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Architectural and Environmental Compositional Aspect
Technological Innovation in the Built Environment.

Mario GROSSO[1], Giacomo CHIESA[1], Marianna NIGRA[1]
(1) Department of Architecture and Design, Politecnico di Torino, Italy
mario.grosso@polito.it; giacomo.chiesa@polito.it; marianna.nigra@polito.it

Abstract
This paper focuses on the complex relationship between historical building design and projects, both from compositional and environmental points of view. In spite contradictions in their nature, their integration is essential from the very both to improve or efficiently preserve the environmental and architectural qu this work is to define a number of guidelines to support and inform the des and eventually ensuring the quality of the built environment, both aesthetically and environme end, the paper explores the use of climatic and microclimatic analysis as a and sustainability performance of future buildings. In particular, the work microclimatic matrix, as support to the climatic considerations about differe and cooling systems; and to the architectural/compositional approach defin

Keywords: architecture, environment, climate, technology, innovation

1. Introduction
The building sector, excluding industrial buildings, represents almost 40% of total pr consumption in developed countries [1]. This percentage includes energy demand for space heatin cooling, hot water production, lighting, cooking and appliances. In addition, considering the warming effects of the current trend of greenhouse gas emission, the energy consumption for space in several countries [2][3]. Within this framework, a passive approach to building des taking envelop rather than HVAC system as the main environmental control technologies, is crucial for c reducing energy consumption in the building sector. This approach can contribute to curb trend related to carbon emission from energy-dependent space conditioning systems. technologies able to increase the efficiency of building equipment are considered and incentivized legislation, standards, and codes of practice. In addition, passive and hybrid solar gains and mitigating internal gains in summer, solutions for increasing solar gains in winter, are well known even if, especially for cooling, if widespread could decrease drastically, more diffused, the energy for heating and cooling a building. However, to reach much more stringent goals near-zero-energy buildings (NZEB), as set by EPBD 2010/31/EU by 2020, or, even more, th positive-energy building (NPEB), a much stronger effort than currently done to i impact technologies to a sustainable architectural design approach needs t In spite of the scientific progresses achieved in the studies of environmental debate about the aesthetic of sustainability seems to have fallen behind in the profession and the academic. The projects categorized as sustainable are often defined either according to th type of environmental systems and technologies utilised, as well as the architectural design approach. The contemporary examples of sustainable different aesthetic approaches that designers seem to have undertaken. T more literal design solution of environmentally aware buildings, in which t was conceived as a design tool; to the more technology oriented approaches, where environmental artificial systems became expressions of architectural aesthetics. Examp

these approach can be considered: 1) the Jacob House 2 by Frank Lloyd Wright in Middleton, W[isconsin,] United States, built between 1944-1948, in which the incidence of the solar light was lite[rally ...] the building and the floor plan; to the 2) the environmental houses larg[...] technological features were heavily applied to the buildings without much design i[...] more sophisticated example of high tech buildings such as the Centre du Po[mpidou ...] France, built between 1971-1977. The architectural jargon of sustainability seems therefore t[...] the mimetic tendencies of relating to the environment in a literal manne[r ...] sustainability by expressing the efficiency of the technological features. The p[...] integration seems not to be explored or discussed as much. This happens [...] software and tools that can assist the design process, by integrating microc[...] systems and technologies. This paper will explain in the next sections how s[...] 1) offer support to the design process; 2) enhance the integration betw[een ...] technological systems; and 3) contribute to the enhancement of the aesthetic definition of sustainabilit[y].

2. The preliminary design process

According to Nigro and Mancini [4], the delivery process of building projects can be subd[ivided ...] theoretical areas such as: building opportunity generation; building sco[pe ...] production; building erection; building functioning and control. Each of these project definition pha[ses ...] from conception to construction is characterised by a number of instances in which the [...] design choices and technological systems can be critical to enhance the [...] performance of projects. Specifically, this paper will deal with the area of p[reliminary ...] design process, as critical moment to explore the integration between a[...] technological features. Several researchers [5] explained that the earliest involvement of [...] awareness in the design process, the more cost, time, and quality effec[tive ...] Moreover, Gibbs [6&7] together with Cherry [8] pointed out a number of critical aspects to consider during the phases of building design programming and building preliminary design[...] clients need, the building scope and the building characterisation according to regulation program [...] another important part of the preliminary design, the site analysis, represents a critical aspect of in[...] between environmental awareness and architectural design approach. The s[ite ...] wind, light, ground, water, surrounding buildings, and urban regulations, has the potential to drama[tically ...] building orientation, dimensions, interrelation, and localization, as well [...] approach. During the preliminary building design, technical and environmental [...] informing geometry, volumes, colours, construction systems selection, and [...] As the flow chart in Figure 1 shows, the building design program phase [...] compatibility and performance assessment of choices related to the definition of virtual spa[ces ...] result of fulfilment of both functional and environmental requirements. Thes[e ...] determining design objectives, activities to be performed, and user needs as well as laws, standards, and regulation at various scales. On the side, often but not less [...] not considered part of the building programming represents an essential operational for the c[...] compatibility assessment of building design choices.

3. Environmental aspects of the preliminary design

The environmental aspects of the preliminary design process are related to [...] affecting the impacts of the to-be-designed building on the physical context at various spatial scales, ca[...] global, regional, local, and indoor/outdoor as well as temporal, i.e., hourly, daily, running, concer[...] the building and its entire life cycle.

Environmental assessment implies different approaches and methods at di[fferent ...] preliminary design phase, two types of analysis are, generally, considered: envi[ronmental building] programming and site analysis. After a brief description of them, this paper will focus on [...] particular attention to site climate evaluation.

3.1 Environmental building programming

Environmental building programming follows a performance-based approach characterized by a process of analysis and assessment from user needs and activities to requirements, a[...] definition, according to the compatibility (environmental) loop above descri[bed ...] During this process, various tools, such as diagrams, checklists and matrices, can be a[pplied]. Examples of these applications are numerous, but generally they do not deal with environmental [...] [9, 10 & 11].

Fig. 1 Flow-chart of the preliminary design process based on a performance-driven approach (image modified from [6]).

The main actions to be carried out in the environmental building programmi

-reception of the client brief including building design objectives and users needs;
-reception of laws, standards and regulations related to the building type t
-list and classification of activities and relevant environmental requirements;
-analysis of input/output flows related to the activities affecting both the outdoor and indo
-list and classification of functions related to the activities;
-definition of virtual spaces as spatial representations of aggregated functions;
-definition of dimensional (order of magnitude) and environmental requirements of virtual space unit

- aggregation of virtual space units according to their reciprocal linkage characteristics
  compliance to the defined environmental requirements;
- alternative configurations of virtual space layout.

A virtual space does not have physical boundaries but just potential links within and with the external context. These potential links are related to various aspects: geometry, communication, physical phenomena (airflow, daylight, solar radiation). The environmental building programming focuses on some of these aspects, the ones which have an imp as mentioned above.

3.2 Site-climate analysis

The site analysis phase of a preliminary design process concerns various transportation, landscape, socio-cultural issues, town planning, land use, economic value, impacts. Within the latter, climate analysis is aimed at evaluating the potential vocatio site to locate an activity, a virtual space or a building, with regard to thermal comfort as a funct factors such as solar radiation and wind flow [7, 8, 12]. The site-climate analysis uses the site microclimate matrix (SMM) that allows for optimising the location of outdoor activities, space units, i.e., buildings, in relation to thermal comfort. The elaboration method was introduced by two American scientists [21] and modified by Grosso [17]. It allows designers to locate properl to a sustainable and bioclimatic approach the activities/space units defined in the building programming phase described above. SMM can also be used to study the optimal form of buildings urban design by evaluating the influence on exposure/protection to solar radiation and win either for new assets or in a specific existing context.
An SMM is elaborated as a graphic overlay of the output from analyses of shading and airflow dynamics on a lot resulting on a four variable zoning derived from the combination of shaded/sunny and windy/sheltered zones (Fig. 2). This zoning is called a matrix because it is discretized by a norm cells are characterized by one of the four variables. Each cell is then associated to a pot level (see Table 1) in order to assess its vocation as a recipient of activities.
The SMM is built on a virtual plane, which is generally the ground level, but it is possible to different matrixes by changing the height or to create a three-dimensional matrix of the project site. depends on the specific needs; however, three-dimensional analyses require a higher investment in terms of time, cost and computing for three-dimensional CFD software airflow studies. It is advisable to proceed with vertical analysis of the building under design, or retro in order to evaluate the mutual influences between the different façades and buildings

Fig. 2 Example of wind wake core analysis in winter and summer (point 4) for a construction lot in
The airflow analyses were conducted by using the software KARALIT CFD.

Theoretically, SMM changes over time following yearly, daily, and hourly apparent position of the sun in the sky and the seasonal (or monthly, hourly, daily) prevailing wind direction considered. However, SMM, being used as a design parameter, refers to extreme climate conditions a during solstices, in morning and afternoon, and relevant seasonal prevailing … As example, the reference dates for the Boreal hemisphere: 21st December at 10:00 and 14:00, and 21st June at 8:00 and 16:00. It is possible to choose different times being the hottest and the coldest day of the year, estimated by using the typical meteorological year (TMY) of the locality or as general reference July 21st and January 21st at 9:00, 12:00 and 15:00 [12]. When the calculation of shadi… is conducted by using specific software, it is important to pay attention to the correct time definition (local Meridian, reference Meridian, solar hours).

The following steps shall be performed to elaborate a SMM:

1. definition of the context and constraints: surrounding buildings and natural obstacles;
2. discretization of the analysed lot by a normal grid with cells dimensi… (for example, 5x5 m);
3. analysis of solar paths and relevant shading dynamics in different reference days and hours;
4. seasonal analysis of wind wake core (see Figure 2) for different temporal analysis, for example day-night breezes);
5. overlapping of the results from the above analyses (steps 3 and 4) on the grid defined in step 2 in order to classify each cell by a 2x2 matrix of climate conditions (sunny-windy, sunny-calm; shaded windy, shaded-calm); this process is repeated for all considered hours and days (see Figure 3);
6. assigning a score to the four classes identified for the activities considered to each matrix developed in step 5 (see Table 1);
7. construction of four time-reference SMM for each type of activities/functions/space u…

In Figure 2 wind wake core seasonal analysis on a specific lot localized in Melbourne, Australia is reported. The prevalent wind directions are from North in winter (from hills to sea) and from South in summer (from sea to land), and a change in directions occurs daily through breeze regime. These analyses are carried out using the CFD software Envi-Met [13]. Existing building context redu… wind velocity at the ground floor in the East side of the construction lot, c… natural ventilation. At the same time, on the same side, Venturi effect of buildings is evident, … consequent increases in the wind velocities. The barrier position and height could represent an effective solution for reducing this potential discomfort situation.
Wind analyses could be done in different ways: CFD using software, which needs specific aerodynamic knowledge and is time-consuming and costly; wind tunnel simulation, which re… physical model, specific knowledge and a laboratory facility; simplified method based on statistical correlation of wind tunnel test data on geometrical models with different dimensions and varying incidence angle such as the one elaborated by Grosso [17] on the basis of a previous research [14].
The score assigned to each cell of an SMM, as indicated in step 6, is based on a classification of potential outdoor comfort conditions related to types of activities and their metabolic rate, that can be assess on a qualitative scale (Table 1) or using quantitative values

Activities		Season	Relation between site microclimate m… conditions			
			shaded calm	shaded wind	sun-calm	sun-wind
Low metaboli… rate	Stay; wal… around	Winter (cold win…	Unfavoura…	Worst	Optimal	Good
			Good	Worst	Optimal	Unfavoura…
		Summer (high RH)	Optimal	Good	Worst	Unfavoura…
			Unfavoura…	Optimal	Worst	Good
Medium metaboli… rate	Walking slow runni…	Winter (cold win…	Unfavoura…	Worst	Good	Optimal
			Good	Worst	Optimal	Unfavoura…
		Summer (high RH)	Good	Optimal	Worst	Unfavoura…
			Unfavoura…	Optimal	Worst	Good
High metaboli… rate	Run fast; activities	Winter (cold win…	Worst	Unfavoura…	Good	Optimal
			Good	Worst	Optimal	Unfavoura…
		Summer (high RH)	Good	Optimal	Worst	Unfavoura…
			Unfavoura…	Optimal	Worst	Good

Tab 1: A classification of outdoor thermal comfort conditions in relation to the microclimate matrix variable… types of activities.

As an example of a quantitative assessment, a score could be, for a high m
running: in winter, 1 for calm-shaded, 2 for shaded-windy, 4 for sunny-calm, 5 for sunny-windy; in summer, 1
for sunny-calm, 2 for sunny-windy, 4 for shaded-calm, 5 for shaded-windy

3.3 Architectural/compositional implications

The SMM presented above was used as a base for a design atelier conducted in the Master of Architecture (Sustainability) of the Polytechnic University of Turin. The call of the atelier was to de design proposal for a new university building in Melbourne, following the ex Building and planning faculty at The Melbourne University.
In this atelier, the microclimatic analysis was applied to the early stages of the design process, to infor the decision-making process on a compositional level.
As showed in figure 3 and 4, the microclimatic analysis produced a reading of the site that sh of calm (wind and sun) over different time of the year. By analyzing the sit was defined optimizing the volumetric definition of the buildings; shape the volumes; define the internal spatial layout allocation of functions; and determine characteristics of each façade profile (figure 4). This latter allowed the design of a which pattern, shading systems, and glazing features where equally balance and surfaces exposures (figure 6).

Fig 3: Example of calculation of a microclimate matrix for a volume study (students: Mamak P.Tootkabo Danial Mohabat Doost, and Xiaochen Song).

The definition of the volumetric organization allowed the definition and the the design proposed. Figure 5 shows an example of solar exposure analysis in whic mapped according to incidence of the sun on each its part. This analysis decisions on the shading devices design as well as the façade fenestration pattern (fig 6).

Further analysis was also utilised to determine the performance and spe components defined in the project proposal. Specifically, glazing charac ventilated façade and curtain screen were selected for each façade, according the exp characteristics, elaborated in the microclimatic analysis.

Fig4: Example of design process in which the volumetric organization was defined to site, previously explored by the microclimatic analysis (study by Maryam P. Tootkaboni, Danial Mohabat Xiaochen Song).

Fig5: Example of solar exposure analysis on the design proposal for the site (study by Maryam P. Tootkaboni, Danial Mohabat Doost, and Xiaochen Song).

Fig6: Example of design process to establish modules, patterns and shading devic
according to the solar analysis on the façade, climatic case (study by Mamak P.Tootkaboni, D
Mohabat Doost, and Xiaochen Song).

4. Discussion

The use of SMM showed a number of aspects that can enrich the design process
providing design alternatives; 2) the assistance in the definition of technologies and specifications; 3) the
contribution to the selection of the construction systems; 4) ensuring quality thr

1. The ability of providing design alternatives could be referred to the ab
   of volumetric configuration and location within the site; the definition
   relation to the building orientation; the use(s) of the land; the inclusion (o
   natural elements found on site as architectural features; and the
   characteristics as main concept for the overall design approach. Moreo
   can also inform elements of façade design such as the relation betwe
   shading configuration and location; colours and patterns diffusion,
   elements; orientation and type of façade elements.
2. The use of SMM can also assist in the definition of technologies and speci
   the relation between performance required and positions within the b

specific technical requirements and therefore of the required guidelines elements; highlighting the opportunity of innovative design/construction elements or details.

3. The awareness of the microclimatic configuration of a site could assi appropriate construction systems, by means of an accurate analysis of areas of the futur could be design or treated with the use of different construction sys contribute in saving in cost and time by applying the use of eco-constructi Moreover, the results of a microclimatic analysis could as well info construction systems.
4. The ability of designing buildings that embed the site-specific conditions can also contribute better conditions throughout the life span of the building itself. Not only architec more effective choices in terms of construction systems, and technolo of sustainability over time.

Fig 7: The image shows the design parameters that can be informed by the use of microcl of the design process and delivery. Above the blue band the design process is characteristics. Below the blue band the parameters that can be enrich/integrated by the use of -climatic analysis are listed for each phase of the design process.

Figure 7 summarizes a number of parameters that can be modified and informed by the use o analysis throughout the design process and delivery. In the image the design process is descr phases and related to all the design parameters that can be used. The ability of relating the use of a site-climate analysis, design phases and design parameters represents that can be applied through all the phases of projects delivery. This me considering technical parameters, and optimizing design solutions, without impinging on the design process, which instead informed on a number of potentials. Moreover, this des methodology could assist the development of requirements and specifications for each technical elemen support the testing of the quality of design and their optimization.

5. Conclusions

Environmental building programming and site-climate analysis can provide designers and ar ability of open an informed discussion on the role of design within the sust Having a number of design alternatives directly informed by the environment a new architectural language that could gather the approaches that have been taken so fa architecture until now, and implementing them toward an integrated languag This language could potentially produce a variety of buildings that not only minimize energy consumption or resources depletion, but that are able to express the identity of those environmental and technological approach to design, driven by a performance approach since the preliminary design phase, is essential for considering these issues in the design compositional solutions and suggesting possible optimization procedures.

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