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Architectural and Environmental Compositional Aspects of Technological Innovation in the Built Environment.

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Abstract

This paper focuses on the complex relationship between historical buildings and modern projects, both from compositional and environmental points of view. In spite of contradictions in their nature, their integration is essential from the very beginning both to improve and efficiently preserve the environmental and architectural quality. The aim of this work is to define a number of guidelines to support and inform the design process and eventually ensuring the quality of the built environment. For this purpose, at the end, the paper explores the use of climatic and microclimatic analysis as a tool to improve and sustainability performance of future buildings. In particular, the work explores the use of a microclimatic matrix, as support to the climatic considerations about different heating and cooling systems; and to the architectural/compositional approach defining

Keywords: architecture, environmental technology, innovation

1. Introduction

The building sector, excluding industrial buildings, almost 40% of total primary energy consumption in developed countries [1]. In this stage, the demand for space heating and cooling, hot water production, lighting, cooking and other energy-consuming activities is increasing. In addition, the warming effect of greenhouse gases, the energy consumption for space heating and cooling in several countries [2,3]. Within this framework, a passive approach to building design, taking envelope rather than HVAC system as the main method, is seen as an effective way to reducing energy consumption in the building sector. This approach can contribute to curb the trend related to carbon emissions from air conditioning systems. In addition, technologies able to increase the efficiency of energy consumption are encouraged by legislation, standards, and codes of practice. In addition, passive design solutions and mitigating interventions are solutions for increasing solar gains in winter and reducing cooling loads, especially for non-cooled buildings. However, to reach much more stringent goals, near-zero energy buildings (NZEB), as defined by the EU Directive 2010/31/EU by 2020, or, even more, the positive energy building (PEB), a much stronger effort than currently done to impact technologies to a sustainable architectural design approach needs to be taken. In spite of the scientific progresses achieved in the studies of environmental design, the debate about the aesthetic of sustainability seems to have not yet reached an academic level. The projects categorized as sustainable are defined either according to the type of environmental systems and technologies utilised, as well as the architectural design approach. The contemporary examples of sustainable buildings represent different aesthetic approaches that designers seem to have undertaken. The more literal design solution of environmentally aware buildings, in which the building was conceived as a design solution, the more technology oriented approaches, where environmental artificial systems became explicit in the design. An example

these approach can be considered: 1) the Jacob House in Framingham, Massachusetts, United States, built between 1943 and 1944 which the incidence of the solar light was lit the building and the floor plan; to the 2) the environmental houses large technological features heavily applied to the buildings without much design more sophisticated example of high tech buildings such as the Centre du Po France, built between 1971 and 1977. The architectural sustainability seems therefore to the mimetic tendencies of relating to the environment in a literal manner sustainability by expressing the efficiency of the technological features. The integration seems not to be explored or discussed as much. This happens software and tools that can assist the design process, by integrating micro systems and technologies. This paper will explain in the next sections how s 1) offer support to the design process; 2) enhance the integration between technological systems; and 3) contribute to the development of sustainability.

2. The preliminary design process

According to G[66] and M[47] the delivery process of building projects can be subdivided into theoretical areas such as: building opportunity generation; building scope production; building erection; building functioning and performance. The process 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 preliminary design process, as critical moment to explore the integration between a technological features. Several researchers explained that the earliest involvement of awareness in the design process, the more cost, time, and quality effects. Moreover, G[66] together with C[78] pointed out a number of critical aspects into the phases of building design programming and building preliminary design. Clients need, the building scope and the building design integration are another important part of preliminary design analysis presents a critical aspect of integration between environmental awareness and architectural design approach. The sun, wind, light, ground, water, surrounding buildings, and their potential to dramatic building orientation, dimensions, interrelation, and localization, as well as design approach. During the preliminary building design, technical and environmental performance informing geometry, volumes, colours, construction systems selection, and materials. As the flow chart in Figure 1 shows, the building design program phase compatibility and performance assessment related to the definition of virtual space result of fulfilment of both functional and environmental requirements. These determining design objectives, activities and performance indicators as laws, standards, and regulation at various scales. On the side, but not less not considered part of the building process is the essential operation for the 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 building on the physical context spatially, globally, regional, local, and indoor/outdoor as well as temporally, during construction, the building and its entire life cycle.

Environmental assessment implies different approaches and methods at different preliminary design phases. Two types of analysis are, generally, considered: environmental programming and site analysis. In the first description, this paper will focus on particular attention to site climate evaluation.

3.1 Environmental building programming

Environmental building programming follows a process of analysis and assessment from user needs and activities to requirements, a definition, according to the compatibility (environmental) loop above described. During this process various tools such as diagrams, checklists and matrices can be applied. These applications are numerous, but generally they do not deal with environmental

Fig. Flowchart of the preliminary design on a performance-based design (image modified) from [

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

- reception of the client brief including building design objectives and users
- reception of laws, standards and regulations related to the building type
- list and classification of relevant environmental requirements
- analysis of input/output related to the activities and the indoor and outdoor
- list and classification of functions related to the activities;
- definition of spaces as spatial representation of functions
- definition of dimensional (order of magnitude) and environmental space unit

- aggregation of virtual space units their reciprocal linkage characteristic compliance to the defined environmental requirements
- alternative configurations of total

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

3.2 Site climate analysis

The site analysis phase of a preliminary design process concerns various transportation, landscape, social issues, and use, economic value, impacts. Within the latter, the main aim is at evaluating the potential vocation of a site to locate a particular activity, with regard to thermal comfort as a function of factors such as solar radiation and wind. The data on a site climate analysis is a microclimate matrix (SMM) that allows for optimising the location of outdoor activities, space units, i.e., buildings to thermal comfort. The data on a site climate analysis was introduced by two American scientists [1] and [2] and [3] and [4] and [5] and [6] and [7] and [8] and [9] and [10] and [11] and [12] and [13] and [14] and [15] and [16] and [17] and [18] and [19] and [20] and [21] and [22] and [23] and [24] and [25] and [26] and [27] and [28] and [29] and [30] and [31] and [32] and [33] and [34] and [35] and [36] and [37] and [38] and [39] and [40] and [41] and [42] and [43] and [44] and [45] and [46] and [47] and [48] and [49] and [50] and [51] and [52] and [53] and [54] and [55] and [56] and [57] and [58] and [59] and [60] and [61] and [62] and [63] and [64] and [65] and [66] and [67] and [68] and [69] and [70] and [71] and [72] and [73] and [74] and [75] and [76] and [77] and [78] and [79] and [80] and [81] and [82] and [83] and [84] and [85] and [86] and [87] and [88] and [89] and [90] and [91] and [92] and [93] and [94] and [95] and [96] and [97] and [98] and [99] and [100].

An SMM is elaborated graphically over a plot of the site, showing the resulting on a four variable zoning derived from the SMM. This zoning is made of cells characterized by one of the four variables associated to a potential level (see Fig. 1). In order to assess its vocation as a recipient of activities. The SMMs built on a virtual plane, what is possible to do is to create a three-dimensional matrix of the site. This depends on the specific needs, however, three-dimensional models require a higher investment in terms of time, cost and complexity. The regional CFD models of a few studies are advisable to proceed with a preliminary design, or retro-analysis in order to evaluate the mutual influences between buildings.

Fig. Example of wake core analysis 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 daily, and hourly variations of sky sun and season (can monthly, hourly), prevailing wind directions etc. However, SMM, being used as a design parameter, is needed to determine climate conditions during solstices month and afternoon, and relevant seasonal prevailing example, the reference date is chosen as 21 December at 10:00 and 21 July at 8:00 and 16:00. It is possible to choose any date from the hottest and coldest of the year, estimating the typical meteorological conditions in general reference July at 12:00 and 15:00. When the calculation of shading is conducted by specific software, important to be noted is the 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 building and obstacles
 2. discretization of the analysed lot by a normal grid with cell dimensions (for example, 5x5 m);
 3. analysis of solar path and dynamic differences between days and hours;
 4. seasonal analysis (see Figure 2) for temporal analysis, for example (night freezes);
 5. overlapping of the results from the analysis (step 3 and 4) on the grid defined in order to classify by a 2x2 matrix conditions sunny wind sunny calm; shaded wind shaded calm; this process is repeated for each grid cell (see Figure 3)
 6. assigning a score to the four conditions for each cell of the matrix developed in (step 5);
 7. construction of the SMM for each type of activities/functions/space use

In Figure 2 wind wake core seasonal analysis is shown in a simplified manner. The prevalent wind directions in the winter (from hills to sea) and summer (from sea to land) and a change in directions occurs during the day. These analyses were done using the CFD software. The building context reduces wind velocity at the ground floor in the East side of the construction lot, causing natural ventilation. At the same time, on the same side, near the entrance, consequent increases in the wind velocity are observed. The approach is to highlight represent an effort to improve the potential comfort situation. Wind analyses could be done in different ways: CFDs of which need specific aerodynamic knowledge and consuming and by using tunnel simulation, which requires physical model, specific knowledge and laboratory facilities. The method based on statistical correlation of wind tunnel test data are also used. The incidence angle increases the one by a factor of 5 on the basis of a previous research [1]. The score assigned to each cell of an SMM, as indicated in the table, is a step potential of comfort conditions related to types of activities that can be assessed on a qualitative scale (Table 1) or using quantitative values.

Activities		Season	Relation between site microclimate conditions			
			shaded calm	shaded wind	sunny calm	sunny wind
Low metabolic rate	Stay; walk around	Winter (cold wind)	Unfavourable	Worst	Optimal	Good
		Summer (high RH)	Good	Worst	Optimal	Unfavourable
Medium metabolic rate	Walking slow running	Winter (cold wind)	Unfavourable	Worst	Good	Optimal
		Summer (high RH)	Good	Optimal	Worst	Unfavourable
High metabolic rate	Run fast; activities	Winter (cold wind)	Worst	Unfavourable	Good	Optimal
		Summer (high RH)	Good	Optimal	Worst	Unfavourable

Tab1: A classification of outdoor thermal environment as a 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, 2 for windy, 3 for sunny, 4 for cloudy, 5 for rainy, in summer, 1 for sunny, 2 for cloudy, 3 for windy, 4 for rainy, 5 for calm.

3.3 Architectural/compositional implications

The SMM presented above was used as a design research tool in the Master of Architecture (M.Arch) program at the Polytechnic University of Turin. The call of the atelier was to design a proposal for a new university building in Melbourne, following the existing building and its faculty at The Melbourne University.

In that sense, the microclimatic analysis was an important step in the design process, to inform the decision-making process on a compositional level.

As shown in Figure 3, the microclimatic analysis produced a reading of the site that showed a high level of calm (wind and sun) over different time of the year. By analyzing the site, the design team defined optimizing the volumetric definition of the building, shaped the volumes; define the internal spatial allocation of functions; and determine the characteristics of each facade (figure 6). This latter allowed the design of a building which pattern, shading systems, and glazing features were equally balanced and surfaces exposed (figure 6).

Fig3: Example of calculation of a microclimate for a volume (studied by Madyak P. Tootkabon, Danial Mohabat Doost, and Xiaochen Song).

The definition of the volumetric organization allowed the definition and the design proposed. Figure 4 shows an example of solar exposure analysis in which the building is mapped according to incidence of the sun on each its part. This analysis informed decisions on the shading devices design as well as the facade performance (figure 6).

Further analysis was also utilised to determine the performance and specific components defined in the project proposal. Specifically, glazing characteristics and ventilated facade screen were selected for each facade, according the experimental characteristics, elaborated in a thermal analysis.

Fig4: Example of design process in which the volumetric organization was defined to site, previously explored by the mi (studying by Mamaky F. Tootkaboni, Danial Mohaba Xiaochen Song).

Fig5: Example of solar exposure analysis on the de (studying by Mamaky F. Tootkaboni, Danial Mohabat Doost, and Xiaochen Song).

Fig6: Example of design process to establish modules, patterns and shading devices according to the solar analysis on the facade, the case study is by the architect P. Tootkaboni, D. Mohabat Doost, and Xiaochen Song).

4. Discussion

The use of SM showed a number of aspects that can enrich the design process: 1) providing design alternatives; 2) the assistance in the definition of the facade elements; 3) contribution to the selection of the construction systems; 4) ensuring quality through the

1. The ability of providing design alternatives could be referred to the ability of volumetric configuration and location within the site; the definition of the relation to the building orientation and use of the land; the inclusion of natural elements found on site as architectural features; and the characteristics as main concept for the overall design approach. More can also inform elements of facade design such as the relation between shading configuration and location; colours and patterns diffusion, elements; orientation and type of facade elements.
2. These of SM can also assist in the definition of technologies and specify the relation between performance required and positions within the building.

- specific technical requirements and therefore of requiring design elements; highlighting the opportunity to investigate elements or details.
3. The awareness of the microclimatic configuration of a site could assist appropriate construction systems, by a detailed analysis of areas of the future could be design or treated with the use of different construction systems contribute in saving in cost and time by applying the use of construction. Moreover, the results of a microclimatic analysis could as well inform construction systems.
 4. The ability of designing buildings that fit the conditions of the site can also contribute to better conditions the life span of the building itself. Not only architects more effective choices in terms of construction systems, and technology of sustainability over time.

Fig7: The image shows the design parameters that can be informed by the use of microclimatic analysis throughout the design process and delivery. Above the blue band the design process is characterized. Below the blue band parameters that can be enriched/integrated by the use of microclimatic analysis are listed for each phase of the design process.

Figure 7 summarizes a number of parameters modified and informed by the use of microclimatic analysis throughout the design process and delivery. The design process is described in phases and related to all the design parameters that can be enriched/integrated by the use of microclimatic analysis, design phases and design parameters that can be applied through all the phases of projects delivery. This method

considering technical parameters and optimizing design solutions, without impinging on the design process, which instead informed on a number of potential paths. This methodology could decrease the time of specific uses for each technical element and support the test and refinement of design and the optimization.

5. Conclusions

Environmental building programming analysis can provide designers and an ability of open an informed discussion on the role of design within the sustainable. Having a number of design alternatives directly informed by the environment, a new architectural language that encompasses approaches that have been taken so far in architecture until now, and implementing them toward an integrated language. This language could potentially produce a variety of built environments that contribute to resources depletion, but that are able to express the identity of those environments. An environmental and technological approach to design, in a preliminary and preliminary base, is essential for considering these issues in the design of compositional solutions and suggesting possible optimization procedures.

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