they originated and developed different configurations as porches, patios, loggias etc. especially in the
northern latitudes where the climate is more temperate and variable through the year (presence of hot summers, cold winters and middle seasons). These intermediate conditions imply the necessity of adapting the building to variable external dynamic stresses, combining the necessity of summer cooling and winter heating. For these reasons, transitional spaces are considered very important passive strategies, especially for their role in moderating the effect of direct solar radiation at a microscale level.

Since a complex network of different public spaces constitutes the structure of Mediterranean cities, the presence of intermediate spaces such as covered streets creates semi-public environments that act as unifying elements and promote a gradual transition between areas with different functions and levels of privacy. The potentially comfortable area they provide makes possible to experience protected zones where to sit, relax and enjoy the surroundings.

They are still built today but often using new materials and formal solutions with the only aim of enhancing the building exterior appearance. In fact, the advent of mechanical systems to control climate in modern buildings led to a standardized architecture with little use of passive strategies. Thus, the results often demonstrate a lack of environmental consciousness. This paper tries to clarify the environmental impact of these traditional forms and explains a method that enables the architect to do first conscious design considerations balancing the different needs required by a specific project.

TRANSITIONAL SPACES

Although transitional spaces have always played a significant role in moderating climate, it’s difficult to completely define their use because of their nature of being always “in between” different conditions (external/internal, public/private etc.). However, they can be classified in categories depending on their relation to the building.

From literature review (Chun et al., 2004; Coch, 2008; Maragno, 2010) there are: the “central type” totally enclosed by building’s walls and opened to the sky such as courtyards, patios and atria and the “perimeter type” covered and located at the border of a building such as porches, loggias and balconies.

Their value in climatic control is recognized from the Greek and Roman architecture mostly because they provide protection from undesired sun radiation, wind and rain, creating habitable semi-open spaces. The two types are sometimes integrated or used in a sequence increasing their value. For example, the Roman “domus”, the most typical Mediterranean residential housing type, is constituted by these different types of space: the impluvium and the court (central) and the peristilium (perimeter).

The advent of the glass in the modern architecture made possible the transformation of these two traditional types of transitional spaces in real “thermal buffer spaces”: the central type became an atrium and the perimeter type a greenhouse. The glazed solution increases the thermal effect but loses partially the relation to the outside that remains only visual. This is an example of how the new technology transforms traditional architectural elements in a way that potentially increases the climatic control but more specific knowledge and a more conscious design is required to avoid undesiderated effects of overheating.

Figure 1 (a) “central type”, (b) “perimeter type” and (c) the Roman “domus”.

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The shading effect

This work is based on the hypothesis that the microclimatic characteristics of transitional spaces influence people’s behaviour and their propensity to use such spaces (Dessì, 2007). The qualities of these spaces are visible at a micro-urban level because they create microclimatic environments that enhance activities and provide social interaction. They can be seen as a comfortable extension of the private living space and a passive strategy of building envelope protection in overheated period. Their “ability” to protect from external environmental factors like sun, wind, rain and the amount of natural light inside the building depends on their configurations (horizontal and vertical limits) and on the materials that constitute them.

Although it is demonstrated that the presence of shaded spaces reduces the temperature fluctuation producing a more liveable environment (Chun et al., 2004), current comfort standards are not appropriate to evaluate well-being conditions in spaces that are neither interior nor exterior.

In this sense, it is necessary to assume a different approach to demonstrate their effectiveness. According to Potvin (2000), the presence of urban transitional spaces as porches provide a progressive adaptation of the body to a new environment. Even though this phenomenon cannot be clearly evaluated, there are researches that deeply investigate the perceived thermal comfort related to the psychological effects (Nikolopoulou and Steemers, 2003). In transitional spaces, the adaptive behaviour of people is demonstrated by the positive feeling resulting from the experience of passing through gradual conditions between the interior and the exterior. Moreover, the vision of a shaded space that anticipates the coolness sensation is a form of thermal “gestalt” which defines the richness of sensations that associate the multisensory perception to the metabolic and behavioural mechanisms of thermal regulations.

Thus, not only the physical effect of shading, but also psychological aspects related to multisensory experience are important issues that induce social use of transitional spaces.

THE PORCH AS A TRADITIONAL CLIMATIC MODERATOR

This research focuses on a particular transitional space usually called “porch” in Mediterranean countries. It is a “perimeter type” that in another part of the world has different cultural or climatic values. In traditional Japanese house where it is named “engawa”, it is a house extension that creates a continuum with the interior, while in tropical countries it has a stronger climatic impact and it is called “verandah” (Maragno, 2010).

In temperate countries, the porch is present both in its introvert and extrovert expression, along the streets and inside the courtyards. It has its origins in classical civilizations but its configuration has changed through the history to meet specific functional and aesthetic requirements.

The term “porch” derives from the Latin word “porticus” referring to a covered, columned space facing to a religious or civil building. On one side with a very symbolic value in relation to the concept of access to the sacred area of the temple, while in its public meaning with the name of “stoli” as place of philosophical, political and commercial meeting. In the private roman house the “peristyle” defined a certain internal realm around a courtyard. During medieval times it has been used in the monastic architecture inside cloisters as a space for meditation, than in the Renaissance it was a recurrent element in palaces courtyards or at upper floors named “loggia”. In modern architecture, it appears in the form of modular balcony or delimited by Le Corbusier “pilotis”. Today the porches are built with new technologies and materials often with bad results in terms of climatic control, as previously mentioned.

The morphology of a porch is defined trough spatial characteristics that are useful also to analyse other configurations of “perimeter spaces”. These spatial characteristics are: the “degree of enclosure” (enclosed or attached) in the building volume, the “proportions” respect to the façade (punctual or linear) and the “level” at which is located (ground or upper floor).

According to these variables, the porch can be defined as “enclosed”, positioned at the ground level and “linear” since normally its length is much more than the other dimensions.
The position on ground floor makes the porch a space with a strong link with the surrounding open space with a potential high level of social interaction and, for this reason, the permeability of the open side (e.g., distance between columns if any, presence of shading elements etc.) acquires great importance. Then the characteristic of being “enclosed” means that the upper horizontal limit is not exposed to the solar radiation but it only makes shade. Finally, the fact that the porch is linear allows its analysis in section, considering only the depth and the height: if it has the proportions of a corridor, it is only a space of circulation while if it is wider it can become a place for static activities.

In the perspective of a new project or a renewal, each of these variables assumes the role of a design strategy with a functional, environmental and aesthetic impact.

**Environmental potential**

Especially in temperate latitudes, the porch has a great climatic importance because of its good response to the variability of the climate: it protects from direct sunlight in summer but allows sun penetration in winter.

From a thermal point of view it enlarges the perimeter “potentially passive zone” (Baker and Steemers 2000) of the building in which the climate can be moderated without mechanical control systems. In relation to natural light, the porch works as an “intermediate light space” which permits the entry of daylight in the adjacent building through wall openings. Thus if it is designed so as not to reduce too much the daylight availability, it can provide a decreased and less contrasting light level to the interior zones facing the porch.

The effectiveness of a porch in relation to thermal and visual comfort depends primarily on its geometrical configuration, the orientation and the materials that constitutes its limits.

The solar radiation is the most critical environmental factor because it needs a contradictory architectural response according to the season and to its direct and diffuse components. Preventing direct sunlight creating shadows means to reduce also the infrared re-emitted radiation. Diffuse radiation is reduced as well affecting the daylight levels inside. The reduction of direct sunlight has positive effects because it increases illuminance uniformity and reduces contrasts preventing glare. It also creates pleasant effects of “penumbra” but you have to be careful in order not to go below the threshold of visibility. It’s worth noting that the amount of daylight inside should be considered together with the wall openings size and position.

All these issues refer to the importance of integrating different (and sometimes contrasting) environmental aspects in the design process in order to balance the effects primarily in relation to the user needs.

**METHODOLOGY TO EVALUATE THE ENVIRONMENTAL CONTROL OF A PORCH**

Many works have contributed to the quantitative evaluation of daylighting and sunlight control with energy simulations but few researches have explored the combined visual and thermal aspects related to solar radiation. The aim of this work is to propose a methodology based on an integrated approach that takes into account the requirements of a shaded area with the need of daylighting inside the building. In this way, architects can be helped to solve the problem of associating aesthetic qualities to environmental issues and functional needs.

**Evaluation process**

In order to evaluate the environmental potential of a transitional space configured as a porch (as described before) it is important to individuate the main parameters which represent its behaviour at micro-urban level.

A configuration comprehends the building surfaces that define the limits of the porch and the urban surrounding space. It is defined in terms of latitude, orientation, proportions and materials. In a preliminary design stage, the geometric parameters are more important than the material’s effect. Later, to have a more detailed analysis, it is useful to introduce the physical properties of the materials. The
key issue is to balance the requirement of shading with the need of opening to the sky. Thus the first step is to evaluate solar accessibility in different seasons. The influence of external obstructions is assessed in terms of “aspect ratio” (H/W, the height of the building to the width of the open space) during the winter solstice when the sun is lower in the sky and the direct radiation is desirable. It is possible to define the two opposite urban scenes in relation to the solar access: a street canyon completely shaded or a wide open space (as a square) without influence of obstructions.

![Figure 2. Solar accessibility in winter solstice at 45°N latitude in two urban contexts with the aspect ratio of a square (a) or of a street canyon (b)](image)

On solar access and urban geometry, Oke observes that an “H/W of approximatively 0.6 seems to be a suitable upper limit to maintain solar access in a city at a latitude if 45°N” (Oke, 1988). The need of opening to the sky is not only related to the thermal aspect but also to the daylight issue. In previous studies (Littlefair, 2001) it is suggested a spacing angle for temperate climate, that is nearly 35°. In fact, a transitional space in a street canyon tend to lower the sky component of daylight but at the same time the reflective properties of materials could increase illuminance levels due to the diffuse light reflection within the canyon.

<table>
<thead>
<tr>
<th>Sunlight</th>
<th>Daylight</th>
<th>View</th>
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<tr>
<td>on ground (central point)</td>
<td>on workplane (h=0.80 m)</td>
<td>at view level (h=1.50 m)</td>
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![Figure 3. Evaluations and related representations. (e.g. H/D=1 and facade completely glazed)](image)
After the context analysis, the evaluation should focus on the geometrical effect of the porch defined in terms of aspect ratio $H/D$, since it is assumed of infinite length (Fig. 4). The prediction of the sunlight and daylight distribution in the transitional space and in the adjacent interior rooms can be performed using different procedures (e.g. algorithms, nomographs, prediction tools, scale model-measurements and simulation programmes).

A simple graphic way to assess the direct sunlight impact in a point consists in overlaying a sun path diagram of the selected latitude to an obstruction mask properly oriented in a plane projection of the sky vault. Thus, it is immediately visible if the point meets the requirement of being shadowed in summer and not in winter. The unobstructed part of the mask gives also information on visual comfort (changing the reference point height above the ground), evaluating two aspects. On one side, it provides directly the percentage of visible sky from that point as Sky Factor (SF) measured considering a uniform distribution of the sky vault. This parameter is related to the pleasant effect of having a visual link to the exterior and for this reason it is interesting to evaluate it at the eye level of a standing person (1.50 m). On the other side, overlaying a dot chart representing the illuminance distribution of an overcast sky (worst-case scenario) it is evaluated the Daylight Factor (DF, the ratio of interior horizontal illumination to exterior unobstructed horizontal illumination) as a first approximation. In fact, actually, the number of dots in the opening area represents the sky component of the DF, the illuminance received directly from the sky (neglecting in this first stage the reflected light from surrounding surfaces). In this way, for Mediterranean countries, sometimes the amount of natural light can be underestimated because in the southern latitudes there is a high frequency of clear sky conditions and that increases the contribution of radiation reflected from ground. In our case, considering the northern Mediterranean areas with temperate climate (latitude of about 45°N) it is reasonable to consider an overcast sky (in a first stage). Moreover, there are many design parameters, such as surfaces reflectances, window shape and size, and optical properties of the glazing that are unknown by the designer at the early design stages. For reference, a room that has a DF of less than 2% is considered poorly lit while rooms with DF between 2% and 5% are considered ideal for activities that commonly occur indoors.

Using different representation techniques, it is possible to have a more comprehensive description of the parameter values in the space. Especially at the early stages it is very useful for a designer to have simultaneous views (plan, section etc.) of the same object (Fig. 3). In this study the parameters described are calculated with the help of Heliodon 2 (Beckers, 2009), a simple simulation software that allows faster evaluations and multiple view of the same geometry. Other more sophisticated tools (e.g. Radiance) enable more precise assessments but they are much more complex to use and the computation takes longer time, thus they may be of help in a further step of the design process to verify the choices made.

The study model

Figure 4. Configuration of the study model.
The effect of proportions and orientation of the porch on the luminous and thermal performances is evaluated through a study model (Fig. 4) considered representative of possible real cases. The model is located at a 45°N latitude, in an urban context in which external obstructions does not affect solar accessibility (Fig. 2, case a).

It is tested in different hours of the day and in the two seasons with conflicting requirements (summer and winter). The proportions tested are based on the observation of different existing porches and ranges from 0,5 to 2 H/D.

The evaluations are performed using indexes that allow comparisons among different configurations. The percentage of shaded area in summer is evaluated on the ground surface (on the 21st of June at noon) as Shading Factor, while the ratio of sunlight area in winter winter (on the 21st of December at noon) is assessed on the building wall as Sun Factor. The Daylight Factor (actually its sky component as previously explained) is evaluated at a work plane height (0,80 m) while the Sky Factor at the eye level of a standing person (1,50 m).

The building wall is the critical limit on which to evaluate the porch and the effect on the interior space depends on the porch’s geometry and the wall configuration, in particular in terms of both windows size and position in the wall.

Results

Regarding the porch orientation: the more the angle deviates from the east-west axis the more the porch becomes useless for all tested proportions. If the porch is very deep (H/D < 0,5) there is a lack of daylight inside and at least 50% loss of solar gains in winter. This first observation highlights the importance of integrating different aspects in the evaluation process.

Fig. 5 shows the comparison between different aspects ratio integrating the thermal and luminous aspect. Therefore, DF and SF are considered as punctual values on the building façade, the physical boundary that separates the inside to the outside.

Observing the graph, it seems that the aspect ratio of 1 offers the best balance between protection and openness to the sky, with the same percentage of shaded ground in summer and wall exposure to solar gains in winter, with a medium value of daylight and view factor on the building envelope. On the contrary, the extreme cases show that: if the depth is double than the height the only benefit is to have a wide shaded space in summer, while if the porch is too narrow it does not provide a usable space and it is only a solar protection for the building envelope. Of course, as it mentioned before, these analysis do not pretend to give accurate results but they are first evaluations to be integrated with other design features.
CONCLUSION AND FUTURE DEVELOPMENTS

The partial findings presented in this paper are part of a wider research that investigates transitional spaces in relation to human well being with the aim of providing guidelines for an architect in the early design stages. In particular, the importance of the porch as a climatic moderator in temperate Mediterranean latitudes has been clarified. Since environmental potential is well exploited only if it anticipates the human expectations, the method presented makes the effort to integrate different and sometimes contrasting needs especially in terms of daylight and sunlight.

Further evaluations can be performed taking in account other design features. In particular, the material effect is to be investigated: on one side in terms of exterior finishing, taking in account the surfaces' multi-reflectances for a more precise assessment of the illuminance levels and eventually the occurrence of glare; on the other side the thermal effect due to reemission of long-wave radiation.

All the design choices modify the building exterior appearance with consequent effects on multisensory perception and on the integration within the surrounding context, especially in the case of building renewal or in an extremely dense urban context. Resolving all of these questions is a complex issue; therefore, the priorities of a project should be defined in relation to the specific user needs and balanced with the external constraints in order to reach a satisfactory compromise.

REFERENCES