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# **TECHNOLOGICAL DESIGN**

## THE INNOVATION IN THE METHOD

Cesare Sposito  
Antonella Violano



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Cesare Sposito and Antonella Violano

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On the Book Cover: *The Jean-Marie Tjibaou Cultural Center in Nouméa (New Caledonia): Sketch of the natural ventilation scheme (Renzo Piano Building Workshop, 1991-1998).*

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This volume presents very interesting reflections on the centrality of Design in the discipline of Technology of Architecture and on the need to adapt the design method to the innovation of thought implemented by the research world. The theme of the Innovation in the Method of Technological Design is an interesting challenge that in this volume has been addressed considering the complexity of the levels of thematic depth, opening up to critical reflections, proposals for tools and illustration of case studies that show the breadth, relevance and multidimensionality of this issue.

We need a premise. The era of digital and information technology have significantly influenced the way of doing and thinking in architecture and this evolution of design thinking takes on different connotations in training or professional practice. In the volume, it is transversally observable as the degree of innovation is to be found in the contents (ideas, techniques and procedures), as well as in the tools. In fact, the volume talks about BIM and the potential of advanced digital design, which is a global priority for the development of a new design paradigm.

The need to adapt the design method to the innovation of thought, carried out and encouraged by the world of research, obliges us to rethink the existing contents and training paths that must generate it and to privilege the didactic experiences in which the traditional procedure (frontal teaching, individual study, profit examination) is passed.

As Vice-Director of Students and International Relations at the Polytechnic University of Madrid, I am currently experimenting with the usefulness of exchanges of experience between teachers and students from different schools of thought. The fertile ground for meeting is always the Scientific Research that stimulates experimentation also in teaching, which qualifies learning, both from a disciplinary and methodological point of view. For this reason, scientific research is certainly an important fulcrum of the training process.

Enhancing and encouraging the ability to deal with usual curricular content in an innovative way, with an integrated interdisciplinary approach, is certainly a winning choice,

especially if it is attentive to the specific needs of the labour market.

Since the labour market rewards those who demonstrate their ability to control the design process with creativity and predictability, concreteness and feasibility, sensitivity and respect for the transforming environment, the book proposes the centrality of the technological project, based on a technical culture, since it is able to guarantee the correct use of resources and an appropriate management of the transformation process. New paradigms of regenerative architecture, 'cradle to cradle' approach that leads the architectural organism in the 'effective' vision of the biological and technological cycle and need to respect with the project the threshold of resilience of the environmental system that hosts it, are all very interesting points of reflection that lead to the change.

The book says: «The real value of change is given by the ability to be innovative and not just improving» and this assertion leads to the renewed value of the innovation of thought with which technicians are called to design. The methodological approach to the design of shelters in archaeological sites, building with water, materials and instruments for digital production in architecture are interesting design experiments wisely described.

Finally, I want to congratulate Authors for the excellent work done. This volume captures these elements of European vision perspective of the technological project and addresses the subject with important theoretical contributions and educational experiences conducted with innovative method, providing an important picture of the problems and perspectives of a very near future.

I believe that the development of such a debate can also lead to useful contributions to the development of technological thinking.

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## INTRODUCTION

This volume presents some reflections on the centrality of Design in the discipline of Technology of Architecture and on the need to adapt the design method to the innovation of thought implemented by the research world. Starting from the observation of the declaratory of our scientific disciplinary sector, the scientific and didactic-training activity in the field of Technological Design of Architecture primarily concerns tools, methods and techniques for the design of architecture at different scales as well as the techniques of transformation, construction, maintenance, recovery and management of the natural and built environment, with reference to aspects related to the technological design of architectural works in the perspective of a demanding and performance approach of artifacts and building heritages. The creative phase of the technical conception is related to the constructive conception of the works and the innovation and technological experimentation are strongly oriented to social, economic and environmental sustainability.

In this assumption, the centrality of the project is evident, as well as the centrality of the user whose needs the project must give a satisfactory response. As in the need-performance approach, which is the foundation of the technological method, the trio of actors in the design process are: the users who dictate the needs, the laws that provide the requirements and the designers who interpret laws and needs by choosing materials, integrating components and creating building organizations, neighborhoods and cities, with multi-scalar logic. In this process, the designer technician is the actor to whom all the attention should be paid.

In fact, the Human capital is fundamental in the process of social growth and production of quality work. Lisbon strategy gives the human capital a central role in the process of social growth to which only scientific research can significantly contribute. Therefore, the didactic activity must be indissoluble from the research activity. No learning path can be considered highly qualified if high competency is not used, besides

a punctual transfer of didactic contents, which will manage to maximize the learning process working not only on contents but also on competence.

University, as an institution charged with promoting scientific research, progress of science and higher education, trains and informs, throwing the seed of knowledge, awareness and professional responsibility. The well-known Endecalogue of training in architecture maintain a balance between theoretical and practical aspects and guarantee the acquisition of the following knowledge, skills and competences. In order to evaluate the contextualized and participatory quality of the didactic experience, a series of so-called Congruency indicators are proposed, which analyze and restore the framework of relationships and synergies between the training system (topics, methods and tools) and the receiving human capital (aims, needs, resources, technologies and skills). The centrality of the user/student is the adopted rewarding strategy.

Design, considered by someone as a 'product' and by others as a 'process', is first of all a 'place' where several equal, multi-scalar, interdisciplinary instances compete, whose specialist contributions reveal to be integrated contributions. Designing means 'being able to choose' and the complex development mechanisms of design ideas must know how to respond to a demand that has evolved/renewed towards higher and higher performance standards in the meanwhile. Considering the changes made in recent years in regulatory tools and the increasing level of performance demanded by the market in the construction sector, in terms of high performances rendered at the lowest cost in established times, the quality management is a mandatory requirement.

The role of technology has undergone a structural evolution, passing from being perceived as a service discipline for the architectural design to a supporting column that allows to respond appropriately to the regulatory requirements, fully satisfying the direct user's needs and with the design of eco-oriented highly performing systems and components. In this panorama of raising requirements, technological research must define a new formal and performing paradigm where the correct use of resources, the reduction of emissions and the shortage of energy needs (and non-renewable resources generally) are not a limit to development, but an opportunity for growth and experimentation. The performative method and the regenerative approach open new frontiers to technological design. The creative vitality expressed by the younger generations, validly reactive towards a different methodology of production of the project oriented to Regenerative Architecture, validates the thesis that the support of Scientific Research can be extremely significant in a didactic path, where the scientific knowledge is structured to orient, qualify and substantiate the teaching, both on the level of disciplinary content and on the methodological one.

The design constraints strictly aimed at Possible Quality have given rise to didactic experiments of considerable scientific interest, some of which are reported in this volume. The theme of Possible Quality, at the base of the didactic method oriented to training technicians prepared to manage the professional problems required by the market, is also the basis of the professional practice that is confronted with the different levels of feasibility every time it is called upon to make choices. The professional choices mainly concern two macro types of work: the project of the new building and the requalification of

the existing one, which assumes characteristics of cultural and historical-artistic complexity in the moment in which it concerns the cultural heritage.

Within the scientific debate on the conservation of Cultural Heritage in general and Archaeological Heritage in particular, due to its twofold nature (material and immaterial) and consistently with the interest taken by Technological Culture in the importance of those aspects in the process crucial for their proper development and broad enjoyment, this volume proposes an evaluation model to understand ‘what’ to preserve and ‘why’ for a sustainable development, even before considering ‘how’ to do so, allowing a clearer reading and an easier interpretation of the complex relationships existing between the archaeological pre-existences, the natural environments and the added anthropic systems. The offered evaluation model can guide operators towards a conscious sheltering planning with an architectural value, promoting the identification of the morphological, typological and technical-constructive solutions most suitable to return the potential significance of the Asset.

However, from a professional point of view, more and more attention is being paid to environmental and energy aspects. Conscious that a photovoltaic panel does not determine the energy efficiency of a building or a system of recovery and collection of rainwater does not make it environmentally sustainable and regenerative, in professional practice the integrated approach is the most skillful response to the management of the architectural project regenerative, in which the building coevolves with its environmental surroundings by transforming light, wind and water into immaterial matter of Design. Within an increasingly consolidated architectural practice aiming at environmental sustainability and energy self-sufficiency, the volume reports international research and experiments carried out on water-architecture. Furthermore, it highlights how, starting from the excellent capacity of the fluid to heat and cool its surrounding space, we can think to water as a material component of architecture.

Finally, attention must necessarily be paid to the tools of the design process. If it is essential that they are learned during university training, it is imperative to manage their potential in professional practice. One paragraph describes tools and materials available today for digital manufacturing in architecture, offering a wide overview of 3D printing techniques and how it could revolutionize the construction world with important come back and not only technical ones. From the concept of mass customization to the creation of the Fab Lab, a prototype platform which provides affordable and economical manufacturing tools, from Contour Crafting to D-Shape technology and to the WASP project, we are witnessing a radical rethinking of the architectural process, but also a continuous research on natural, sustainable and ‘programmable’ materials. The interest that the volume can arouse in identifying methods, tools and procedures for technological design in the various illustrated experiments, is not limited to the analysis of specific cases, even if significant, but it turns the attention to the wider discussion on innovation of thought to which we are called as teachers and as operators in the construction sector.

«The mission of Architects is to transform the environment in which man lives and works in order to make it more appropriate for the performance of his activities. However, both man and environment, tools and resources are placed in the same complex and dynamic reality, and any transformation, any intervention has an impact on the surroundings, sometimes creating adverse reactions, sometimes unexpected or uncontrollable results. The Technology, understood as ‘study of applied sciences related to the transformation of matter into objects useful to man’, institutionally involves a fairly wide area of this field of relations of cause and effect, because only through this kind of knowledge is it possible to control the processes of transformation».

(Pierluigi Spadolini, 1974)

# SCIENTIFIC RESEARCH AS CORE OF THE TRAINING PROCESS

## ABSTRACT

*Human capital is fundamental in the process of social growth and production of quality work. Lisbon strategy gives the human capital a central role in the process of social growth to which only scientific research can significantly contribute. Therefore, the didactic activity must be indissoluble from the research activity. No learning path can be considered highly qualified if high competency is not used, besides a punctual transfer of didactic contents, which will manage to maximize the learning process working not only on contents but also on competence. University, as an institution charged with promoting scientific research, progress of science and higher education, trains and informs, throwing the seed of knowledge, awareness and professional responsibility. The well-known Endecatalogue of training in architecture maintain a balance between theoretical and practical aspects and guarantee the acquisition of the following knowledge, skills and competences. In order to evaluate the contextualized and participatory quality of the didactic experience, a series of so-called Congruency indicators are proposed, which analyze and restore the framework of relationships and synergies between the training system (topics, methods and tools) and the receiving human capital (aims, needs, resources, technologies and skills). The centrality of the user/student is the adopted rewarding strategy.*

## KEYWORDS

*Lisbon strategy, endecatalogue, knowledge, skills, competences*

Enhancement of the Knowledge Society, strengthening of Human Capital and Lifelong Learning are the keywords of the European 2020 strategy aimed at training technicians who must be more resilient in order to be less vulnerable to changes in work organisation, able to work within a complex network of multi-disciplinary and multicultural relationships. In a system governed by economic rules in which knowledge plays a central role, human capital becomes a fundamental resource of the productive system. Human resources require increasingly specialised and up-to-date skills, the ability to manage complex situations and the ability to interact with people in multicultural contexts.

Human capital is fundamental in the process of social growth and production of quality work. Lisbon Strategy gives the human capital a central role in the process of social growth and it gives learning the function of essential tool in the management of both human sources and work qualification. In this scenario, the support from the Scientific Research world can be extremely meaningful for a didactic path, where the scientific knowledge is structured to orientate, qualify and substantiate teaching, both on the disciplinary contents level and on the methodological one. Therefore, the scientific support is

configured not only under the pedagogic profile, but also above all as a support structured to acquire specific knowledge/competence. This is to favour the most rightful and complete acquaintance of knowledge gained and scientifically tested by experts of the sector, who, as professors, can transfer their theoretical knowledge, practical experiences and specialist disciplinary skills. This was the format of the Workshop 'NA\_est: effettocittà being vs. transiting', in which the potentialities of design methodologies emerged during the PRIN research were tested on a pilot area with students and PhD students and it was the opportunity to offer to public and private stakeholders, tools and specific indications for the implementation of recovery interventions (Amirante, 2008).

Therefore, the didactic activity must be indissoluble from the research activity, because scientific research could significantly contribute to the development of didactic process. In fact, the outcome of research, i.e. scientific knowledge is capable of orienting, qualifying, and substantiating teaching, regarding, on the one hand disciplinary content, and on the other hand methodological approach. Furthermore, scientific research is valuable per se, in that it allows the researcher to acquire in most effective way specific knowledge/competence. The researcher/trainee best assimilates this kind of knowledge; therefore, it is most complete. In addition, whenever research is guided by specialist scholars, such as it occurs with faculty members in Higher Education Institutions, extra benefit is involved thanks to contribution also of the scholars own theoretical background, practical experience and disciplinary skills.

The value of scientific knowledge, structured to orient, qualify and substantiate teaching, both on a disciplinary and methodological level, is proven worldwide. The traditional paradigm of education, based on the standardized approach with classroom lessons and final test on the acquired knowledge to be passed or a proficiency exam during which graphic-descriptive elaborations are debated, has been changed into a more efficient educational model. The scientific support is configured not only from a pedagogical point of view, but above all as a structured support for the acquisition of specific knowledge/skills. The higher the level of quality obtained, the more rigorous and frequent is the use of supports and contributions based on scientific studies, not only experimental and applied, but also coming from basic research.

Learning based on Scientific Research and so supported by university system and public and private research centres is an essential and qualifying tool. It is the only one able to give a real added value to the different methods of communication and transfer of knowledge, and substantiate them of innovative, updated contents suited to the different needs of dialogue among the actors, who intervene in learning path. The higher is the quality level obtained the more rigorous and often is the use of supports and apports based on scientific, experimental and applied studies. No learning path can be considered highly qualified if high competency is not used, besides a punctual transfer of didactic contents, which will manage to maximize the learning process working not only on contents but also on competence.

**We throw the seed of knowledge** – University, as an Institution charged with promoting scientific research, progress of science and higher education, trains and informs,

throwing the seed of knowledge, awareness and professional responsibility. In almost all cases, the latest-generation approach focused on Customer Satisfaction has ensured that the training design in the various syllabus are structured so that the students and all the external partners' needs, directly and indirectly involved (stakeholders), are identified and changed into requirements that the training offer must satisfy. This pays particularly attention to the specific needs of the labour market, analysed and monitored both through local authorities, firms and professional offices' opinions (that can be defined as the natural area of employment) that stipulate stage agreements, curricular or extra-curricular internships with Universities, and through consultations made by Universities, at National and International level, with organisations representing the production of goods and services (firms and associations) and professions (professional orders). This is because the trainee must be ready immediately after graduation to enter a European labour market at least, if not a global one. As a matter of fact, «the acquisition of professional knowledge is directed to the inclusion of the graduate in the labour world and the operation of the related professional activities, regulated, in compliance with the provisions of the law and the European Union, [...] with particular reference to the evaluation of training needs and professional opportunities».<sup>1</sup>

The freedom of movement and practice of the profession in the EU single market is, in fact, an important achievement. To this end, the EU has established rules that facilitate the recognition of professional qualifications (for example for doctors or architects) and Directive 2013/55/EU helps to evaluate if the new National professional requirements are necessary and balanced to ensure a consistent and a homogeneous approach. In accordance with Article 41 of Legislative Decree 15/2016 (the implementing legislative decree of Directive 2013/55/EU which constitutes the most recent regulatory act including the well-known Endecatalogue of Council Directive 85/384/EEC), training in architecture «[...] must maintain a balance between theoretical and practical aspects and must guarantee, at least, the acquisition of the following knowledge, skills and competences: a) an ability to carry out architectural designs that satisfy both aesthetic and technical requirements; b) an adequate knowledge of the history and theories of architecture as well as the related arts, technologies and human sciences; c) a knowledge of the fine arts as factors that can influence the quality of architectural design; d) an adequate knowledge about urban design, planning and techniques applied in the planning process; e) an ability to understand the relationships between men and architectural works and between architectural works and their environment, as well as an ability to understand the need to adapt architectural works and spaces to one another, according to human needs and scale; f) an ability to understand the importance of the profession and the functions of the architect in society, particularly by developing designs that consider social factors; g) a knowledge of the methods of investigation and preparation of the design project; h) a knowledge of structural design, constructional and civil engineering problems associated with building design; i) an adequate knowledge of physical problems and technologies as well as the function of buildings, in order to make them comfortable indoor and protect them against climatic factors, in the context of a sustainable development; l) a technical skill that allows the design of buildings that satisfy the users' requirements, within

the limits imposed by the cost factor and building regulations; m) an adequate knowledge of the industries, organisations, regulations and procedures necessary to carry out building designs and for the integration of plans into an overall planning».

This approach, of Vitruvian memory, refers to point i), as the only integration with respect to the Endecatalogue of Directive 85/384/EEC (which truly in point e) spoke about architectural creations rather than works), the term «in the context of sustainable development» (introduced by Directive 2013/55/EU) which denotes the need of a training strongly focused on architecture, but environmentally conscious. The proposed vision is systemic and the real innovation consists in changing monothematic communication (e.g.: energy efficiency, environmental compatibility, etc.) into integrated and transversal communication, aimed at managing the complexity of interdisciplinary and intersectoral topics. The innovative approach for the design management (particularly the technological one) must firstly highlight the implications of all the environmental, social and economic aspects that contribute to define the problem and its potential solutions, but that can also borrow methods and processes from other disciplines that do not belong to those ones of the design itself, but that reveal similar aims (Perriccioli, 2017).

These aims are not accidental; they come from complex design thoughts that wisely combines compositional knowledge with constructive knowledge, orientating the choices based on the resources available, the requirements expressed, the eco-compatibility of the proposed transformations and the operation effectiveness. The topic can be faced according to both eco-cultural and eco-social and eco-aesthetic approach. This moves the architectural debate into the sphere of metaphorical and paradigmatic values (far from the logics of simple energy efficiency, environmental protection, technological innovation), but utopically connected with ecological awareness and resilient intelligence, an antidote to modernism and materialism (Goleman, 2009).

The International research panorama on this topic offers very interesting insights. As an example, the focus varies from analysing the thermal behaviour of a technical element such as a brick, applying the bio-mimetic approach (Mirajkar and Agrawal, 2018), to the conscious transposition of natural biological processes to the artificial world (Benyus, 2002; Fournier, 2018), ‘mimicking’ the mechanisms that govern nature, which manifestly occur according to the three levels: how it is done; how it lives; how it interacts. Valorising and encouraging the ability to deal with usual curricular contents (not only in the topics, but also in the didactic approaches sustained by scientific research), in an innovative way, and underline the opportunity to apply the protocols of a discipline to another one, in a perspective of integrated interdisciplinarity, could be a winning choice. The added value deriving from a training design made in these terms is given both by finding out the evidence that these strategies are feasible, and by the possibility to define Best Practices. Therefore, we propose an interesting and alternative vision of innovation, with specific indicators that positively evaluate the didactic experiences that introduce new and original contents, whose value for the development of specific and transversal knowledge and competences is high (Losasso, 2011). The experiences that, from the trainee’s point of view, analyse the most meaningful factors for understanding the reality, where he must operate, are valued, but he also has an added value of no minor impor-

tance, linked with the parallel construction of ‘citizenship’ (Cirafici et alii, 2015), which is nothing more than the citizen’s awareness of being part of a community, he evolves with, he acts ‘well’ for and where he must be an active, unique, important but not essential part: that is the training of a fully proactive citizen.

Moreover, the training actions, which use both the new technologies of the information society in a functional, conscious and critical way, and experimental methodologies based on scientific research and functionally involve actors and institutions external to the university (stakeholders), are rewarded, possibly in a European dimension. In order to evaluate the contextualised and participatory quality of the didactic experience, a series of so-called Congruency Indicators are proposed, which analyse and restore the framework of relationships and synergies between the training system (topics, methods and tools) and the receiving human capital (aims, needs, resources, technologies and skills). From the regulatory point of view, a system of Accreditation (see Art. 5, Paragraph 3) of Degree Courses was structurally introduced in Italy with the Law 240/2010. The new Decree has structured the evaluation system into four requisites (divided into indicators and points of attention): the first two requisites are orientated at evaluating the University (Vision, strategies and policies of the University on the quality of teaching and research and effectiveness of the policies of University for Quality Assurance), the fourth requisite evaluates the Quality of the research and the third mission of the Departments; but the third requisite is aimed at establishing the teaching Quality implemented by the Degree Courses (DC).

Great attention is paid, preliminary, to the cultural and professional profile formed, as defined since the beginning of the DC training project, as it is essential to be consistent with the cultural and social needs of the civil society that shall welcome these professionals. The direct consultation of the interested partners and the support of sector studies<sup>2</sup> is useful to define innovative forms of learning in a future vision based on new and current paradigms. The consultation of the interested partners, anyway, is not only useful to define the profile of the outgoing figure consistent with the requirements of the labour market. Also during the training process, the involvement of the social partners must be continuous and constructive and may concern internships and stages, but also different forms of cooperation for the elaboration of the thesis and the involvement in specific seminar moments (as it happens for the Cycle of events scheduled at the Department of Architecture and Industrial Design of the University of Campania on Wednesdays)<sup>3</sup>. The centrality of the user/student is the rewarding strategy adopted in order to plan a shared improvement and a differentiated training offer, able to support the shortcomings in entry and in itinere, but above all to valorise the excellence with flexible profiles. It is asked, in fact, to guarantee adequacy of services but, above all, a teaching that uses appropriate and updated, flexible and innovative methodologies. An integrative training offer for the worthiest students, professionalizing or strongly orientated to satisfy the real demand for professional skills, can be a possible answer, especially when it issues recognised certificates that can be spent on the labour market after graduation. This can be considered as a form of introduction or accompaniment to the labour world that a DC can do.

Furthermore, in a globalised professional world, the International dimension of teaching rewards DCs having double or joint degrees with foreign Universities, which qualify the educational offer with visiting professors who open up new teaching perspectives and/or host foreign students with linguistic and cultural diversities that constitute a true experiential richness for Italian students. Particularly, the agreement for International mobility for the exchange of teachers strengthens, in fact, the scientific cooperation between different groups of Universities working on similar topics and register an added value not only for the didactic offer, but also for research. The aim consists in developing teaching and research methods of common interest in order to promote the exchange of skills and experiences. They are, therefore, an opportunity to strengthen an International research network, to experiment teaching methods in different cultural contexts and give the opportunity to students, who haven't got the possibility to take part in International mobility programs and benefit from the knowledge and competences of professors belonging to other Universities, at the same time. Effectively a tool of social equity! All this activity of verification and evaluation of the didactic offer, rewarding in any case, risks to limit the investment of resources and energies to the control and management of the document flow.

The real quality of the didactic experience doesn't consist only in the documentation of the activities carried out, not focusing the attention on a given historical contextual moment; it must also and above all describe the cognitive deltas that can be registered at the end of the experience itself: a sort of Productivity Index which shows a growing trend denoting continuous improvement over time. This happens even when the action implemented does not produce the expected results. In any case, monitoring the process implemented provides useful suggestions for improvement. The tools and methodologies for coding and leaving traces of this evaluation moment are several and range from Yearbooks (real 'board books') to comparisons and periodical debates on the process, from the thematic workgroups experienced as 'learning communities' to the design workshops, in which all the actors of the experience take part: teachers and learners. The important thing is leaving a trace of it!

At the end of the activity, then, drafting a final report that can take the form of illustrative tables, models, videos, short films, publications telling the didactic process and its results, is the natural epilogue, which can be enriched with a diffusion on the social networks and/or moments of collegiate meeting (popular event) among the people who have directly (teachers and students) and indirectly (stakeholders) taken part in the training project, but also with those variously interested, who have not taken part in it (civil society, professional orders, public administrations, associations, etc.). So the final moment of disclosure of the results acquires an added value linked with the gratification and satisfaction that the students and teachers involved feel in relationship with the work carried out: a certain sense of additional compensation, which in terms of costs/benefits returns the capitalisation of the efforts made and of the human and economic resources invested evidently and collegially.

Especially in case a 'participatory education' has been activated, able to involve the students closely, redefining the awareness of the role that each individual subject has got as a professional, working within the community and producing new identities enriched

with professional awareness, the most evident and meaningful result is the assumption of responsibility. Since the definition of the Quality level of scientifically assisted didactic planning has got also a more quantitative aspect, the effort must consist in highlighting it through the production of cards, maps, thematic maps, videos, photographic documentation, hypertexts, creation of (also artistic) objects, publications, debates and exhibitions. These products and/or their documentation may also be posted on the network to be used by a wider public and constitute a data that quantitatively represents (and must represent) a meaningful example of quality training.

**The training model and the motivational component** – From what has been said up to now, it is evident that Innovation, Competitiveness, Updating and Flexibility are the key words in the choice of tools for the training of professional technicians. The valorisation of the acquisition of knowledge, competences and skills acquired throughout the training and experiential path is one of the main innovations introduced by Directive 2013/55/EU. The essential indicators to determine the innovation level of the training proposal are to be found in design, methodology and contents, as well as in tools. The transfer of knowledge and the evaluation of acquired competences can take place in different ways ranging from self-orientation and self-evaluation to lectures up to Distance e-learning tools (FAD). The trainee transfers information/knowledge also to the social, cultural and economic scenario of reference, where the problems faced are framed, thanks to such tools.

The aim must consist in contextualising the wealth of knowledge and competences to be acquired, verifying the adequacy of the training intervention, in terms of expected learning results, that is not only of Knowledge and understanding acquired (knowledge and understanding), but also of knowledge and applied understanding skills acquired (applying knowledge and understanding). There is also a series of transversal competences to be monitored, such as communication skills, making judgments and learning skills. These descriptors (better known as Dublin Descriptors) are neither prescriptive nor disciplinary and they do not represent minimum requirements, but the network of information/links within which knowledge must be built. To this end, the educational system concerning the training action, can use: study of example cases faced with an approach aimed at developing broad problem setting and problem solving skills; appropriate use of multimedia tools able to interactively lead participants in the acquisition of basic, transversal and technical-specialist competences; active and involving teaching based on moments of group and laboratory work; evaluation systems of the training path, able to monitor in progress and ex-post the effects in terms competences and knowledge, able to give a measurable and comparable picture of the results achieved.

The instrumental use of the case study, for example, aims at creating the working and motivational condition with which future technicians shall interact: a cognitive premise that anticipates the direct experience in the field. The aim consists in increasing motivation through the choice of topics close to direct and daily experience, using methods that involve a strong active participation and tools that have a particular appeal of interest (in line with the new communication technologies: interactive tools, multimedia communication techniques for exhibitions and events, use of interviews

rather than statistical analyses, etc.). Moreover, the presence of students with special needs for the most different reasons (disabled students, with specific learning disabilities, foreigners with different cultural backgrounds, etc.) determines the choice of different and appropriate methodologies.

Creating a relationship between didactic contents and pursuing concrete goals, learning activity is perceived as interesting, stimulating and correlated to the professional context. Spontaneously a push to be engaged arises, that is represented by the motivation linked with the possibility to use educational contents to pursue a professional concrete goal. They say the motivation is interior. In other words what you learn is useful in a direct way (and not only in an indirect way, as it happens for some basic disciplines), because adult learning is focused on the problem more than on the content.

The comparison among peers' mind is a stimulus for a constructive competition and gives the motivation to grow up in knowledge and Schank's model gives an important role to the motivation aspects of learning (Schank et alii, 1994). Schank's educational model is based on Goal-Based-Scenarios (GBSs), that is simulations where the student acquires knowledge in the former phase and soon after (sometimes at the same time, depending on the different cases) pursues a concrete goal applying it. The training expectations represent a decisive moment in the development of competences and interest represents the motivation nucleus in activating your own knowledge. Moreover, you should consider that university students are a typology of trainees close to enter the world of work (in some cases the work experience is being already made) and it is shown that they are more interested in issues immediately linked with their personal and/or professional needs.

**Learning by doing** – The traditional training paradigm, based on a standardised approach that includes classroom lessons and final test of the acquired knowledge, by passing a test or a profit exam during which graphic-descriptive documents are discussed, can be changed into a more effective training model that aims not only to maximise the knowledge, but also the competences that shall accompany the trainee throughout his future professional life, overcoming the time limits of the degree course. This is the 'learning by doing' approach, thanks to which the team-based organisation, the stimulation to take shared technical decisions and the continuous invitation to consider the whole design process (including the direct user's point of view, according to the demand-performance approach) allows satisfactory results to be obtained in a relatively short time.

New design production models redefine the technological competences for the innovation that requires creativity and courage, but also awareness and sensitivity. In any case, there can be no technological innovation without any mental innovation: interdisciplinarity is not, therefore, a 'cool-word' but a speculative line, methodology and practice are based on. In this way, the Socratic concept of 'knowledge mediated by experience' and experimentation take shape. This knowledge, however, is neither teachable, nor it can be transmitted to words, because it is not a technique; the teacher must help the student to give origin to it, perhaps stimulating him/her to look for it in his/her daily practice.

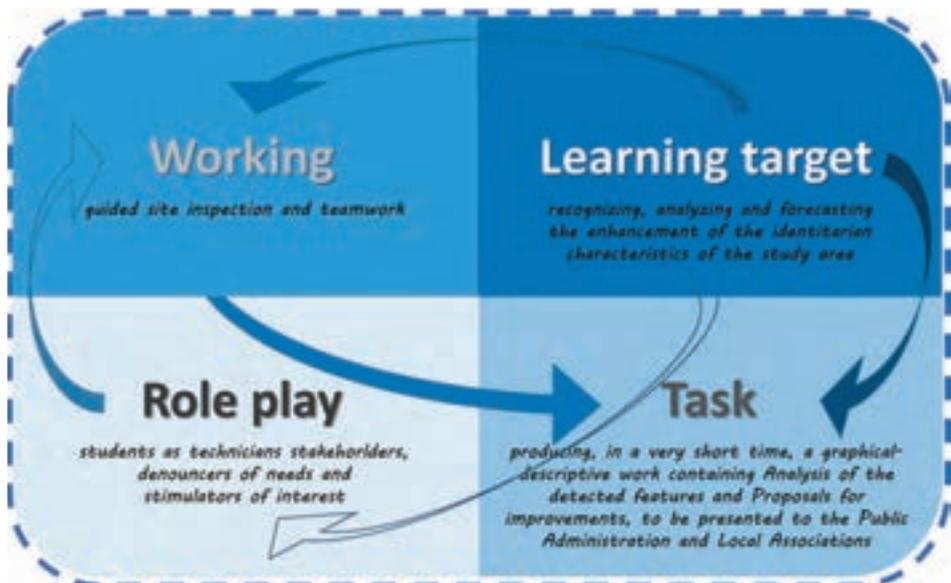


Fig. 1, 2 - Learning by doing: hierarchy/pyramid of learning: The learning process.

In identifying the phases of the learning process (Fig. 1, 2), the task phase represents the result of the learning target, declined in the problematic situation where the trainee is called to put into play all his/her knowledge, both the one acquired during the specialised seminars and the previous one, creating an ideal ground for the integration of both new and old knowledge. The role play is the rule of the game, how he/she is asked to interact with the environmental and social context of reference, which requires all the support of the teachers, as well as the indications of the experts. After analysing, designing and producing one or more improvement solutions, there is a comparison phase with the stakeholders, to whom he/she illustrates the real benefits deriving from the implementation of those ideas and from which receiving information about the real needs of the local community.

A process which goes on thanks to feedback. In this way, competences are noticeably developed, as it happens in real professional practice. The project experience on field, outside the university classrooms, in an international comparison is a major strength of this experimental teaching. The didactic methodology combines/alternates front lessons, seminars, direct and participatory debate with students and lab activities on field. The lab phase allows a close examination of the issues faced, applying them to a real case study, as in the case of identity recovery and urban regeneration of the rural village of Cappella in Bacoli (NA) (Fumo et alii, 2017; Fig. 3).<sup>4</sup>

During the introduction seminars, the components of GBSs have been deeply ana-



Fig. 3 - The educational experience of rural village regeneration of Cappella in Bacoli (Naples, Italy).

lyzed: 1) Case Study: the identitarian architectural elements of Cappella and the anthropic and social characteristics that make up the ‘connective tissue’ of all – past and future – transformation actions; 2) Learning target: recognizing, analysing and forecasting the enhancement of the identitarian characteristics of the study area; 3) Working: guided site inspection and teamwork; 4) Task: producing, in a very short time, a graphical-descriptive work containing Analysis of the detected features and Proposals for improvements, to be presented to the Public Administration and Local Associations; 5) Role play: students as technicians stakeholders, denouncers of needs and stimulators of interest. The task phase represents the result of learning target, declined in the problematic situation where students must call into play all their knowledge, both the one acquired during specialized seminars and the previous one, creating an ideal territory for integration between old and new knowledge. The role play are the play rules, how students must interact with the political and social context of reference that needs all support from professors and indications from experts, as well. After having analysed, planned and produced one or more improving solutions they need to be able to ‘sell their own product’, that is be able to explain their own choices and convince our potential professional interlocutors about the real benefits from carrying out those ideas.

The skills acquired by students after attending the educational path are the results achieved. They have learned to know how to design in response to social needs as well as technical and technological requirements, giving a correct graphic representation. They have also learned to know how using the technical nomenclature of the various constituent elements of each type of technical element; selecting the traditional materials in relation to their use, methods of processing and performance; designing an envelope stratigraphy under the cogent minimum requirements. Being able to recognize the peculiar characteristics of a prestigious context with the same sensibility as a restorer, being able to select the technological solutions mainly compatible with the historical and environmental conditions of the place with the same mastery of a technologist and being able to integrate innovative solutions with traditional significance makes a background of essential competences to be spent in professional practices, above all in a country like Italy with a great and diffused presence of Cultural Heritage.

**Process-focused learning** – The adult education must be focused on the process more than the disciplinary content; the study cases that students can find on the field for analogy/similitude results as a very valid strategy, anyway. Besides ‘learning by doing’ approach, also other two interesting adult educational models are important references: Career Development Program Adkins Life Skills; Andragogy Theory by Malcolm Knowles (1997). Learning for phases by Winthrop Adkins helps people to both know themselves and the world of work, and set personal goals and develop a long-term career. According to Adkins «learning should follow the following phases: 1) Stimulus: introduction of the problem, representation of the difficulty (phase of the instinct); 2) Evocation: discussion about the problem in order to identify the elements (phase of emotions); 3) Objective investigation: reaching a conceptual awareness through dialogue and exchange (phase of the reason); 4) Application: practical experience, in both classrooms and situations of the

real world to define the behaviour (phase of acting)».<sup>5</sup>

Following the evolution of the different phases, the capability to acquire competences useful to be affirmed in the professional world is gradually reached. Malcolm Knowles' Andragogy Theory, instead, puts in evidence the trend to self-management from adults, who tend to assume the burden of decision-making they are involved with. «Andragogy starts from the following hypothesis about knowledge planning: 1) adults need to know why it is necessary to learn new notions; 2) adults need to learn through experience; 3) adults approach learning in a problem-solving logic; 4) adults learn in a better way if the issue shows an immediate value and utility».<sup>6</sup>

More complex and newly introduced methodologies refer to Open Space Technology, an extremely interesting tool that proposes an innovative approach for the management of work groups, that have identified a common issue and are widely and homogeneously interested in providing a personal, creative and constructive contribution on the topic (Harrison, 2008). The teacher, who plays the role of 'facilitator', renounces to have a direct control over the work group and gives the students the freedom to express themselves in full autonomy of modalities, contents and tools. This is fully consistent with the indicator<sup>7</sup> 'Organisation of flexible paths and teaching methods', on the basis of which it is worth creating the conditions for the student's autonomy (in critical learning, in organising his/her study), whose teacher is a guide and not a problem solver.

That's why modern education pushes towards an interdisciplinary design firmly founded on the contributions of a scientific experimentation, which is suitable to the new needs of educational systems and updated to new professional roles, carried out in a participated and valued (better monitored) way over time. Moreover, bringing to the students the results of the research increases the quality of the knowledge transmitted because it is based on structured and tested scientific assumptions, but above all on a permanently updated and, for some aspects, also pioneering process of the proposed solutions, as the scientific research anticipates trade.

In order to reach adequate learning aims, the university training action in the field of architecture teaches how to manage the transformation processes in the natural and built environment by answering these questions: what?, how?, where?, when? and who for? calibrating up-to-date, flexible tools, approaches and methodologies, not only for the simple construction of knowledge. The potentialities of the training action are connected to the wide margin of opportunity that it has to deepen knowledge, modify behaviours, rationalise information and orientate the choices; in other words, University must produce and transmit 'culture', just like a learning organisation. To each educational action, a cultural reaction must correspond, which in the specific case of architect students is also a technical culture (Losasso, 2011).

If it is true that culture is what remains to a man when he has forgotten everything that he has learnt, doing 'culture' means teaching strategies, methods and tools for the way you live as a proactive citizen in a civil society, that is more and more complex in the determination of rules, more and more conflicting in social dynamics and more and more disobedient in observing the rules. Abandoning an image of culture as a sum of knowledge to develop a dynamic conception, where disciplinary points of view are

considered different aspects of the same knowledge, creates the need to analyse reality in a multidisciplinary way and orientate the development of actions, languages and forms of communication appropriate to each individual and different target.

Since University has got a culture of communication and documentation in itself, typical of a learning organisation, which always looks for new information and deepens its knowledge to confirm, rationalise and modify its behaviours, a Best Practice is an action evaluated as the best possible one to achieve such an aim. In this scenario, in terms of eco-oriented technological design, the rationalisation of the actions that can be summed up in a few but clear and absolutely mandatory rules, which can be identified in meaningful Best Practices, becomes the opportunity to own the forms of a sustainable management of the environment where we live and we interact with. In the ambit of the quality of the experience made, the skill to conceive the didactic action as a research-action is positively evaluated, as well as the skill both to explain the methodological approach of teaching and to demonstrate awareness of the theoretical basis, the work was based on, is considered a merit indicator, through an analysis of the literature and the state of art related to the topics on which the research-action was carried out. The Quality level, especially with regard to scientifically supported teaching design, can be defined according to three aspects: 1) Quality of the experience made (acquired know-how); 2) Quality of the reflection made on the experience, which has led to improvement actions; 3) Quality of experience documentation (cultural capital).

In conclusion, from a more strictly organisational point of view, the experience must start from a context analysis, move from a design perspective and be the result/outcome of a work group in which human resources, roles and responsibilities are clearly indicated. The teaching methods include the development of meta-cognition, autonomous and/or cooperative learning strategies, the valorisation of multiple intelligences, individualised teaching with a specialised and differentiated response in relation to all types of students, as well as a degree of experience integration in the overall development of the actions carried out by that work group over time.



High Line, New York City (credit: G. Guglielmo).

# THE CENTRALITY OF THE TECHNOLOGICAL DESIGN

## ABSTRACT

*Design, considered by someone as a 'product' and by others as a 'process', is first of all a 'place' where several equal, multi-scalar, interdisciplinary instances compete, whose specialist contributions reveal to be integrated contributions. Designing means 'being able to choose' and the complex development mechanisms of design ideas must know how to respond to a demand that has evolved/renewed towards higher and higher performance standards in the meanwhile. Considering the changes made in recent years in regulatory tools and the increasing level of performance demanded by the market in the construction sector, in terms of high performances rendered at the lowest cost in established times, the quality management is a mandatory requirement. The role of technology has undergone a structural evolution, passing from being perceived as a service discipline for the architectural design to a supporting column that allows to respond appropriately to the regulatory requirements, fully satisfying the direct user's needs and with the design of eco-oriented highly performing systems and components. In this panorama of raising requirements, technological research must define a new formal and performing paradigm where the correct use of resources, the reduction of emissions and the shortage of energy needs (and non-renewable resources generally) are not a limit to development, but an opportunity for growth and experimentation. The performative method and the regenerative approach open new frontiers to technological design.*

## KEYWORDS

*technological design, cradle to cradle, regenerative architecture, performative method, quality*

The constant effort from architects and engineers in designing high-performance and efficient technological solutions is a meaningful thermometer of the increasing attention paid to design, not as a linear process (positivist approach), but as a multi-scalar and interdisciplinary decision-making process, with a fair level of complexity linked with the technological and innovative rate of the choices made in the field. This interest creates a strong impulse to innovation, on which the knowledge factor has a high impact, an added value. Design, considered by someone as a Product and by others as a Process, is first of all a Place where several equal, multi-scalar, interdisciplinary instances compete, whose specialist contributions reveal to be integrated contributions. In this perspective, the technological design, as a search for the point of balance between ends and means (Schön, 1993), culture of the shape and culture of technique (Habraken, 2000), aims at checking performances with a complex approach and should go even further, aiming at implementing the paradigm change that Elizabeth Sahtouris (1999) saw in the gap between scientific growth and cultural evolution some years ago.

Designing, therefore, means opening new visions. The architect needs courage (in his/her choices) and skill to see, interpret and shape future scenarios. In fact, there is no technological innovation without any intellectual innovation and behaviour, which invites us to think in terms of needs as opportunities. If in the XX Century Functionalism led to territorial planning according to technocratic decisions, the XXI Century is the Century of the Relational when the transformation of the territory is based on the existence of existing relationships: decisions must be made at a level of subsidiarity, that is as low as possible. That's why, the architect must observe, analyse and make the immaterial element of the architectural design first of all the dynamism of flows, processes, activities, transformations and environmental energies that define the becoming of natural capital on which we base all anthropogenic transformations (Geocentric View) and then the behaviour of the people who live, work and make their primary functions in the place for which the new architectural object was designed (Anthropocentric View).

«By avoiding obscure technicalities and reductive specialisations, designing is asked for the capacity to focus on the symbolic meaning horizon that is implicit in the technological culture of architecture, the capacity to meet the tangible and intangible needs of those who inhabit built spaces and places» (Campioli, 2017, p. 31).

Today more than ever, the architectural object is the consequence of the context and the existing: an intellectual, a cognitive and a purposeful tool, before being a descriptive tool (Vittoria, 1986). Since the first design sketch it is not pre-written but re-written what necessarily must satisfy current needs. Current needs include an integrated environmental design. After all, designing means 'being able to choose' and the complex development mechanisms of design ideas must know how to respond to a demand that has evolved/renewed towards higher and higher performance standards in the meanwhile. Therefore, before being a tool of transformation, design is a tool of knowledge. It is not risky saying that the technological approach is the only one able to re-establish the socio-cultural background, on which design choices are based or should be based, to the sphere of eco-compatibility. The contribution of technology is not reduced, in fact, to technicistically controllable procedures and patterns that recall the design activity to a renewed responsibility in strengthening the link between theory and practice. The vision is complete and complex. Technological innovation has its point of strength in being preceded by a scientific experimentation, based on an environmentally conscious technical culture that dictates the rules not only to define the object, but also to suggest 'how' more appropriately. «No longer does technology bend, dominate, overcome environmental constraints. Instead it is the environmental limits that inform, control, dominate and originate consistent technologies» (Matteoli and Peretti, 2013, p. 41). In the interpretation of architecture as a whole, in fact, the choice of a technological solution implies not only a structurally defined shape, but also an adequate performance for evolving needs, today more than ever, tied to the rapidity of needs and uses transformations.

Referring to the Cradle to Cradle (C2C) approach, the management of transformation through environmental control, on an urban scale, assumes substantial social aspects (they talk about promoting inclusive prosperity all over the world – The Dynamics of Inclusive Prosperity Conference<sup>8</sup>, which took place in Rotterdam in November 2018),

repercussions are systemic and strategies go beyond the original interpretation of sustainable waste management (recycling of materials); on a building scale, the design based on the C2C principle, can be seen as a bank of raw materials (McDonough and Braungart, 2010), each one with its own quantitatively evaluated construction ID. The systemic view, that exceeds the limit of the first life cycle, considers the value of the single materials dismissed during the demolition phase and tries to find their subsequent reuse (the technosphere follows the same closed cycle of the biosphere). Perfectly compatible with the Vitruvian concept of ‘an enduring architecture’ (in our country we record a very low demolition rate and a strong propensity to recover the artefacts), the C2C building is not built to be demolished after a few decades, but its parts are designed by planning in advance either its recovery in a new building cycle, or its partial replacement in case of physical or functional obsolescence localised. An innovative atmosphere is a prerequisite for promoting a change, but innovations in firms (materials and products), in professional practice (plans and designs) and in governance (standards and facilities/funding), especially if orientated to technological innovation, can have both positive and negative effects, if the pragmatic, moral and prescriptive branches of innovation are not investigated and monitored (Losasso, 2010).

This is an excellent example of innovation research ... for a positive change!

**Design Quality control both as a process and as a product** – In parallel with the change of direction imposed on the ideational concept of architecture, in our Country we must look at the change of direction in the implemented concept of everything that has already been designed. Considering the changes made in recent years in regulatory tools and the increasing level of performance demanded by the market in the construction sector, in terms of high performances rendered at the lowest cost in established times, the quality management is a mandatory requirement. This tendency is demonstrated not only by the vivacity of the National debate and the studies in progress on the topic, but also by the actions made by the Italian and EU governing bodies that are more and more attentive to absorb the concept of quality in action strategies and operational tools, even if the approach is always fragmented and partial in comparison with the complex vision that the new paradigms of the regenerative design impose on us.

However, the increasing demand for guarantees on the design quality, as a meaningful factor for the reduction of the risk of both inappropriateness of the contracted design and its impossibility to be awarded of a public contract, can be seen in the new strategic role of the Contracting Station<sup>9</sup> at national level. From a controller of formal requirements to ensure the right custody and contract performing, it becomes a verifier of the correspondence of the planning elaborations of all the design levels (technical and economic feasibility design, final design and executive design), verifying<sup>10</sup>, through the use of specific IT methods and tools<sup>11</sup> (more commonly known as Building Information Model – BIM), architectural social qualities (satisfaction of the collective needs and health and safety protection, accessibility and removal of architectural barriers), technically functional to the work, in relationship with its context; compliance with environmental and city planning standards, as well as with standards of protection of cultural

heritage and landscape, including the limited consumption of the territory, the respect for existing (archaeological, geological, geomorphologic, hydro-geologic, seismic, forest, etc.) limits, savings and efficiency and energy recovery, throughout the life cycle (not only during the life of the work, but also in the construction phase). The attempt is that one of an overall vision, which is however far from being complex, because «Architects and engineers address the efficiency of buildings while failing to understand the earth systems that are the very systems we are trying to sustain. Urban planners use formal design guidelines to pattern communities that are ‘alive’ without understanding or addressing the health of the ecosystems that sustain and inform life in the place they are creating» (Reed, 2007, p. 675).

Shortly Quality is an added value, where it denotes feasibility, consistency, compliance, control, coordination of both the process of creating design ideas and the specific instructions necessary for their implementation. In fact, with the term Design, both a product and a process are configured simultaneously, and the application of the concept of Quality substantially changes whether we speak of one or of the other interpretation. Moreover, the profession of the architect, more than others, is expressed into two moments: one of service and the other one creative, intellectual, predominant in most cases. Design as a process is a real decision-making process, where the succession of the operations of ideation-production-control is cyclical. The quality level of this form of process is given by the skill to manage the flow of information from a phase to another, without losing the quality of the information itself, but increasing and systematising it with the information flows coming from the other systems, directly or indirectly, related to it (not least the environmental systems of soil, air and water).

As a Process, which involves either private individual or associated professionals or engineering companies with various specialism and competences, Design qualifies itself by disciplining the methods of relationship between the parts that collaborate in the planning phase through operating procedures. Certainly, from the procedural point of view, the aim is the full satisfaction of the client-committee. Losing quality, not working in quality means losing in image and, in a market that bases the rules of competitiveness on the image means losing the market. Such a vision must necessarily be extended to another range of customers-users (not necessarily human beings!) that will pay the costs of their wrong choices and will enjoy the benefits of their appropriate choices in an indirect, potential or even future way. The design Quality, therefore, is not applied directly to the product (building, neighbourhood, city, etc.), but to the process that leads to both its intellectual conception and the ways of producing it. However, quality is not pursued only with the virtuous tools of competition. The hoped close correlation between design, technological choices and construction choices, which Pierluigi Spadolini (1981) hoped to carry out in the 1980s, has been translated into a computerised control of technical choices, put into logics of a Computerised Constructive Model, because we think that design will be more correct if we manage to control it well. Undoubtedly, the overall control of the process phases and the management of the various instances that the specialists cite is useful and facilitates the good design execution, limiting the risks of non-communication. However, it is not only the control of the process that makes a

design good, but the quality of the ideas that are at its origin.

The role of technology has recently undergone a structural evolution, passing from being perceived as a service discipline for the architectural design to a supporting column that allows to respond appropriately to the regulatory requirements, fully satisfying the direct user's needs and with the design of eco-oriented highly performing systems and components (Perriccioli and Ruggiero, 2018). Moreover, thanks to the new tools supporting design, it plays a central role in the management of all the actors in the supply chain, finally able to communicate effectively. Certainly the designer's work, which today is increasingly represented by a design team, is effectively supported by the BIM methodology that represents a different approach to design, in each point of the design process (from conception to construction, from site management to maintenance). «Well-conceived architecture turns new technology into an asset» (Neuckermans, 2017, p. 35). Analysing the complexity of the creative process of design production, the rule wants that the quality management of the process is virtuously assisted by an innovative model of data management related to the design, which is the tool able to manage the passages between the different process phases without any loss of information, but capitalising specialist's knowledge and skills, who take care of its conception in all its parts. In fact, if the multidisciplinary nature of the work groups is undoubtedly a necessity as well as a normal consequence of both the increasing complexity of the topics to be faced and the sectorialisation and specialisation caused by today's professional training, it is also a complication in terms of managing the process of quality control.

The real value of change is given by the skill to be innovative and not just improving. In such a perspective, a possible interpretation of the concept of quality applicable to a Professional Study can be: doing only what is useful (theoretical efficacy), in the best way (effectiveness), in less time and less cost (efficiency), through procedures and controls by those who are more competent to do it (skills and competences), providing the required result (satisfaction) and being highly innovative and competitive (Perceived Quality). In such a sense, quality is Customer Satisfaction, while ensuring the right management of knowledge (Knowledge Management). However, don't forget that Knowledge Management means not only a process to acquire and archive knowledge and organise it, but also a tool to generate new knowledge through learning and create the (organisational, technological and socio-cultural) conditions that allow knowledge transfer and sharing within a multidisciplinary work group. The support of the world of scientific research, which is able to orientate the choices towards new regenerative paradigms, is essential in it.

From this point of view, the Management System is the tool able not only to Certify the Quality of both professional performance and production and producer, but also to reduce the environmental and social risk, indicating what to do; how to do it is delegated to the skill of each organisation that decides to adhere to the International standard. The use of ISO standards, in fact, can never guarantee designer's skills, abilities and ethical correctness, but it certainly ensures that he/she is in the possible conditions to meet customers' needs (meant in a broad sense), even the most complex ones, in the best and most appropriate way. The logic of reducing risk and evaluating the context, as a factor that helps in anticipating the choices conceived as priority actions rather than as corrective ac-

tions, is a strategy that allows to make targeted and conscious decisions in the design phase, on the base of customers' defined needs, the performances that the design must satisfy derive from.

**The Technological Design as research-action in process innovation** – Considering what has been said up to now, it is evident that design, before being an instrument of transformation, is an instrument of knowledge. It must satisfy old needs, be at the service of renewed functions and be subjected to complex management. Research continually proposes new materials and new technologies with renewed 'meanings and formulations' that require a systemic methodological approach to govern the design process in its complexity, systemising the specialised knowledge, but above all articulating the logical relationships between more or less clearly declared requirements and more or less quantitatively measurable performances, for a global sustainability of the interventions, aimed at improving the quality of life and the eco-systemic integration of anthropic transformations.

New design production models lead to repositioning the contributions and redefining the technological sector competences for innovation. In some cases creativity and courage, in other cases awareness and sensitivity are needed; but in both circumstances, there must necessarily be a mental innovation close to technological innovation: a renewed approach to the interdisciplinary design with a range of conceptual lines on which methodology and operating practice must be based. As Albert Einstein said, «Problems cannot be solved at the same level of awareness that created them». The Technological Design is really the natural place of this innovation since, being a connection element, it fills the gap that separates the ideational moment of the design compositional phase from its constructability, giving it technical, legal, administrative, economic, but above all environmental feasibility. Since even the best design, if not feasible, will never become a building, a liveable floor or an urban space, the invitation is to consider strongly the five levels of feasibility (Violano, 2012) that make it possible all together, without any exception, the implementation phase.

However, the path of innovation has a series of intermediate stops, one of which is certainly the generation of the idea: 'the concept', in which the experimentation phase, above all the one that adorns the scientific research and is honoured by it, is the fulcrum of 'development'. «Scientific research encompasses multiple scales of knowledge, linked and composed differently in the post-modern society, in which, with the emergence of the knowledge economy, the disciplinary components disperse in a reticular pattern as opposed to the traditional pyramidal structure» (Schiaffonati, 2011, p. 52).

The share of 'diffused quality' required in a multi-scale manner to the single material as well as to urban spaces, passing from the analysis of technological requirements to the environmental ones, is explanatory increasing and creates expectations so that to be correctly satisfied, require substantial performing levels, mature and conscious environmental approaches and high comfort conditions. In this panorama of raising requirements, Technological Research must define a new formal and performing paradigm

*Fig. 4 - Hearst Tower (Foster & Partners, 2006): the first commercial building in New York City to achieve both LEED Gold for New Construction and LEED Platinum for Existing Buildings (credit: Maks Erli).*



where the correct use of resources, the reduction of emissions and the shortage of energy needs (and non-renewable resources generally) are not a limit to development, but an opportunity for growth and experimentation (Fig. 4).

If quality does not mean excellence but adequacy, then a spontaneous question is asked: how is it possible to guarantee a balanced relationship between rational use of resources, production of goods and services, able to satisfy the demand, and minimisation of rubbish/material waste strongly impacting the entire system with a continuously increasing demand? The perspectives and approaches with which you can face a situation is often crucial: we should focus not on how to do something or how to get a particular service from the technological tool, but simply on what you want to do and get. The vision moves from the horizon of efficiency to that one of effectiveness. Starting from a substantially negative pre-sustainable scenario, through a sustainable scenario that is less bad, we pass to the virtuous regenerative scenario that is 100% good. We are talking about the C2C approach. The design of more and more complex and performing materials, systems and components are leading towards the replacement of the LeCorbusierian idea of architecture as a 'machine' with the idea of architecture as an 'organism' in a constant co-evolution with its context, so that it adopts the process rules from Natural Sciences (Biology, Physics, Genetics). Regressive architecture becomes Regenerative Architecture and Technological Innovation makes a real revolution in our way of conceiving the relationship between building and environment. The paradigm change is essential if we have to reduce our ecological load by 2050. The fragmented technical approach acting on individual processes in a perspective of incremental efficiency, makes the aim unattainable.

The new design paradigm cannot be based exclusively on the symbiotic behaviour of the shape, but on the co-evolutionary behaviour of the material (according to the C2C approach). Bio-design is an added value compared with the current eco-compatible design, because it operates on a double level: the artificial imitation of natural processes and the integration of biological dynamics in artificial systems, materials and components (man-made). For example, Philip Steadman's metaphorical-biological approach, applicable to objects designed by the man, is based on the search for the coherence of each single part with the whole, which is the foundation of the harmony of the parts on the base of the Vitruvian concept of *Venustas*, but also of the integration between the object itself and its environmental surroundings, adopted in the principles that are the basis of bioclimatic architecture (Rogora, 2012).

However, modern architectural research goes beyond the border of the visual and formal analysis of the biological metaphor, to study natural phenomena and 'structures' also from a metabolic and biological point of view. In this way, a renewed relationship between shape and function is configured in architecture, which is reflected in the no longer symbiotic relationship between material and shape, carefully investigated also thanks to the potentiality of simulation tools. With a market based on C2C principles, economic growth is separated from resource consumption (Tucci, 2018). The products are no longer sold, but they are available for their use, after their use, the materials are collected as a part of a reprocessing system and therefore they remain in circulation and the value chain passes from raw materials to product regeneration. This requires a deep innovation in the

technical aspects (such as modular products design), new recycling Methods and Innovative Eco-design, but also new logistics concepts, product traceability and alternative business models up to the redefinition of requirements (mandatory standards).

We should indeed reconsider the role of the material in the design process, with all its morphological, eco-systemic and fruition quality. The technical and environmental quality must certainly be added to these ones, which are transformed into the same amount of levels of feasibility until they reach a complex, but not overall result of Possible Quality, where the limits are variable from place to place, from case to case. And certainly, in this fluid society, constantly looking for innovation and changes, based on appearing more than on being, the benefits induced by the aesthetic and emotional quality are not negligible, a real added value immediately perceptible and communicable. Even the Vitruvian triad of *Firmitas*, *Utilitas* and *Venustas* can be reinterpreted through the canons of contemporary materialism, which gives the role of responding to specific requirements of efficiency to the material and the (architectural) system as well. Thus the material must be enduring and reliable (*Firmitas*), widely usable and functional (*Utilitas*) and of fine workmanship and innovative (*Venustas*). It must also have the added value of aesthetic pleasure as well as morphological reliability, eco-compatibility, being low emission, zero carbon emission and recycled as well.

Today, eco-friendliness, recyclability and renewability are not just slogans of effect, but real design need. The awareness that making architecture means activating processes rather than offering products is increasingly widespread. The technological transfer is the enlargement and diffusion of the material knowledge in its intimate characteristics and potentialities, not in being produced by a construction. Material is on the basis of the process. It is not a coincidence that Stanley Davis (1987) argues that the cities of the future, far from being made of glass and steel, will be largely built of rough bricks, straw, recycled plastic, concrete blocks and recovery timber. These materials won't be only outputs of a transformation process that at the end of their life tries to reintroduce its material waste and rubbish into the production cycle. They will be renewed materials in shape, appearance, performance and use concept, because the aim is not to build but to promote architecture as a development process.

**The Regenerative approach** – The projection into the future is a core principle in order to organize and define the behaviour of man, which is by his nature impatient with the limits, projected into the absolute and avid for knowledge. As Ulysses by Dante, he needs to broaden his horizons, to reach what is unknown and to go beyond the emotionless certainties. The designer has in addition (or particularly) the creative component that empowers to see and live future scenarios still unrealized, but already alive and real in his mind. The reserves of resilience from which to draw to feed these scenarios are in the nature and its generous capacity to reintroduce in its life cycle the dialogical and sensitive human-made processes. According to the ecocentric approach, the scientific paradigm emphasizes the epistemological integrity implied within ecology, and ecological metaphysical reality. Therefore, the architecture with consumerism, pollution and parasitic development calls into question its design and construction processes.

The evolution of how to design, but above all how to think about the design as a place rather than a product, creates several considerations, we have to reflect on. Metamorphosis, evolution, transiency, adaptivity, sensorial-perceptive involvement are the new passwords of an architecture that doesn't want to be simply used but lived, and co-evolves with its own environmental surroundings and chooses quality as measurements for its performances. With this point of view, the Vitruvian concept of architectural being, structured with the human being in an analogical way, is not overcome, but it evolves involving not only architectural components and systems as independent parts that are functionally well defined, but also as a complex holistic system towards the approach of the living building. So we can see the overcoming of the Aristotelic conception that in nature sets two great categories of beings one against the other: natural and artificial beings (traditionally buildings and the completely hand-made capitals belong to).

The former are considered as linked with the concept of becoming (that enjoys four essential causes: immanent-material substance, cause agent, formal- intrinsic cause to the being itself and final cause – the last aim prefixed within nature towards all beings tend to their becoming), while the latter are generally linked with the static concept of non-becoming. The Regenerative Design proposes buildings in harmony with nature, which have limited ecological footprints, and the eco-social approach claims that there is a dialectical connection between nature and humans (Reed and 7 group, 2009; Wahl, 2016). Architects must build harmonies, they must transform themselves into «intermediaries who create open schemes» (Ratti, 2014. p. 114).

If the whole design process follows the approach C2C, the synergic relationship between the building and its surrounding increases, not only through an energy and environmental balance in which the total energy consumption of the building in its whole life cycle is equated and, in some cases, exceeded by the energy produced from the building itself. Thanks to its materials (biotic and processed-biotic materials: bio-based materials) the building takes on the behaviour of a real living thing interacts, adapts, evolves, it protects and takes full advantage of context. It uses the sun's energy and uses the resources of the soil, produces oxygen and sequesters CO<sub>2</sub>, closes the cycle of water and waste, breathes, suits several seasons, is built from recycled materials which will be recyclable at the end of their useful life (C2C). Let us analyse the steps made towards this future architectural scenario that comes from a constantly increasing performing demand. The starting point is represented by yesterday architectural scenario, the so-called Code Phase, the traditionally designed and built architecture belongs to, that is widely overcome. The increasing demand of comfort and efficiency brought the building sector to promote the so-called homeostatic architecture, the whole class of High-Performance Building, among which Nearly Zero Energy Building (NZEB), Plus-Energy Building, Zero Waste Building, etc., belongs to. These representing today architectural scenario define the qualitative standards of the Sustainable phase. Green Design focuses on single issues, for example the inclusion of recycled or recyclable plastic, or consideration of energy consumption (Baker and Steemers, 2000).

According to Eco-design, environmental considerations are considered at each stage of the design process. Design for sustainability considers the environmental (for exam-

ple resources use, end of life impact) and social impact of a product (for example usability, responsible use). Instead, sustainability is considered to be more of a direction than a destination that we will actually reach (Bhamra and Lofthouse, 2007). Eco-oriented planning choices acting on the ‘hardware’ component of the building are preferred, positively affecting environmental costs of the ‘cradle’ and ‘grave’ phases (materials and components from renewable source, recycled/recycling, reused/reusable), but experimentation aims at optimising the ‘software’ component with mechanical/home automation systems that stimulate natural processes. An historical example is the Institute of the Arabic World in Paris, where Jean Nouvel was the pioneer of the homeostatic architecture, fancying a dynamic façade reacting to the direct solar radiation as well as the pupil of the human eye, opening and closing the diaphragm filtering the necessary quantity of solar light. Analogously, Decker and Yeadon’s study proposes the application of nanotechnology to Homeostatic Façade System, a double ‘meteoropathic’ envelope (Fig. 5), which can be open and close according to the external temperature. Nevertheless, the scientific experimentation has gone even farther, opening new frontiers to technological design and delineating the future architectural scenario. It aims at tuning design methodologies (rather than specific technological solutions) aiming at giving an added value to an architectural being that, already perfectly meeting the cogent requirements of efficiency and environmental compatibility, has a high biological added value.

We are speaking about the Regenerative Design that proposes buildings in harmony with nature, with a limited ecological footprint (Reed and 7 group, 2009). Therefore, we can see the overcoming of the LCA approach and the attempt to close the biological cycle of the eco-system, integrating architecture (habitat, people, buildings and infrastructures). If the whole design cycle follows the C2C approach, the relationship between the building and its surroundings becomes synergic and the environmental-energy balance is balanced up to obtain that the overall need for energy from the building in its whole life cycle is lower than the quantity of energy produced by the building itself. Designing an



Fig. 5 - Homeostatic Façade System: double ‘meteoropathic’ envelope.



envelope that cultivates algae able to capture CO<sub>2</sub>, constructing infill wall with bacteria and insulating it with fungi, adds a new meaning to the term Green Building (Fig. 6). The improvement of the conditions of adaptability to the context determine not only that the building needs a lower and lower quantity of energy, but co-evolve with the eco-system where it's built, without any negative impacts, but even giving a positive contribute to the environmental balance. In fact, the living architecture overcomes the performances of the homeostatic process, in case the original planning choices are marked with an 'environmentally friendly behaviour', that is they care for the reduction of the environmental impacts in both the cradle and grave phase.

**The Performative Method** – To define the quality of the architecture and the role of design, the need to assess the level of quality performance arises, highlighting the difference between sustainability performance of a building and its contribution to a sustainable development. Particularly, the former is closely linked with the intrinsic qualities emerging in the phases/stages of the life cycle; the latter is linked with the positive self-multiplicative effects that can be produced as a consequence of appropriate choices. First of all, it's a question of value! When the need is that one of evaluating reality in an objective and rational way, through numerical data, with the support of scientifically tested methods, based on universally applicable mathematical formulas, quantitative research provides useful supporting tools. Qualitative research is helpful when it becomes essential to consider the perspective of the individual, his/her behaviours, his/her expectations 'case by case', when we are in the presence of complex realities where uncertainty and conflict of value prevail, that is when it is not possible to represent reality in a meaningful way with quantitative indicators. It gives value judgments mainly expressed as 'nonnumeric data'. These are verbal expressions that represent different levels of preferability that cannot be represented mathematically on an orientated line. In some cases, we rely more on analysis protocols than on real multi-criteria evaluation methods for determining these value judgments (Martens and Martens, 2001).

In recent years a new 'experiential' research methodology has been widespread, which has got neither the methodological restrictions of quantitative research nor the expressive conditioning of qualitative research. This is the 'performative' research. It is particularly suitable for identifying 'problems' or 'relevant issues' by analysing reality and its diversified and often conflicting aspects. This innovative scientific method is especially useful if the questions to be investigated presuppose a high level of creativity, such as architectural designs, artistic installations or new types of communication/training (especially if addressed to younger generations) where there is a high level of emotional involvement ... of all sensory activities. The starting point is always a well-structured state of art, from which the aims and the most meaningful questions, to investigate on, emerge. It can also be a structured list of hypotheses or a series of practical and design experiences made.

We should look for the possibility of combining experiences made in the fields of engineering and architecture that require the sharing of a polytechnic knowledge free from

*Fig. 6 - BIQ, IBA Hamburg: the first building in the world to have a bioreactor façade.*

traditional specialism, in which the parcelled knowledge is combined together and in which technical and scientific knowledge is implemented like a resource within the field of research. Not all the statements of a knowledge system have the same importance; some knowledge systems have a higher level of rooting, affecting on what to preserve, what to transform and what to abandon, based on revision mechanisms able of reviewing scientific contents and statements (Tagliagambe, 2004). At this point, the dialectical problem of knowledge and means that characterise the practice of architecture and their verification before the specificity of the conditions is opened. The research practices should therefore be more opened and avoid the rejection of a dialectic with the contradictions of contemporary reality, since the construction, use, collective meaning, costs or duration of the works are above all questions with which architecture as a whole is compared, in the responsibility of critical interpretation of realities where you operate (environmental, urban, construction, production) and you give answers to, based on the values to which you choose to adhere (Gregotti, 2011).

The crucial problem of our time, according to the thought of Edgar Morin, lies in the necessity to enhance a thought that is able to afford the challenge of the reality complexity and to govern multidimensional phenomena. The language is mixed: graphic/descriptive, variable in relationship with the topics analysed. The main requirement of a performative research is an appropriate analysis of the circumstances in which the analysed phenomena occur, the ‘contextualisation’ of the choices. These are important starting data conditioning the performative research. Particularly, the appropriate choice of the circumstances, or rather the ‘contextualisation’ is an important datum for the process of performativity applied to the architectural design.

The aim consists, first of all, in building a coherence among knowledge, values and behaviours. To this end, various ways can be followed, technically called actions, which aim at developing: 1) knowledge of the reality where you live and work; 2) sense of responsibility in relationship with your own actions; 3) willingness to change your *modus vivendi* in case you realize that it is wrong/inadequate; 4) propensity to listen, understand and share environmentally conscious behavioural models, perhaps already experimented in other social contexts, recognising a specific value of potential social enrichment to other cultures; 5) elimination of cultural barriers that create stereotypes and prejudices behind which to screen improper actions, at the margins of legality.

Conscious and responsible behaviours are encouraged, which create that form of capital called Social Capital, on the basis of which each subject has got value in himself/herself also as a part of a community with which he/she cooperates to shape aims, intentions, goals and growth strategies. The success that inevitably occurs at the end of this type of behaviour create trust and generate the awareness that you can improve the quality of your environment by acting correctly. Civil society will have reached such a level of environmental maturity that it can promote an appropriate knowledge: a knowledge that can understand the essential global problems in which to inscribe partial and local knowledge. In this way the moments of training are intertwined with the dynamics of local development. Competences are thus transformed into potential competitiveness in the construction sector and its correlated professions.

# A METHODOLOGICAL APPROACH TO PROCESS SIGNIFICANCE AND VALUES IN ARCHAEOLOGICAL SHELTER DESIGN

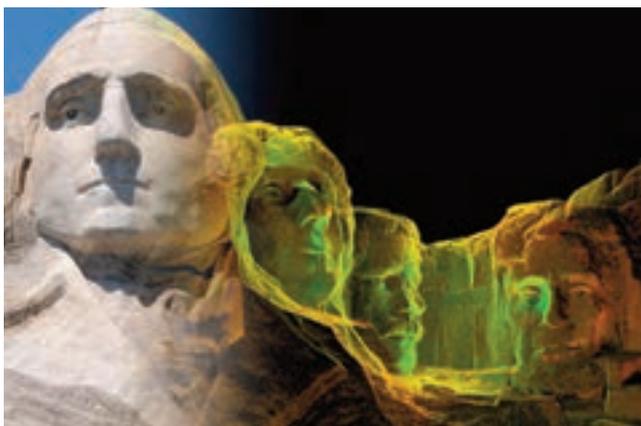
## ABSTRACT

*Within the scientific debate on the conservation of Cultural Heritage in general and Archaeological Heritage in particular, due to its twofold nature (material and immaterial) and consistently with the interest taken by Technological Culture in the importance of those aspects in the process crucial for their proper development and broad enjoyment, this paper proposes an evaluation model to understand 'what' to preserve and 'why' for a sustainable development, even before considering 'how' to do so, allowing a clearer reading and an easier interpretation of the complex relationships existing between the archaeological pre-existences, the natural environments and the added anthropic systems. The offered evaluation model can guide operators towards a conscious sheltering planning with an architectural value, promoting the identification of the morphological, typological and technical-constructive solutions most suitable to return the potential significance of the Asset.*

## KEYWORDS

*conservation process, values, significance, assessment method, technological culture, shelters*

Over the last twenty years a series of events (globalization, mass tourism, diffusion of participatory democracies, significant economic fluctuations, technological innovations, etc.) have substantially influenced the approach to conservation and management of Cultural Heritage. These events have introduced, on the one hand, new and innovative tools<sup>12</sup> to know and support material aspects (Scianna et alii, 2014; Netti, 2017; Figueiredo et alii, 2018; Fig. 7), and on the other, have retrieved the principles expressed



*Fig. 7 - Laser scan at Mount Rushmore (credit: CyArk).*

by the Nara Document (ICOMOS, 1994) and by the first edition (1979) of the Burra Charter (ICOMOS, 2013). They highlight the importance of a wide range of values and meanings of the Cultural Heritage, the need to involve the social context in the decision-making process, the Heritage valorization and enjoyment for current generations and its transmission to future ones.

These changes and theoretical developments on Cultural Heritage have required a clear strategic policy aiming – in the long term – at a sustainable conservation of archaeological sites through Management Plans able to restore a holistic and dynamic vision of their structure, value-based and developed through the planning of a participatory and cross-disciplinary process (Mason and Avrami, 2000; Della Torre, 2013). From a theoretical point of view this approach is shared by scholars, in practice, Management Plans are very rare and there are really few references cases<sup>13</sup> for good practice (Williams, 2018). The ineffectiveness of these Plans is probably due to the fact that they are often seen more as a ‘product’ than as a ‘process’, whose definition in the conservation area, paraphrasing Alberto Sposito (1995), identifies the set of activities, changing over time, which concerns the material/tangible (already transformed matter) and immaterial/intangible (identity and values) aspects and which identifies the criteria, structures the programmes and defines the fundamental procedures for conservation, protection and safeguard, the boosting, enjoyment and management of the cultural artifact, also and especially, to be passed on to future generations (Fig. 8).

The fragility of the materials coming from the past, the fragmentary nature of the artifacts, and the limited financial resources in relation to the great amount of Heritage we have inherited, impose specific and sometimes urgent actions to protect and preserve these Assets, according to an intervention philosophy that, since the ‘60s, prefers to

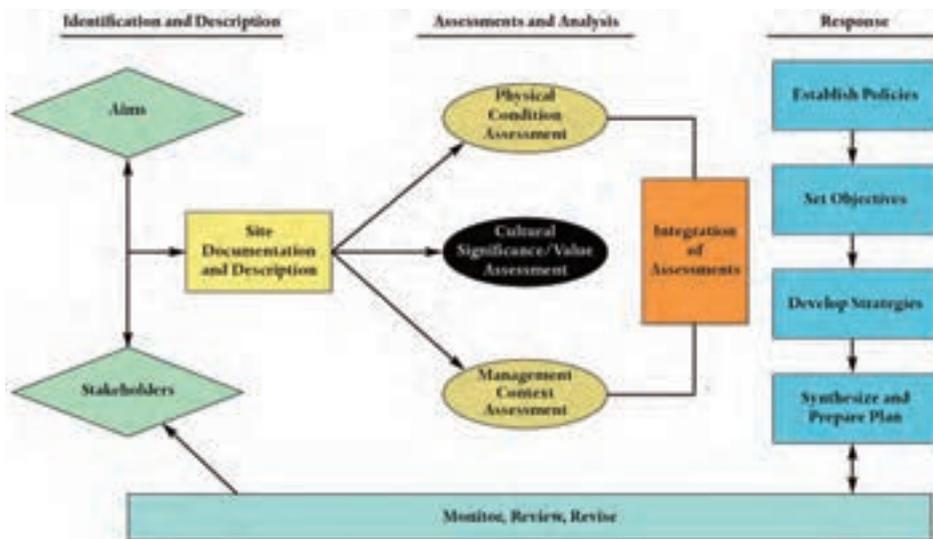


Fig. 8 - Planning Process Methodology (credit: Mason, 2002).

maintain them in situ (Minissi, 1987; Ranellucci, 2012). On the one hand, this is done to reckon their active role on the place identity formation where the artifacts are found and kept, on the other to facilitate their identification, understanding and passing on to future generations. But the 'passive conservation' alone cannot be the ultimate objective of the intervention: in fact, the more evident is the Cultural Heritage in its material and immaterial, natural and anthropic elements, the more we feel the need to implement boosting, enjoyment and communication actions, necessary to foster a new role for these realities deprived of their original identity, resolving the dichotomy between two of the main necessities: the 'conservative' (necessity) and the 'enjoyment' (pleasure) aspects (Sposito, 2012).

To reach these fairly complicated objectives we have often used architectural protection systems, sheltering or casings, rarely getting good results for the aforementioned necessities. The need to organize the acquired knowledge on sheltering systems, because of the substantial lack of general univocal shared guidelines, is dealt with in an interesting article by Marta Demas, published in 2001 for the Protective Shelters for Archaeological Sites in the Southwest Usa Congress (Tumacacori, Arizona). In the article, the scholar takes stock of the state of the art by examining a first exhaustive review, updated in 2013, of texts in English, French, German, Italian, Spanish and Portuguese, that have been published since the 1960s. She highlights how the literature often does not report on the design aspects and on the criteria analysis that guided the project, on the functionality of the sheltering during its life cycle, and on guidelines-standards for the design of protective sheltering for archaeological remains (Demas, 2001, 2013).

Without mentioning the studies that report the inadequacy of technical and technological solutions for the protection of the weak chemico-physical stability of ancient matter (Stanley-Price and Jokilehto, 2002; Yaka Çetin and İpekoğlu, 2013; Novaković et alii, 2016), among several difficulties, the literature highlights the inability of the sheltering project to act as an interpretive tool, fundamental to recognize values and return their meaning. In most cases, architectural interventions are made up of 'catalogue' elements, similar in materials and shapes, excluding particular archaeological emergencies and intervention contexts (Bartolone, 2013), often returning imaginative/misleading images of (missing) volumes, lacking a relationship with their function and based on the philosophy that Gaetano Palumbo (2002) has defined as 'the shape before function' (Figg. 9, 10). In other cases, denying the accessibility that Marié Berdecou (1990) intends not exclusively as a possibility of physical enjoyment but as an opportunity to know and learn the values and meanings of the Asset, both for scholars and general users. The same problem was noted twenty-five years later by Elena Mussinelli. She states: «the problem of the enjoyment and communicability conditions of the Archaeological Asset emerges, as well as the social and cultural role of Archaeological Heritage problems, with the need to seek new approaches and strategies to make laymen, often lacking the necessary cultural tools, understand the meaning of findings and artifacts, which are mostly not monumental, not easy to read and difficult to be approached» (Mussinelli, 2016, p. 75).

Frequently, there are cases in which the decision to preserve a ruin outdoor is exclusively made for its potential to become a tourist attraction and/or a monetary resource to support the local economy (Castellanos-Verdugo et alii, 2011; Della Torre, 2013). And



*Figgs. 9, 10 - El Molinete Archaeological Park in Cartagena, Spain: the transparent roof designed by Andrés Amann, Atxu Cánovas and Nicolás Maruri in 2011 (credits: D. Frutos).*

there are cases in which the lack of economic and managerial self-sufficiency of the project, over time results in an unbearable burden for the local community and the archaeological Asset is, slowly but steadily, left to its destiny (Agnew, 2002). Instead, there are only a few cases of interventions based on a careful analysis of socio-cultural fall back and the ones based on ethical analysis are even rarer. The latter are of great importance, as they concern choices both for the current and future generations. In fact, in addition to the original ‘material deterioration’ caused by anthropic action and/or natural factors, bringing the remains back to light marks the beginning of new instability and stress processes caused by the change of a multi-secular equilibrium (determined below the surface level), but mostly it produces a process of ‘conceptual deterioration’, a transformation characterized both by the ‘subtraction of meaning’ induced by physical deterioration and by the ‘over-densification of meaning’ derived from contemporary interpretations and actions (Lowenthal, 1995).

Considering the above statements, it is clear that the design of an architectural shelter for archaeological sites is a conceptual operation with an ethical, more than a technical, matrix, which must fit within a wider critical process that is more appropriate to the complexity of the archaeological problem, verifying – with the support of the different areas of knowledge – the possibility to compensate for the subtraction with the over-densification of meaning, identifying the values, interpreting and communicating the meanings for the enjoyment and fruition of every generation, if it is not required only a solution of technical-functional aspects. Critical thinking is twofold: on the one hand aims at knowing the past, on the other aims at interpreting how to better present and communicate the memory. This shows that, despite the many potential approaches for designing protection systems<sup>14</sup>, it is necessary to consider only a systemic methodological option, depending on the value judgements that are expressed on the Asset, how its fragmentary nature is shown, on the relationship of the fragments with the missing part and the different parts with the original image.

Within this framework, this paper deals with the importance of the cognitive process stage aimed at the recognition and multidimensional significance of the values brought by these particular Cultural Heritages. It emphasizes the need for a cross-disciplinary dialogical approach, within a holistic and systemic methodological system capable of understanding and interpreting the complex relationships between the archaeological resources, the natural context and the added anthropic systems. It proposes an evaluation model that provides a tool to understand ‘what’ to preserve and ‘why’ in terms of sustainable development, even before knowing ‘how’ to do it, a valuable tool for a conscious design of protection systems with an architectural value. Its purpose is to facilitate the identification of the morphological, typological and technical-constructive solutions most suitable to reconstitute the potential significance of the Asset or the identification of possible levels of enjoyment (Ruggieri Tricoli, 2012; Figg. 11, 12).

**Value-based and problem-based theory** – Not being able of enhancing and making accessible the whole and vast Archaeological Heritage, we should decide, even before identifying the different viable solutions that operate between the backfilling and the in



*Figg. 11, 12 - The Great Shinto Shrine of Ise rebuilt on the occasion of its 62nd anniversary in 2013, according to a well-established practice that since the Seventh Century has been repeated every twenty years (credits: Ise-Schrein).*



*Figgs. 13, 14 - The Roman Villa La Olmeda in Palencia, Spain: the wide metallic structure of four vaulted roof modules designed by Parades Pedrosa Arquitectos in 2009 (credits: R. Halbe).*

situ museum (Sposito, 2012), ‘what’ should be enhanced and made accessible and what meanings bear the Asset and if they are relevant and to whom. The Burra Charter (ICOMOS, 2013) helps to answer these questions. By defining cultural value as aesthetic, historical, scientific, social and spiritual, and specifying that it is embodied by the place itself, by its structure, by its context, by its use and by its documents as well as by places and objects related to it, the Charter includes (since the first draft of 1999) a series of activities related to cultural value (from conservation to reconstruction, scheduled maintenance, preventive conservation, compatible use, etc.) specifying how they should all be focused on the materiality of the Asset, on its meanings and on its possible associations with other Assets or societies. Although this assumption has been recognized and shared by scholars – starting from Stephan Michalski (1994) and the Reports of the Get-

ty Conservation Institute (Avrami, Mason and de la Torre, 2000; de la Torre, 2005) – and is mentioned on significant publications on the management of the Heritage (Aplin, 2002; Smith, Messenger and Soderland, 2016), the methodological aspects that allow to evaluate, share, weigh and communicate the tangible/material and intangible/intangible values that the Heritage bears are still not sufficiently investigated.

Often diminished as ‘subjective’ or ‘changing social constructs’, then linked to individuals and defined typical to a place and time (Pearson and Sullivan, 1999), values have actually always guided the conservation of Heritage in different cultures. These have often changed their meanings or have attributed different importance to values according to time and context, but always through the promotion of the universal principle that preserving objects and places of the past is a vital function of society and it is an indispensable contribution to human and social development. In the indications of the Nara Document (ICOMOS, 1994, article 11) it is stated that «all judgements about values attributed to cultural properties as well as the credibility of related information sources may differ from culture to culture, and even within the same culture. It is thus not possible to base judgements of values and authenticity within fixed criteria. On the contrary, the respect due to all cultures requires that Heritage properties must be considered and judged within the cultural contexts to which they belong». In this respect, Erica Avrami, Director of Research and Education for World Monuments Fund at the Getty Conservation Institute, states that culture is better understood as a set of processes in which artifacts and sites are conduits for evolving notions of identity and history (Avrami, 2016). Among the different Cultural Heritage Assets, archaeological sites have the best narrative potential and offer an important key to read history and human evolution, crossing the boundaries of time and space.

Universality is the assumption that some Heritage is meaningful to all of mankind, regardless of cultural, social, economic, political, or other differences (UNESCO, 1972). The different approach of Western and Eastern culture on conservation philosophies and on how an entity (material or immaterial) continues to exist – to ensure transmission of Heritage to posterity – shows how identifying a universally applicable code of ethics is a difficult purpose to achieve (Jokilehto, 2009). On the one hand, for the Western culture a Heritage Asset exists as long as its original constitutive material survives – therefore it is mainly interested in the material aspects among which the stop of the physical deterioration, restoration of its previous condition, and so on. On the other hand, Eastern culture is based on the principle that a Heritage Asset continues to exist also with a new appearance (with new materials) linked to the original object, thus allowing the practices of demolition with reconstruction. A typical example can be the Japanese historical buildings, which are often completely rebuilt with new materials and traditional techniques without compromising their historical values (Ruggieri Tricoli, 2012).

Although both approaches use different ways to achieve the same purpose (maintain the meanings and legacy of the Heritage), they share the same evaluation tools, both cultures recognize that the Heritage status for a material or immaterial Asset which contributes to cultural identity is based on the values it bears (Smith, Messenger and Soderland, 2016). On this subject, Iris Kapelouzou (2012, p. 176) observes: «What is further

accepted is that the same Heritage entity may be the carrier of multiple values at the same or at different times. This means that people may attribute different values to the same entity at the same time; that people may attribute different values to the same entity at different times; and also that people may attribute the same values to the same entity at different times. Diverse meanings, associations, beliefs, etc., which accompany Cultural Heritage, may be considered under their respective value, i.e. the value of having that meaning, or of generating that belief». If the aim of conservation is to extend the life-span of the Heritage, then the value of the Heritage itself influences the curators on the necessary tools to reach the main purpose, consistently with the statement of Cesare Brandi (1977, p. 5): «the artwork influence restoration, not the other way round». In other words, the purpose of conservation is to extend the lifespan of the values defining the Asset as Cultural Heritage, while the ‘cultural values’, that constitute the identity of an Asset Heritage identity, define its conservation approach.

Therefore, assuming that the ‘political values’ and ‘economic values’ have often determined which Assets should be included in the Heritage – by using them as a political instrument to shape the identity of a Nation or as an Asset to ease economic growth (Aplin, 2002) – since they do not embody a cultural identity and do not impose a moral duty for the conservation of their respective value (Ruskin, 1982), they must be considered as lower-order values, unable to determine the decision-making process autonomously. At the same time, since different values often pose different conservation demands, once the Asset is known and the purposes are identified, they can be organized on a hierarchical base according to a dynamic model that facilitates a flexible relationship, changing according to the moment in which the identity is perceived (de la Torre, 2005).

**A new method-based evaluation approach focused on significance** – It is established that the cultural value of an Asset has always been the reason for its conservation and if the Heritage was not considered precious, human and financial resources would not be used to preserve it. By integrating the contributions of various scholars (Mason and Avrani, 2000; Demas, 2000; Muñoz Viñas, 2005; Appelbaum, 2007; Cane, 2009; Fredheim and Khalaf, 2016) to evaluate ‘what’ to preserve and ‘why’, it is possible to propose a value-based evaluation methodology, comprising several stages, in order to identify, maintain or amplify, and improve the meanings of an Asset whose significance is the total value of the Asset or the sum of its values. The first stage identifies the values of the Heritage; the second stage defines the reason why the values are significant; the third stage assesses significance through specific value qualifiers (Fig. 15).

Regarding the first stage, the scientific literature has offered many interesting contributions<sup>15</sup> that identify, define and implement the different value types related to the material and immaterial aspects presented in the Burra Charter. Among these values there are: landscape, urban, archaeological, architectural, documental, technical-constructive, functional, educational, economic, political, associative, commemorative, and of context, rarity and authenticity. In order to try and include everything, some scholars have written long lists, while others are ‘incomplete’, and represent only possible examples. On the one hand, in the first case «the wide range and variety of types

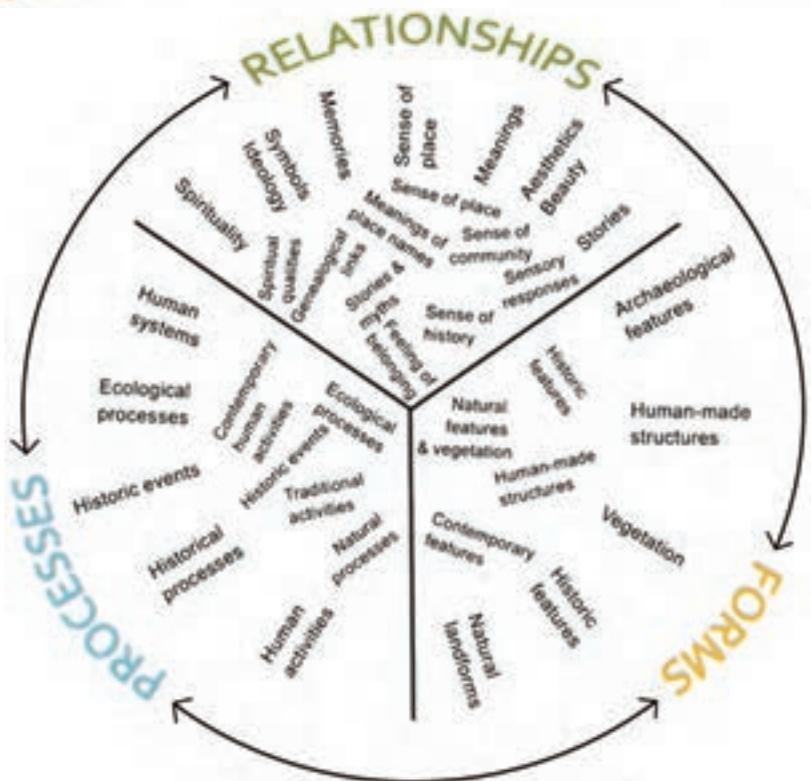


Fig. 15 - Diagram with the sequence of the three identified phases of significance assessments.

Fig. 16 - The three fundamental components of Cultural Heritage: 'forms', 'practices' and 'relationships': the outer circle represents the disciplinary interests in Cultural Heritage and the inner circle represents the values expressed by associated communities (credit: redesign image from Stephenson, 2008).

proposed shows that any attempt to categorize all values is destined to fail» (Rudoff, 2006, p. 60). On the other, a concise list according to which evaluations can be carried out, without grasping the complexity of the holistic interpretations of the Heritage, can question the assumptions that must characterize the decisional stage of the conservation process. If at first, the available literature shows that finding shared values typology is difficult, after a careful analysis it is shown that the long lists can be contained in a shorter but inclusive list, since some values and their typologies can be grouped or combined with others (for instance: the spiritual, the religious and the symbolic, the architectural and the archaeological, etc.).

In this paper it is useful to mention the contribution of Janet Stephenson (2008) who, in response to the mismanagement of the Landscape Heritage in New Zealand, developed a model of cultural values to include the full range of potential values that a landscape can contain – both inside and outside the city – and to promote the understanding of the dynamic relationships they have. Although it has been proposed exclusively for landscapes, the model could be a reference for all kinds of Heritage and even more for the Archaeological Heritage which «can be a tool for building knowledge of places, stratigraphic memory in the territory and cities» (Mussinelli, 2016, p. 76), being part of a context in which they reverberate their sense, showing a historical, structural and systemic attachment.

According to Stephenson, the set of cultural values of a landscape can be represented by three components: ‘forms’, ‘relations’ and ‘practices’. The ‘forms’ include the physical, tangible and measurable aspects of a landscape or a space, that is the totality of natural features (orography, flora, etc.) and anthropic interventions (artifacts, routes, etc.). The ‘relations’ identify the meanings and interpretations of the relationship between man and landscape – including identity, memory, the sense of belonging to a place, spirituality, myth, and so on – but also those in which human involvement is irrelevant or absent, for example ecological relationships. Finally, among the ‘practices’ there are both the anthropic activities and the natural processes – that is, on the one hand, past and present activities, traditions and events, on the other the ecological and natural processes – because, as the scholar stated, they often depend on one another (Fig. 16).

The above-mentioned model allows to grasp on the tangible and intangible characteristics (values) of a Cultural Heritage by using simple languages and types to ease the collection, integration and interpretation made by numerous scholars, technicians, managers and users. By limiting the categories to three – although forms/practices/relations can still be integrated with the typical characteristics of an archaeological landscape – we can have a dynamic reading of the model, necessary because practices, forms and relations interact continuously to change Cultural Heritage (Fig. 17). The economic values have been intentionally withheld because they come from potential values and should be considered only in the final stage of cost/benefit analysis.

Acknowledging that Heritage enhancement should relate to the context in which it lies, it is fundamental for the decisional phase of the conservation process. In its long revision process (1979-2013), the Burra Charter provides that the understanding of the meanings lying in a Cultural Asset happens through the consultation of the community,

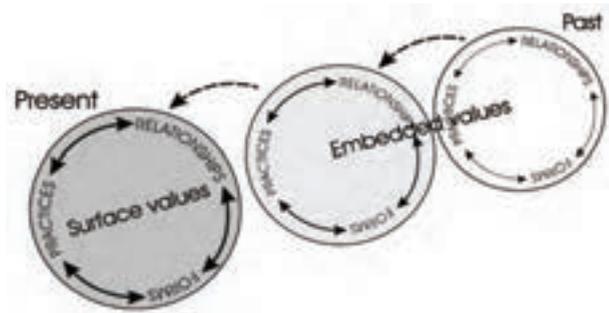


Fig. 17 - The Cultural Values Model, showing surface and embedded values (credit: Stephenson, 2008).

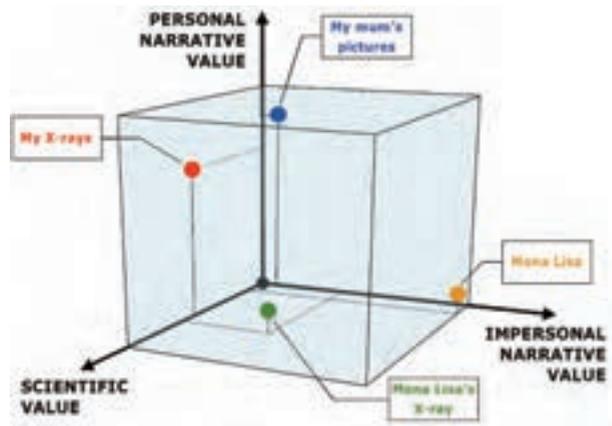


Fig. 18 - The values of conservation objects, according to Michalski: the farther an object is from the axis origin, the more likely it is to be considered a conservation object.

as well as through physical examination and historical research. It is clear that a type of value must grasp and effectively communicate the vision of the different stakeholders – through consolidated participation forms, despite the short time and limited resources of the conservation process – by a ‘symmetrical’ (Schofield, 2016) and ‘dialogical’ (Harrison, 2013) grouping of varied values, not always convergent, that are expressed differently by the different stakeholders, ‘avoiding the abuse of power groups’ (de la Torre, 2005), in order to create common meaningful expressions.<sup>16</sup>

On this subject, we have to mention the interesting and documented study carried out by Stefan Michalski (2018), about shared conservation Heritage decisions that shows how the ‘shared conservation’ usually does not influence the decision, or at least, the experts tend not to consider the contribution of the stakeholders about their special area of competence. Paul Nutt (2002), a Canadian researcher, in his study identifies among the main causes that contribute to a wrong decision the ‘rush to judgement’, the use of ‘unsuitable resources’ and an ‘idea-driven’ evaluation rather than a ‘discovery-based’ one, that is based on knowledge, on the definition of the problem and on the evaluation of the various scenarios. Michalski then proposes a decision model whose consolidated tools of the decision-making matrix and of the decision-making table (together with the main criteria of ‘reversibility’ and ‘stability’ or the ‘priceless’ and ‘irreplaceable’ concepts) are

used as a means to organize and document a ‘shared reflection’, and not to automate complex choices, in which ‘empathy’, ‘responsibility’ and ‘overcoming the dominant technical perspective’ must play a key role.

Once the value typologies and the stakeholders take part in the conservation process, the second stage of a value-based evaluation process has to define why these values are meaningful by identifying their ‘valuable aspects’ for each meaning characteristic. A first rather simplistic evaluation model was proposed by Stefan Michalski (1994) who identified three significance parameters: scientific, social and personal (Fig. 18). The scientific values, determined by the experts, justify the conservation for their evident usefulness and for their unconventional historiographical meaning, on which instead the social values are based. Held by individuals, personal values can be attributed to a minor Heritage. According to the Canadian scholar, by placing the values on a three-dimensional Carthusian reference system, it is possible to find out the overall ‘narrative value’ of an Asset: the more distant it is from the origin, the greater the probability that it becomes the object of conservation.

The proposition of Leif Harald Fredheim e Manal Khalaf (2016) is best structured and clearer. They identify four useful ‘aspects of value’, associative, sensory, evidentiary or functional that should be identified for each feature of significance (value) identified in the first stage. The associative aspects express significant connections. These can be connections to people, events, places, practices, traditions, stories, objects and so forth, overcoming the limitation intrinsic in the adjective ‘historical’ resolving the ambiguity between history and memory. Sensory aspects are sources of visual pleasure, traditionally linked to aesthetics, but also for the other four senses, to favour the inclusion of non-western cultures, and for the intellect. Evidentiary aspects are those that provide evidence for conducting or examine researches, that are not necessarily scientific research. Functional aspects are those related to a use, potential or active, which in some cases helps to justify a continuity over time of the conservation process. It should not, however, be conflated with benefits of use derived from other aspects of value. For instance, Archaeological Assets could be perceived as educational tools; in this context, the word ‘functional’ has a different meaning, as the educational benefits are likely to be derived from evidentiary, associative and sensory aspects of value.

The complexity of the relationships between the different aspects of values underlines the need for meaning interpretation made through the contribution of different humanistic-technical-scientific disciplines but also through the presence of local stakeholders – even admitting a hierarchical sequence – that are explicit without preconceptions favouring the inclusion of knowledge forms that may seem marginal (Waterton, Smith and Campbell, 2006; Lemonnier, 2012). The third stage has to consider the resolution of possible discord caused by the previous two and identify the most meaningful characteristics and aspects of value. This type of evaluation is fairly complex because, as stated by Iris Kapelouzou (2012), it cannot be connected to quantitative parameters but must be expressed through qualitative judgements and by assessing levels of significance that are complex and hard to deconstruct. Some of the values identified by scholars can be better understood as value qualifiers, or rather, as value multipliers,



*Fig. 19 - The Roman Archeological Excavations in the area of Welschdörfli in Chur, Switzerland. The envelope horizontal texture, designed by Peter Zumthor in 1985, is composed of horizontal wood timbers that shade the sun while allowing air in and suggest a temporary form in contrast with the permanence of the stone ruin inside (credit: clemsoningenoa; Felipe Camus).*

*Fig. 20 - The Praça Nova archaeological site in Lisbon, Portugal. Designed by João Luis Carrilho da Graça and João Gomes da Silva in 2010, the shelter follows the contour of the ruins, proposing a complete perception of the living space; it is a poetic design, congruent with the museographic requirements of a captivating and evocative communication (credit: F. Guerra).*



*Figg. 21, 22 - The Great Baths and the Römer Museum in Archäologischer Park Xanten, Germania, designed by Gatermann und Schossing Architekten in 2000-08 (credits: LVR Archäologische Park Xanten and Axel Thünker).*

since, although they are not sources of meaning, they can increase or decrease their weight or perception; three of these are ‘authenticity’ (Throsby, 2002), ‘rarity’ (Appelbaum, 2007) and ‘state of conservation’ (Pye, 2001).

About authenticity, both the Venice Charter (1964) and the Nara Document (ICOMOS, 1994) state that it should have a fundamental role in all scientific studies on Cultural Heritage, in conservation and restoration planning, to qualify – through valuable judgements – a great variety of material and immaterial ‘sources of information’. Although the authenticity, as it was defined, may not be equally relevant for every aspect of value or for all stakeholders – it can also qualify the associative and sensory aspects of value (perceived) – it is crucial for the research that deals with the evidentiary aspects of value as it represents the quality of the evidence. If rarity can be used to sharply increase the meaning of aspects of value, by highlighting the Heritage considered as ‘irreplaceable’ (Throsby, 2002; Staniforth and Lloyd, 2012) and therefore ‘infinitely’ valuable (Michalski, 1994), the state of conservation, that shows the past damages and the potential vulnerability to the future damages, influences the significance of an Asset,



*Figg. 23, 24 - Protective shelter and reconfiguration of the Porta and via Pretoria of the Roman town of Vindonissa, in Windisch, Switzerland, designed by Peggy Liechti, Lukas Zumsteg and Adreas Graf in 2007 (credits: Tricoli, 2011).*

since as the deterioration progresses, the capacity of the affected aspects of value decreases. According to UNESCO, conservation aims to protect Cultural Heritage from any change, damage or loss caused by time or by man, foreseeing the transmission to future generations, thus avoiding the «impoverishment of the Heritage of all the nations of the world» (UNESCO, 1972, p. 1). In these terms, the results of a conservation intervention can be evaluated according to the caused or avoided damages and losses.

**Conclusions** – Finding the right balance (compromise) between the different necessities (values), often in contrast, about conservation and protective sheltering for archaeological Assets is not easy and the debate originating from different interventions of contemporary matrix (for example the cases of the Roman Theatre of Sagunto, of the Ara Pacis Museum in Rome and of the Villa Del Casale in Piazza Armerina; Figg. 25-29) confirms the fragility of this matter and the need to face the subject with caution. On the one hand, the conceptual difficulties should not promote the renunciative principle of case-by-case (although the peculiarity of every intervention, archaeological rest and context in which we



*Fig. 25, 26 - The ruins of the Roman Theater of Sagunto, Spain, and its reconstruction designed by Giorgio Grassi (1985-1993).*

intervene is shared). On the other hand, we must recognize that some theoretical cornerstones can be useful to fix 'basic' principles and to open to constructive reflections.

1) The Cultural Heritage is intended as a dynamic concept, bearing different meanings, allocated according to different hierarchical scales by different organizations types that are not only geographical (linked to different places) but also temporal (linked to different historical eras). This entails that identity and Heritage – from past and current values – detected now are just one of its possible projections. Similarly, conservation interventions should not be considered as a product of the current actions on ancient matter, but as a process concerning a set of activities, changing over time, which concerns the material/tangible (already transformed matter) and immaterial/intangible (identity and value) aspects and which identify the criteria, structure the programmes and define the fundamental procedures for conservation, protection and safeguard, the boosting, enjoyment and management of the cultural artifact, also and especially to future generations. Although the transition from a material-based to value-based conservation does not necessarily require radical changes in operational strategies, the value-based paradigm provides a different approach for assessing and communicat-



*Figg. 27, 28 - The Ara Pacis Museum in Rome, Italy, was designed by Richard Mayer (1997-2006) to replace the previous building considered inadequate to protect the Monument.*

ing the necessary conservation actions and it influences its practices. If the evaluation of cultural value and meaning has a less impartial basis than the technical-scientific evaluations abiding with material/physical aspects, the value-based paradigm, with the support of the different disciplines, offers a new vision for conservation, overcoming the traditional imperatives of ‘revealing the original object’ and of ‘minimal intervention’.

2) We can reduce the wide range of values to three types: forms, relations and practices, according to a dynamic model that allows to collect, highlight and interpret with a clear language (also for the users) the various tangible and intangible values (more difficult to understand and therefore easier to ignore or reject) of a Cultural Heritage. Then, we should explain why the values are significant and evaluate their levels of significance through particular qualifiers/multipliers, in order to identify, maintain or amplify, and improve the meanings of an Asset whose significance is the total value of the Asset or the sum of its values.

3) The identification of clear and precise objectives is a fundamental step for the development of an operative method aiming to Archaeological Asset conservation, influencing the planning stage and supporting the evaluation stage, ensuring that the decision-



*Fig. 29 - The Villa Romana del Casale in Piazza Armerina, Sicily, Italy: the reconfiguration projects designed by the Istituto Centrale del Restauro (2004-2012); the recent project resolves the problems of conservation performance, lighting and visitor circulation, and improves the visitor experience (credit: Roman Babakin/Alamy Stock).*

al phase considers the identified values, defines their priority, and solves potential clashes due to the different importance that the different stakeholders attach to them, identifies the intervention levels and finds the right compromise between design approach and presentation mode, within the matter protection demands and value enjoyment.

4) The appropriateness of an intervention strategy is determined by the specific cultural meaning of the site, from which values and messages to be conveyed derive, and their understanding does not depend only on the methods used in the investigative approach, but often on the level of involvement of the stakeholders, a variety of people with different cultural and social backgrounds that take part into the interpretation and demand different fruition conditions, and in an open dialogue between the archaeological Asset (artwork) and the concerned person (Eco, 1962).

5) The success of a conservation intervention can be evaluated through the adequacy of the communication of the set of values and meanings of the Asset – even before the proposed technical solution – being the conservation more an art than a science and being technical tools simple means to extend the lifetime of a site through messages that reflect its values (Stovel, 1994). The value-base approach involves the creation of value judgements that result in evaluations of the meanings of the object to be preserved, not wanting to undermine the strategic scope and effectiveness of this type of approach, it is necessary to explain what is precious and why, through clear documentation that can make it possible for future generations and designers/conservators that

will work to understand the whole decision-making process, what values have been considered, their interpretations and why those specific actions to enhance and enjoy the Asset have been taken.

To this purpose a 'statement of meaning' might be useful, it must detect and express the significance of an Asset and how this significance has been damaged over time. The contents and the organization of the document should allow to confront the different value judgement. Then a 'statement of conservation purposes', that must clearly express the purposes of the intervention and the envisaged actions to show or improve significance or the general conditions of the Asset. The structure of the document should allow to observe the conservation intervention as a cultural process, beyond its merely technical and scientific aspects. Finally, a 'statement of importance' that must summarize the important values and meanings according to a hierarchical scale and present the final evaluation as the conjunction of meanings attributed by the community to a specific Cultural Asset.

6) The range of subjects that comes into play in the conservation process, the not so objective nature of the significance evaluation and the importance that is attached to it, the risk that some kind of values can overcome others for ideological, political or economic matters, demand final decisions marked by sustainability principles well defined by David Throsby (2002): a) foster intergenerational equity, considering the necessary transmission of the Asset to future generations; b) foster intragenerational equity, that is allowing a wide participation of the community in the cognitive and decisional phases of the conservation process; c) foster 'cultural' diversity; d) using the available resources – economic, human and environmental – in a wise and strategic ways, on a long-term period; e) adopt the precautionary principle, acknowledging that there are irreversible consequences and that they can lead to the total or partial loss of matter or values and their meanings; f) recognizing interconnectedness, particularly between our Cultural Heritage and our contemporary society (development, education, and so on).

7) Although the reference literature suggests a first classification as 'provisional' or 'permanent' due to their lifespan linked only to excavation procedures and restoration or to the longest boosting operations aiming to its enjoyment (see note 14), all the sheltering interventions with architectonic value are considered 'temporary'. This concept is based on the dynamic-evolutionary dimension of the knowledge of the material aspects (depending on the results of potential excavation processes in neighbouring areas or on typological-distributive comparisons with Archaeological Assets of the same period and belonging to the same culture that can be revealed in the near future). The concept is also based on the temporary/subjective characteristics of the immaterial aspects (meanings), interpretation proposed by the generation participating in the conservation process and in the new meanings of future generations.

In the light of the aforementioned principles, within the conservation process of Archaeological Heritage it is clear how the Technological Culture can play an important role for the central aspects of processes necessary to a suitable enhancement and great enjoyment of the Asset. But it should also make its contribution to the knowledge of some material and immaterial aspects and to build a holistic and systemic methodological apparatus capable of understanding and interpreting the complex relationships be-



*Fig. 30, 31 - The Villa Romana San Pancrazio in Taormina, Sicily, Italy: the project of the protection shelter designed by Alberto and Cesare Sposito (2005), with the evocative reconfiguration of the peristyle and the walkway systems for the fruition of the mosaics.*

tween the archaeological resources, the natural context and the added anthropic systems. On the basis of the stated objectives, once the declarations of meaning and importance are acquired, the unexpressed needs of the subject and the expressed needs of the communities are evaluated, the technical project will be able to identify the requirements for the enhancement and enjoyment of 'forms', 'relationships' and 'practices', give to the Asset a new role and a new identity within consolidated or formation fabrics (urban, non-urban or landscape) and set up a contemporary sheltering system (with morphological, typological and technical-constructive solutions most suitable to return the potential significance of the Asset) being performing, reliable, sustainable but also reversible, due to the different meanings that the following generations will or might allocate.

# **WATER**

## **A TRADITIONAL MATERIAL TO BUILD A NEW SUSTAINABLE ARCHITECTURE**

### *ABSTRACT*

*Within an increasingly consolidated architectural practice aiming at environmental sustainability and energy self-sufficiency, the article reports international research and experiments carried out on water-architecture. Furthermore, it highlights how, starting from the excellent capacity of the fluid to heat and cool its surrounding space, we can think to water as a material component of architecture.*

### *KEYWORDS*

*water, architecture, innovation, trans-structure, multifunctional element*

Among the materials that nature offers us, water has always been closely linked to man, driving his choices in settlement and production processes, his activities of changing the landscape and the environment. The water-man relationship, focused since its start on managing subsistence and regulation problems, through a continual remodelling of the water-land line. Water is essential for the different life forms, and has taken on various symbolic meanings, stimulating different artistic expressions, from literature to painting,



*Fig. 33 - Kaufmann House, Fallingwater, Pennsylvania (Frank Lloyd Wright, 1935-37).*



*Fig. 34, 35 - Kaufmann House, Palm Springs, California (Richard Neutra, 1946); Farnsworth House, Plano, Texas (Mies Van der Rohe, 1951).*

from sculpture to architecture. The relationship between water and architecture has always been characterised by many forms, functions, systems, sometimes by failures and others by with successes. To stay close to our times, we should only mention the great masters of the last century who, in their operational research on housing units, used water with a symbolic value or as an instrument for a better integration with the landscape (Rowe et alii, 1997; Weston, 2004; Williamson, 2013). For instance: Frank Lloyd Wright, breaking traditional patterns, geometry and volumes, integrates architecture



*Fig. 36, 37 - Casa de Canoas, Rio de Janeiro (Oscar Niemeyer, 1953); Waterfall, East Side e Brooklyn Bridge, New York (Olafur Eliasson, 2008).*

with the landscape in Fallingwater (1935-37), fully assimilating water in the building (Fig. 33); in the Kaufmann House (1946), Richard Neutra used the pool to mediate the impact with the arid landscape (Fig. 34); Mies Van der Rohe realised the Farnsworth House (1951) on a mezzanine to solve the continual flooding problem (Fig. 35); Oscar Niemeyer with the Casa de Canoas (1953) in Rio de Janeiro, offered free curves and sinuous shapes through a perfect combination of glass, concrete, vegetation, rocks and water (Fig. 36). Even artists are attracted to the possibility of using water in their works, as:



*Figg. 38, 39 - Floating Piers, Lake Iseo, Brescia, Italy (Christo e Jeanne-Claude, 2016); Fondation Cartier pour l'art contemporain, Parigi (Jean Nouvel, 1994).*

the recent macro installation of Olafur Eliasson, *Waterfall* (2008) in New York, an artificial waterfall located in the East River, and the Brooklyn Bridge, consisting of a steel scaffolding from which the water comes down (Fig. 37); and Christo and Jeanne-Claude's *Floating Piers* (2016) macro installation made with polyethylene walkways at

Lake Iseo near Brescia, which allowed visitors to walk just above the surface of water (Fig. 38). Those are some famous examples. But in the last twenty years, new operational research and experimentation have determined interests and development of which we will deal with in the paper, to conclude with some considerations on the role that water might have in the near future of architecture.

**First experiments on integration between water and architecture** – Already in the 1980s, the Archistar went down a new path leading to the dematerialisation of architecture, through the use of transparent glass volumes. The blurring architecture theorised by Toyo Ito, with the support of technology and an in-depth research of materials, generates architectures free from their own materiality and can be traced back to that fragility that usually characterises temporary installations (Fig. 39-41). According to Ito, the representation of a fluid space is achieved with the extreme reduction of its structure following of Mies Van Der Rohe motto «less is more». The researched fading of matter has new forms of expression through the use of the most natural and ancient material: water. Even though water attracted consideration and experiments for its environmental value, it still is hardly integrated to the architectural project and its role of building material is more ideal than real.

In this respect, the few attempts are attributable to a strand of physical-technical research which, thanks to innovative hydraulic and technological systems, creates scenes with a symbolic, narrative or scenographic value, while simultaneously addressing environmental and microclimatic issues. Schiaffonati remarked how in recent years water has played «the role of re-representative paradigm of new forms and intervention modalities in the buildings» and that we count on it to characterise the environmental, architectural and landscape project (Schiaffonati and Mussinelli, 2008), in its three states gaseous, liquid and solid (Ruban, 2014). The following three interventions are particularly significant.

The first project was defined by the designers as an architecture of the atmosphere, which shapes a low-definition space, is the Blur Building: a temporary pavilion built in 2002 on Lake Neuchatel in Switzerland designed by Diller Scofidio + Renfro on the occasion of the National Exhibition. The steel structure is surrounded by an artificial cloud made of sprayed water, taken directly from the lake, obtained through a complex hydraulic system of pumps, filters and nozzles run by an IT system and sensors. The sensors regulate the pressure according to atmospheric parameters, detected in real time, such as wind direction and speed, atmospheric pressure, humidity and air temperature (Fig. 42). The goal of the designers, fully achieved, was to generate a surreal experience, first visual at a distance, then sensory on the inside, making the user perception blurred and out of focus, from which the term blur. The technologies used are not strictly functional to the building, but create an interactive system in which the raincoats with sensors, once wet, colour and emit sounds (Gasperini, 2012).

The second project is the Digital Water Pavilion, created for Expo 2008 in Zaragoza and is the result of the collaboration between Carlo Ratti and MIT. It offers us a new reading of the curtain wall, this time fluid and dynamic, creates flexible spaces and with



*Figgs. 40, 41 - Mediatheque, Sendai, Japan (Toyo Ito & Associates, 1995-2000); Glass House, Groningen, Olanda (Bernard Tschumi Architects, 1990).*

light modulators, is able to interact with its users and the microclimate. In an area of 400 sqm, the two small boxes (Info Point and Café) are juxtaposed, incorporated in a single mobile roofing, a thin slab filled with water, with voids of different sizes, two of which coincide with the service boxes (Fig. 43). Twelve hydraulic pistons shift the horizontal



*Fig. 42, 43 - Blur Building, Neuchâtel, Switzerland (Diller Scofidio + Renfro, 2002); Digital Water Pavilion, Saragozza, Expo, designed by Carlo Ratti and MIT in 2008 (credit: M. Tomasinelli).*

surface, removing the internal space when the level of the roofing corresponds with that of the ground. The pavilion takes to the extremes the relationship between space and structure, full and empty, inside and outside; vertical partitions dissolve in diaphragms of water, thanks to digitally controlled high-frequency jets, always allowing different



*Fig. 44, 45 - Hydropolis | Centre for Environmental Education, Breslavia (ART FM Architecture Studio 5, 2015); Ice Hotel, Jukkasjärvi, Sweden (2007).*

spatial configurations. This pavilion was a contemporary version of the futurist architecture, characterised by its communication ability: the digital control of the water jets and the intrados of the roofing permit to create drawings, textures and write in the water curtains, real timed voids that keep changing the work. A similar experience is offered by

the Hydrocolis Environmental Education Centre in Breslavia, project designed in 2005 by ART FM Architecture Studio 5 (Fig. 44); also in this case the use of water is relegated to a simple digital water curtain, juxtaposed with a casing covered with perforated copper sheets illuminated with multicoloured LED (Mattei, 2012).

Finally, the third intervention: unlike the previous examples, in which water is used in gas and liquid states as a media tool and scenographic expedient, in the ICE Hotel solid water is a structural material, although ephemeral, and never bound to the weather or the place. Every year, mainly in the Arctic Circle, hotels are created thanks to huge steel entrings, which are removed every two days as soon as the snow vaults become self-supporting, and the central ice columns turns into the only support for the roofing (Fig. 45).

**The Water Drum Wall** – Is a particular system, experimented from the 1940s to the early twenty-first century based on some principles. An important part of total primary energy consumed by buildings is used for heating, cooling and ventilation, which have a considerable impact on management costs, energy demand and carbon dioxide emissions. Its high thermal mass allows water to be used in passive solar systems, mainly in climates with a significant thermal excursion between day and night. The Drum Wall is an alternative to stone, brick or concrete partitions, according to the operating system of any Drum Wall, or it can be a roof with the roof radiation trap, widely theorised and experimented by Baruch Givoni in the 1970s (Haggard et alii, 2000).

The Water Drum Wall works in a rather elementary way: the rays of the sun crossing the glass surface are intercepted by a mass of water or other liquid that converts them into heat, distributed by convection or radiation from its ventilated cavity to the served room, through the wall's internal face. The relationship between the heat exchange surface with the indoor environment and the storage mass also determinates the extent of the thermal transfer and its delay. Convective heat transfer through a liquid mass is faster than by conduction within a wall. Therefore, unlike what happens in the Drum Wall, the heat transfer to the indoor environment by radiation and convection from the inner face of the wall is almost instant (Simmons, 2011). Therefore, in order to control convective motions, controls delaying heat transfer should be installed: on the inside of the water wall it is necessary an insulating screen with openings at its top and base, while on the opposite side a mobile insulating screen that prevents overheating or, if necessary, outward heat loss (Emmitt, 2012).

Far from being a new technology, the water drum wall was first tested in the late 1940s by Hoyt Hottel and the students of the Massachusetts Institute of Technology in Boston. Despite its good performance and low cost, the building sector has turned to more expensive and often less performing passive solar systems. In the 1970s some designers had renewed interest in this technology: Steve Baer in his home in Corrales, New Mexico, used 208 litres of water in drums to provide thermal mass with an innovative passive solar design (Fig. 46). The same system was used, but with the variant of the underground water wall, by John Hammond on his farm, in a new office building in Winters and by Marshall Hunt and Virginia Thigpen in Davis, both in California. Both passive systems are still fully functional after more than 30 years. Also a couple of en-



*Fig. 46 - House with Water Drum Wall, Corrales, New Mexico (Steve Baer, 1972).*

*Fig. 47 - Translucent fibreglass cylinders for heat storage, SUN-LITE®, Solar Components Corp.*

*Next Page. Fig. 48 - The Water Drum Wall with porous ceramic containers (credit: Melero et alii, 2011).*

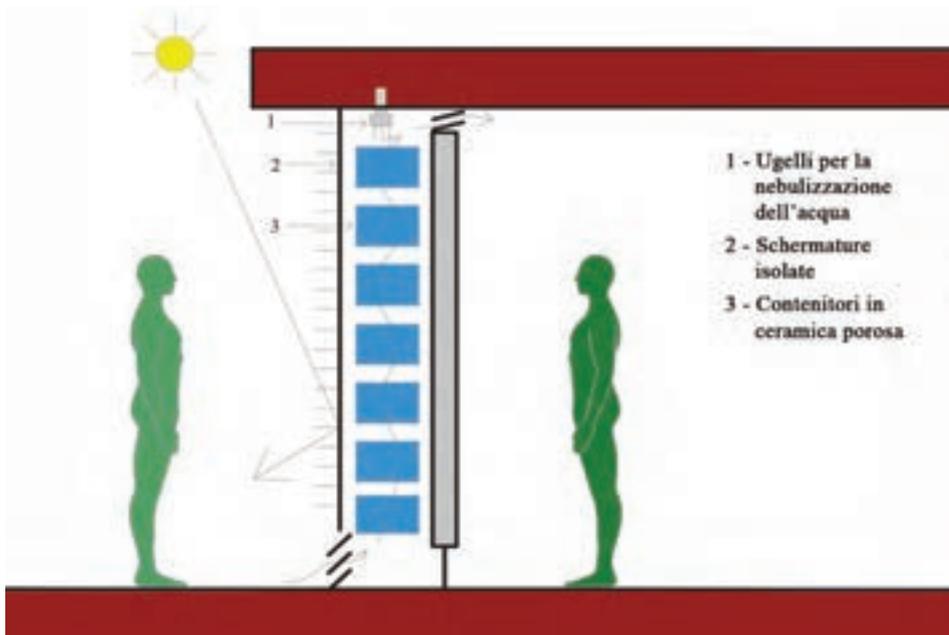


lightened builders, Mike and Judy Corbett, invested in new technology and built 220 residential units with large water walls inside the Village Homes in Davis, designed by John Hofacre (Bainbridge, 2007; Corbett J. and M., 2000).

Starting from these pioneering initiatives, over the years, many have provided an important contribution to research and experimentation of the water walls (Bainbridge, 1981, 2005), including: Tom Neubauer an agricultural engineer who dealt with the seismic safety aspects; Denny Long designed and built for the Passive Solar Development different types of steel tanks; Wayne and Susan Nicols, after studying cement tanks, contributed to the development of the Heat Wall™ system that employs vinyl containers with an aluminium and stainless steel frame; Tim Maloney, of One Design, has tested

modular systems with plastic containers and metal sheets; Solar Applications and Research Group of Vancouver, California, and the Water Wall Engineering Group, in Ohio, have worked on thin steel pipes with plastic coatings; a group of engineers from Kalwall Corporation (now Solar Components), together with other technicians of the Ames Laboratory, patented special cylinders and translucent fibreglass panels (Fig. 47).

**Recent research on the Water Walls** – In the last fifteen years, within an architectural practice increasingly aiming to environmental sustainability and energetic self-sufficiency water was rediscovered for its ability to heat and cool the microclimate of enclosed spaces (Saadatian et alii, 2012). The research and experiments initiated by many professionals that deserve to be mentioned and read: on the optimisation of computer models to evaluate the qualities of water as an energy accumulator (Gupta and Tiwari, 2002) and on the development of calculation methods to evaluate its energy performance in relation to ISO 13790: 2008 (E) (Brig-Sáa et alii, 2014); on experimentation, aiming to optimise the water wall thickness to allow the indoor environment, in winter to increase the temperature at a higher speed, to reach higher overall temperatures and to maintain high temperatures for more time (Adams et alii, 2010); on the overall energetic performances of the buildings that use water walls, with improvements between 25 and 88%, in summer and winter (Moustafa and Aripin, 2014; Wang et alii, 2012; Yang et alii, 2011); on innovative materials such as porous ceramics (Melero et alii, 2011), that can absorb significant quantities of water sprayed by nozzles, appropriately placed at the opening intrados, and release it as a steam to cool the indoor space (Fig. 48); in the study



of shading typologies, such as Venetian blinds in different colours, and of natural and forced ventilation controls (Zhongting et alii, 2015).

Finally: on the conceptual development of dynamic facades with seasonal dimorphism, called Transparent Water Storage Envelope (TWSE), for better thermal stability in summer and more effective thermal insulation in winter, with technical details useful to facilitate the necessary maintenance of the casing (Liu, Shen, 2007, 2008). We should mention the review by a group of Chinese researchers on the Drum Wall in buildings, which emphasises fundamental design parameters such as: the parameter Drum Wall (performance of windows, surface and shading devices, depth of the space between walls, thickness and stratification of the internal partition, natural or forced ventilation systems); the parameter building (thermal inertia and total insulation level of the building, presence of other glass panels); finally, the position parameter (solar radiation, orientation, speed and wind direction). All indicators are summarised in terms of energy, environmental sustainability and cost (Zhongting et alii, 2017).

**A new conceptual model** – The experiments described above on the integration of water in architecture, as well as the physical-technical research, could make us think that in the near future we will be able to use water as building material. Build with water, will represent a new frontier for sustainable architecture, provided that it is based on a new energy model, able to enhance the thermal mass and energy medium of the natural green fluid characteristics. The new architecture must be conceived as a living organism independent from the energy distribution networks, as a trans-structure, energetically self-sufficient, made of multitasking materials, capable of real-time responses for preserving the indoor comfort.

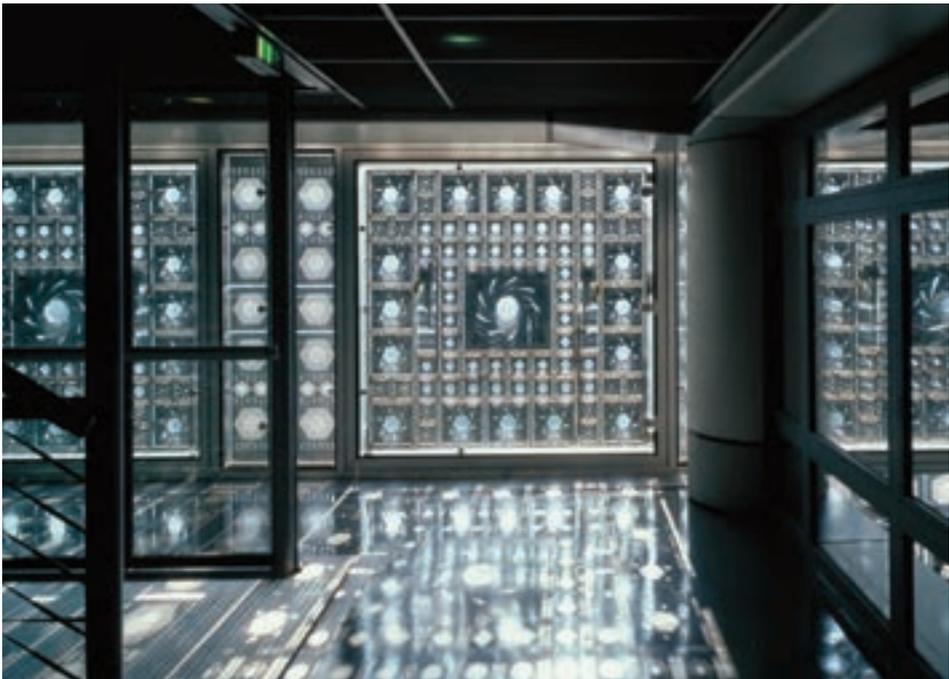
The two approaches of the sustainable architectonic practice, Passivhaus (Fig. 49) and Active House (Fig. 50), do not deal with the critical subject of embodied energy: the total amount of primary energy consumed in the life cycle of the material, which includes the energy needed for the extraction, processing and transport of raw materials, periodic energy for maintenance and final energy for disposal (Cabeza et alii, 2013; Hammond and Jones, 2008). Also, the energetic and environmental sustainability assessment methods for buildings (leed, breem, casaclima, itaca, dgnb, hqe, casbee, etc.), although valid and effective design guides, neglect the embedded energy, not allowing an objective comparison between different projects. No difference is highlighted, for example, between a building made with traditional technologies and with laser-cut curtain wall profiles with immense energy demand. In order to make an objective comparison could be useful tracing all the variables of the project (availability and sustainability of raw materials, processing and transportation of building materials and components, heating and cooling, ventilation, consumption, disposal, recycling, etc.), connected and interconnected to a single unit of measurement: the energy related to the unit of square footage, expressed in MJ/m<sup>2</sup>.

The versatility of the system is another important requirement to reach the objective. A Trans-structure can be defined as a structure that, subject to an external action such as a force field or an environmental stimulus, can change its composition, shape or



*Fig. 49, 50 - PopUp House, Passivehaus (Multipod Studio, 2013); Genyo Building, Building Integrated Photovoltaics (BIPV), Granada (Planho Architects and Onyx Solar, 2008).*

function to respond to stress, maintaining its structural and/or energetic stability and reversibly adapting to changes (Schnädelbach, 2010). In case of a building, several factors have to be considered, changes may occur rapidly and be concentrated in some cases; while they can be slower and affect the whole building in others. Either way, trans-structure can work effectively if the system generates rapid responses even for small changes in the environment. Because, when it comes to thermal comfort even change of 2-3 degree Celsius can make a difference. In addition to speed in reaction, we need



*Fig. 51, 52 - Al-Bahar Towers, Abu Dhabi (Aedas Architects e ARUP, 2012); Institut du Monde Arabe, Paris (Jean Nouvel, Architecture-Studio, Pierre Soria and Gilbert Lezenes, 1987).*

to predetermine what measures to implement. For example, an increase of indoor temperature can be counteracted with cooling, or more thermal mass and complex mechanised dimming systems (Figg. 51, 52). The smart materials, result of the electronic and computer revolution, are the most recent expression of this artificial intelligence. Although in some respects, they are similar to biological systems and natural organisms and favour a good energy efficiency and a better thermal comfort, most smart materials are characterised by a very high embodied energy (Casini, 2016).

Generally speaking, the buildings both traditional and more recent are based on the principles of bio-architecture and are mainly made with mono functional building elements: for each new task and/or demand (function) a new element is added to respond. On the contrary, fulfilling the requirements of sustainability and energy efficiency only brought additional components in the modern buildings, exponentially increasing its embodied energy. A Trans-structure uses a few multifunctional materials capable of generating rapid responses, affecting the whole building. For example, a water wall is not only a boundary or support but, when necessary, also a heat collector, a heater or cooler. In this respect, conventional elements used in the design like orientation and solid-transparent proportion of facades become obsolete, we could be free to use north and south glass casing, equal in the sense of energy and thermal comfort.

**Water as a building material** – The research and experiments of Matyas Gutai goes in this sense of progress, they were carried on respectively at the Department of Architecture at the University of Tokyo and the Thermal Physics Laboratory of the University of Technology in Budapest. The results are shown by the Allwater panel patent and the realisation of the Water House prototype (Gutai, 2013; Figg. 53-56). The developed model provides a casing made of a multifunctional component, which acts as a partition but also as a structural element, thermoregulation, insulator, medium for energy distribution, thanks to the thermal mass supplied by water. The panels were made with Structure Insulated Panels (SIP) and from glass with a cavity containing water, which provides structural mass and weight. The insulation of the structure, necessary because of the strict legislation in Europe, was sufficient enough to protect the water layer from freezing or in case of heating system failure. Experimental data shows striking results, since, during the calendar year, with outdoor temperatures between -15 and +35 °C, the internal surface of the partition maintains a temperature between +20 and +26 °C, eliminating the external energy demand for thermal comfort (Gutai, 2015; Fig. 57). When the optimal indoors temperature is reached thanks to convection, the energy surplus, stored when necessary, is transferred (through a two-dimensional water flow, hot or cold, which flows inside the partition panels, floors and ceilings) in an external tank in the ground (Figg. 58, 59). The only energy demand for the thermoregulation of indoor spaces is the energy required to move water around in the circuit.

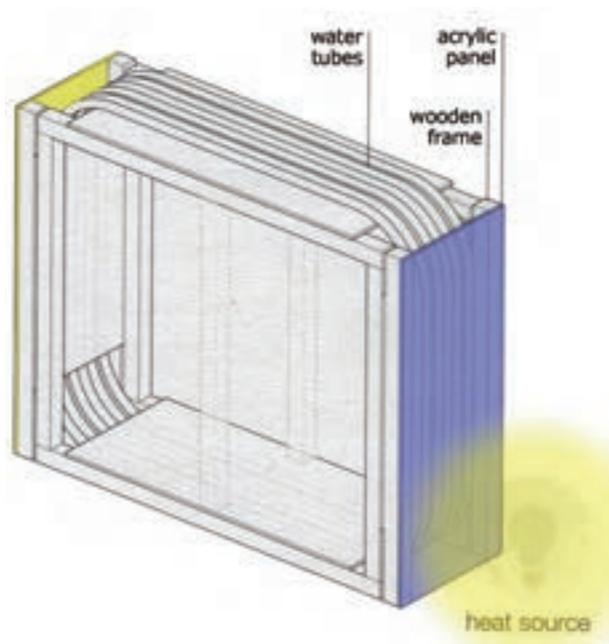
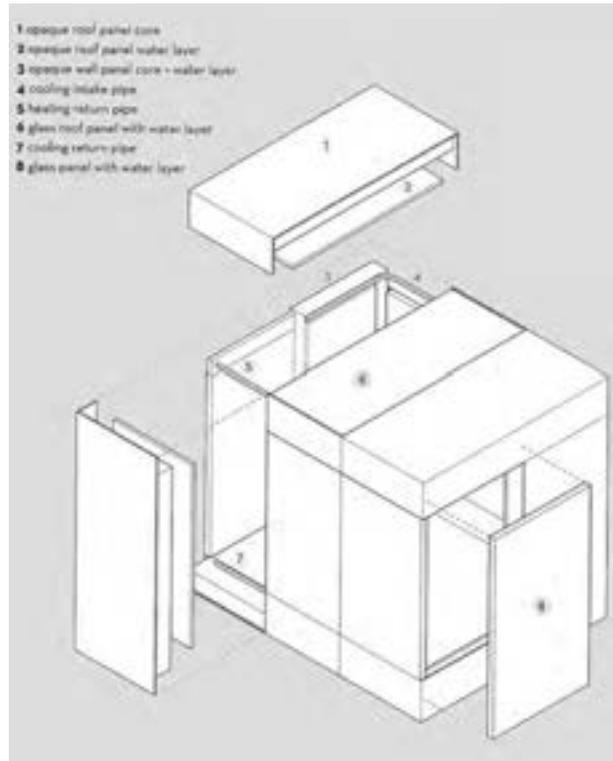
Similar is the Water-branch House by Kengo Kuma, a Japanese architect and designer, who in his research has often investigated minimal architectures, based on the use of simple and easy to set up structures that would allow to quickly build an effective shelter in case of emergency (Figg. 60-62). The Water-branch House, partially exhibited at the



*Figg. 53, 54 - Prototype of the Water-House (M. Gutai, 2014), Kecskemet, Hungary (credits: AFP).*

*Next Page. Figg. 55, 56 - Water-House (credits: M. Gutai, 2015).*

MOMA, New York, in 2008 for the exhibition Home Delivery Fabricating the Modern Dwelling, uses light plastic blocks filled with a fluid for the heating/cooling of the indoor space. The component is like a brick made by the union of five cubes of 100x100 mm, and can be assembled by interlocking: thanks to the particular geometry of the modular element it is possible to arrange it to create floors, partitions and roofing. Con-



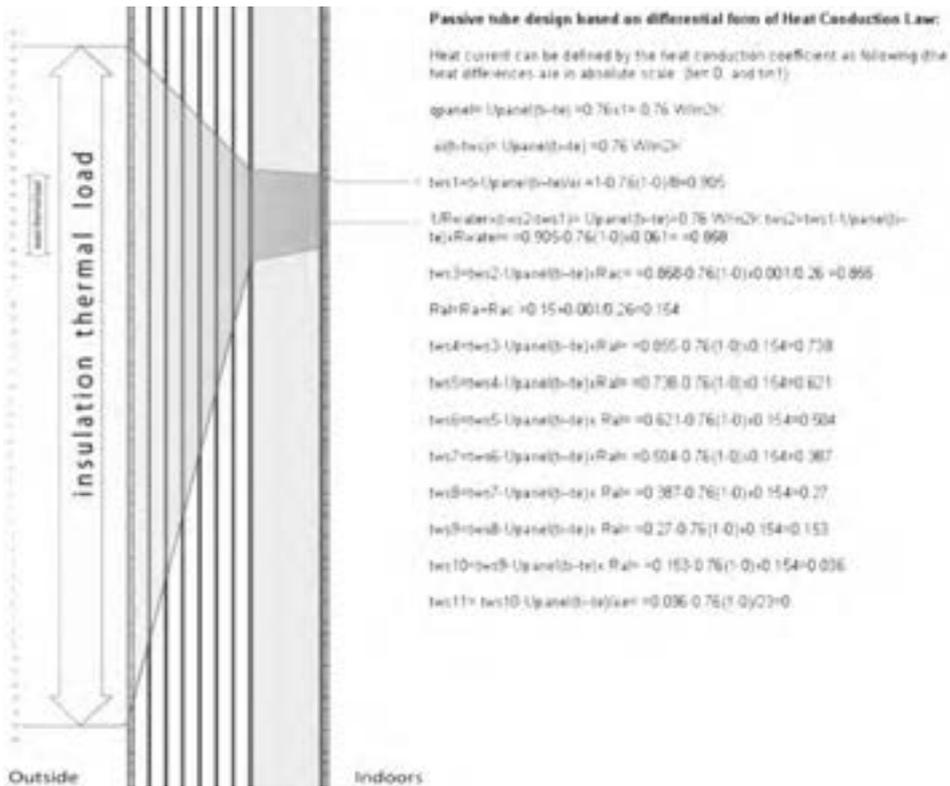


Fig. 57 - Water-House: diagram of variation of the internal temperature in summer and winter (credit: M. Gutai, 2013).

ected to geothermal heating and cooling, available almost any location in Japan, the hypothetical structure is an ideal fusion of lightweight structural core and thermic medium: water. Also in this case, thermic external effects were counteracted by the considerable water thermal mass, and in case that proved to be insufficient, geothermal energy would be used. The solution proposed by Kengo Kuma is even more innovative if contextualised in the energetic reality of Japan, where all the cities of the archipelago depend on Tokyo’s centralised services.

**Conclusions and future developments** – Within a current design practice increasingly characterised by the attention to natural materials and that employs sustainable technological solutions, even though not always passive, water can play an important role in integrating new functions to the ones currently undertaken. Natural and endlessly recyclable material, easy to find on site, with high thermo-hygrometric performances, excellent energy medium with very low operational energy and zero embodied energy. Water can take on the role of a new representative and constructive paradigm for architecture, on the basis of the above-mentioned architectural experiments and of physical-technical research. To do so, it will be necessary to examine in depth a number of issues on various subjects.

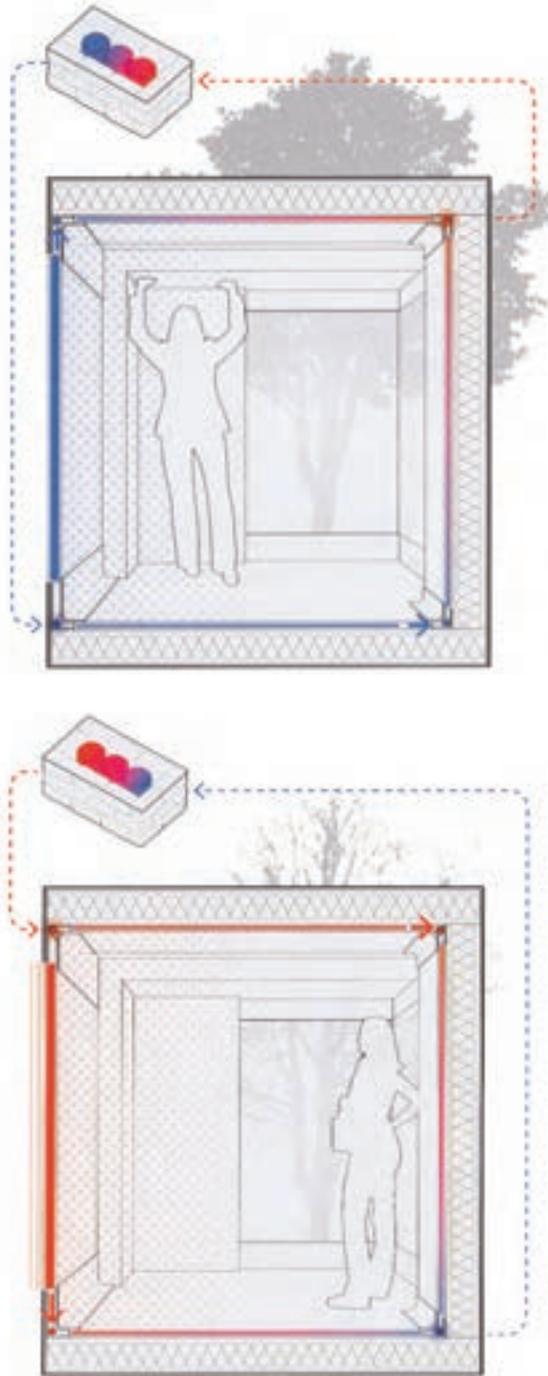
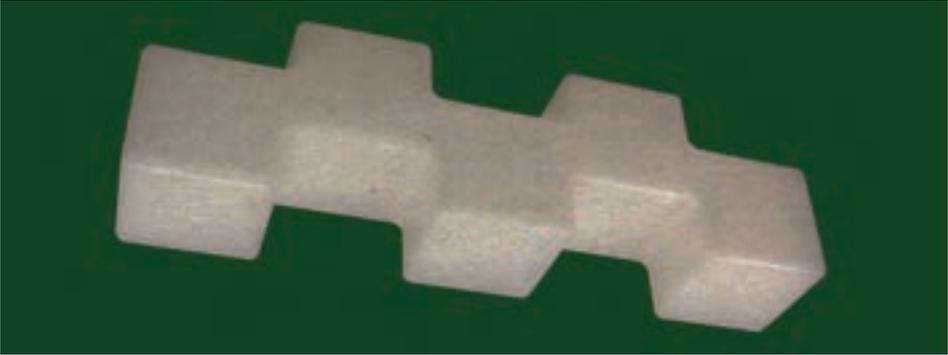
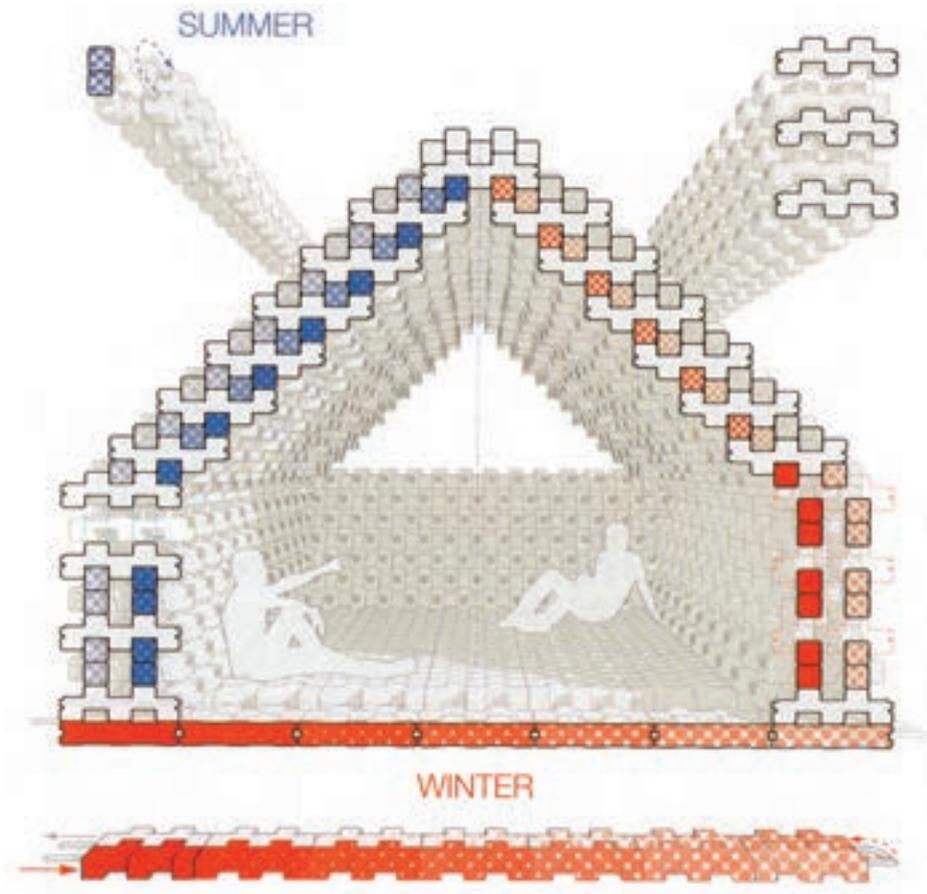


Fig. 58, 59 - Water-House: operation of the bidirectional water circuit for indoor cooling in summer mode and in winter (credits: M. Gutai, 2015).



*Fig. 60-62 - The Water-branch House designed by Kengo Kuma (MOMA, 2008); modular component; energy section and diagram in summer and winter (credits: Gutai, 2015).*





About environmental issues, it will be necessary to define a new adaptive energy model, based on the physical and thermodynamic characteristics of water and, due to its high energy storage capacity, able to guarantee, on the one hand, the energy self-sufficiency to the heating and cooling needs of a building, on the other the transfer of surplus energy to neighbouring public buildings with immense energy demand, through a system of heat storage and networks. About technological issues, the creation and development of new materials and building components might concern other lines of research. Material engineering and synthetic biology might support the development of more sustainable, resistant, solid, transparent and insulating materials, with a low embodied energy. For the components of the water casing, research on multifunctionality requirements should be done, to minimise the number of technical elements, durability and endurance, strained by the presence of water inside. All of this, done while evaluating the overall performance of the system in response to external, mechanical and thermal stresses. Moreover, since the new multifunctional components will characterise future architectures with their own shape, size and section, it will be necessary to deepen man-



*Fig. 63, 64 - Kengo Kuma's Water Glass House (1995) in Atami, Shizuoka Prefecture, connects architecture with the sea by means of a veranda of water.*

ufacturing systems – among them there is digital manufacturing – allowing, according to the individual needs of designers, a personalisation of the components, a linguistic and formal variety, suited to the intervention background.

In conclusion, for using water as construction material there is still a long way to go but, thanks to the experiments and research above mentioned, it seems that it has been fluidly traced: we still must understand if these technologies, products and materials can innovate the architectural score, and to what extent.

# DIGITAL MANUFACTURING

## NEW INSTRUMENTS AND MATERIALS FOR ARCHITECTURE

### ABSTRACT

*The contribute describes tools and materials available today for digital manufacturing in architecture, offering a wide overview of 3D printing techniques and how it could revolutionize the construction world with important come back and not only technical ones. From the concept of mass customization to the creation of the Fab Lab, a prototype platform which provides affordable and economical manufacturing tools, from Contour Crafting to D-Shape technology and to the WASP project, we are witnessing a radical rethinking of the architectural process, but also a continuous research on natural, sustainable and 'programmable' materials.*

### KEYWORDS

*digital production, digital manufacturing, 3D printing, mass customization, innovative materials*

In the long essay on the operators of the building process related to ancient architecture, Giuseppe De Giovanni presented the processes of formation and transformation of the buildings, studied its operators, materials, techniques, procedures and work tools; from homo faber to homo sapiens, from the Mesopotamian culture (ex oriente lux) to the beginning of the Modern Age. A wide historical overview, concise but significant, with the questions addressed in each era and culture on operators and workforce changing in quality and number, with different materials and equipment, with appropriate procedures to the constructions and with an adequate planning of the works. He came to the conclusion that, since the seventies, with the introduction of the «construction management, there is the opportunity of correcting project choices, continuously transforming the planned project; the construction management, in the name of a public or private client, handles the whole building process from planning to construction, through distinct and independent contracts with an active control and coordination action. Usually deployed for large-scale interventions, construction management is comparable to the clerici operationum, to the curatores operum or to the epistátai of the ancient building process» (De Giovanni, 1992, p. 83).

However, as Vladimir Bazjanac (2008) – a researcher at Lawrence Berkeley National Laboratory at the University of California – explained, in the 1990s the design and construction process of buildings has quickly changed: the change was especially due to the rising of the BIM method and its intrinsic capability of ensuring the righteousness of the artifact data in every step of its life cycle, allowing an integrated realization of the order that until that moment was impossible. Although it is one of the driving sectors of our economy, the construction world is perhaps one that historically has shown greater resis-



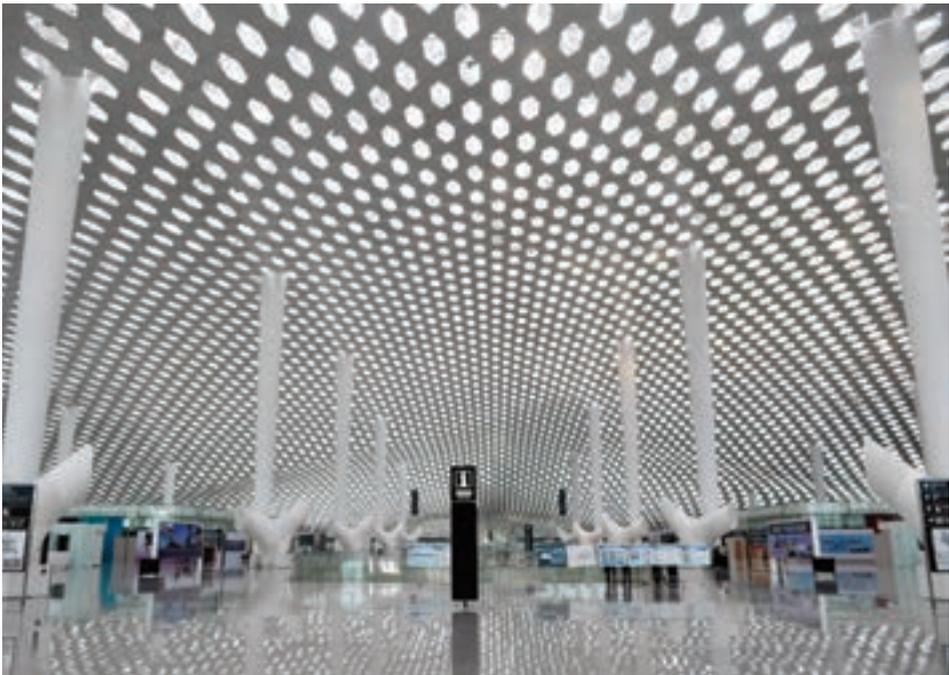
*Figg. 65-67 - Aqua Tower in Chicago (Gang, 2009).*

tance to innovation: innovations are undergoing slow evolution and with the same slowness they are perceived by builders and designers, resulting in not few problems of adaptation. Innovation, in the building industry, is the result of its interaction with an increasingly advanced industrialization reality. This meeting can have a positive effect only if mediated and regulated by a culturally prepared designer (Nardi, 2003).

In recent decades, professional figures have changed and design tools have evolved: moving from CAD to 3D digital instruments; these tools have created a profound transformation into contemporary production through a repertoire of infinite forms and contents which can be traced back to what in 2008 Patrik Schumacher defined Parametric Architecture, free from the stereotypes of tradition and the form-function relationship, direct expression of parameters and their dealings, mathematically determined, to the BIM software (Building Information Modelling). The relevant data of the building are stored, combined and digitally linked in it to allow a greater level of integration between its technological components, checking in advance the possible interferences and eliminating design and implementation errors (Figg. 65-72). The figure of the architect was then enriched with the skills introduced by using new digital manufacturing processes: not only he has to design forms to be realized with sophisticated machinery, but he must acquire programming skills and a profound knowledge on manufacturing techniques and on materials. We are moving towards a production capable of overturning the traditional designer-producer-performer-user relationship: this is the dawn of a new era, when self-producers, also known as Makers, will become the main operators of the building process (Anderson, 2012).



*Fig. 68, 69 - Bird's Nest, Beijing National Stadium (Herzog & de Meuron, 2008); Heydar Aliyev Center in Baku, Azerbaijandi, designed by Zaha Hadid Architects in 2013 (credit: Iwan Baan).*



*Figgs. 70, 71 - Terminal 3, Shenzhen Bao'an International Airport, China (Fuksas, 2013): the Airport will be the fourth largest airport in China; up to 45 million passengers a year are expected.*



*Fig. 72, 73 - Serpentine Gallery Pavilion in Londra (Ito, Balmond e Arup, 2002); Peix d'Or, covered with bronze-colored steel panels on the waterfront of Barcelona (Gehry, 1992).*



*Fig. 74, 75 - A brick wall built by a robot (credit: NCCR Digital Fabrication); Art Gallery in the Shanghai's West Bund District, whose brick-framed façade was laid by a robot (Archi-Union Architects, 2016).*

*Next Page. Fig. 76, 77 - Marble object produced by ARC, worked with a 5-axis numerical control machine (credit: Lapidia, Erosion Collection 2017); 3D printer with additive technology for silicone objects.*

**Digital Manufacturing**– It is a process through which it is possible to achieve solid and three-dimensional objects starting from digital designs; it is used in manufacturing for the rapid creation of models and prototypes, but also in the automotive and aerospace industries. It is common opinion that digital manufacturing is ushering in a new era for the building industry (Gershenfeld, 2005; Anderson, 2010). Today, as Neri Oxman, architect and founder of the Mediated Materia group at the MIT Media Lab, points out, «digital technologies, as an additive production, enable artisans and industry to merge, generating crafts with the help of technology». At the pace of current research, it is likely that in the near future buildings will be of the ‘hybrid’ type, partially built with traditional systems and partially printed in 3D. What surely makes 3D printing interesting for the building sector is the ability to enhance the typical benefits of industrial production (save resources, reduce waste, quality control of the finished product), with almost an unlimited adaptability to the specific needs of the project. So far, serial-produced technologies have had great difficulty to gain a foothold, mostly because of the rigidity of the architectural language. But, with 3D printing a diametrically opposed scenario opens up, in which the means of production can fully support the project in its ‘formal’ and complex geometrical articulations.

The Gehry & Partners LLP Studio experimented with the digital manufacturing process for the first time at the end of 1980 and in 1992 used it to construct the fish-shaped pavilion on the Barcelona Waterfront (Fig. 73): production and assembly of the various structural components have been governed exclusively by the digital model, since producers could not operate with traditional tools. The use of modelling software has drastically expanded design possibilities reducing time and possible errors due to information transfer, whereas digital manufacturing technologies have greatly expanded the range of what can be built (Kolarevic, 2003). The combination of these two tools has made it possible to imagine and create a mass architecture that is also highly customized, beyond all limits of complexity and efficiency, creating fertile ground for experimentation on machines, manufacturing techniques and materials used for construction (Figg. 74-77).



**Mass customization** – The expression mass customization was used by Stanley Davis (1987) in the book *Future Perfect*: here is a conceptual contest for that emerging process defined as a combination of craftsmanship and serial production elements, six years later by Joseph Pine (1992). In the building field, radical innovation is represented by a new approach on architecture production, in which the stages of planning and building have a seamless development. In this regard, digital design and numerical control machining have been fundamental, its first prototype was developed by MIT and was put on the market in 1952. After approximately seventy years since the creation of the first Numerical Control Tools, the digital manufacturing machinery has greatly evolved and has become more affordable, mostly thanks to MIT's Centre for Bits and Atoms headed by Neil Gershenfeld, an experimental laboratory born with the aim of exploring the boundary between computer science and physical science and, in the case of digital design, of studying how to transform data into things and vice versa (Gershenfeld, 2012). Interface solutions are applied between two crucial historical phases of architecture: design and implementation (Katz, 2002). Nowadays, digital tools for design and construction allow us to imagine new ways to connect these two dimensions, to briefly describe the physical environment and its behaviour through advanced simulation tools – to connect bits and atoms.

One of the most prominent projects of the Centre for Bits and Atoms is the Fab Labs, a prototype platform that provides affordable and economical manufacturing tools for rapid prototyping of any object, replicable anywhere in the world, self-sufficient and available to be used by students, educators, technicians, researchers, managers and innovators (Fab Foundation, 2014). Widely disseminated in Architecture Schools, Fab Labs (Fig. 78, 79) have developed design-building programs to provide a first-hand experience of the production of architecture, not only for design, but also machinery, materials and tools that globally intervene in the creative process. Quoting the designer Alastair Parvin, we can affirm that we are directed towards a future in which the factory is everywhere and we are the design team (Parvin, 2013). Fab Labs are places of production where knowledge and information are shared in a network; their diffusion is also the beginning of a new industrial model, integrated within the urban fabric, as a tool that is shaping the city, and vice versa (Diez, 2012).

With the diffusion of the Fab Labs and the digital manufacturing machines, several authors have theorized the advent of a third industrial revolution (Rifkin, 2011; Troxler, 2013). While the first industrial revolution was characterized by the mechanization of the production process and the second opened the era of mass production (product standardization), the third industrial revolution makes the production tools accessible for mass customization, and the user himself becomes a producer, he is a prosumer (Troxler, 2013): it has shifted from the democratic spread of products to the democratization of production. The opportunity for a change in production, given by 'computational control' in advanced manufacturing, has already been devised in many industrial sectors. Although it is difficult to imagine that advanced manufacturing can fully replace industry production tools, it stimulates the vision of a new concept of customization for a wide variety of components, capable of overcoming the stagnation of repetitive production of the prefabricated buildings (Gramazio et alii, 2014). According to Anderson, the third in-



*Fig. 78, 79 - Fab Lab House presented at the Solar Decathlon 2010 and designed by the IAAC, Institute of Advanced Architecture of Catalunya (credits: Adrià Goula).*

dustrial revolution has to be considered as a combination between digital and personal productions (Anderson, 2010), this idea suggests a possible answer to the doubts on radical diffusion of customized products.

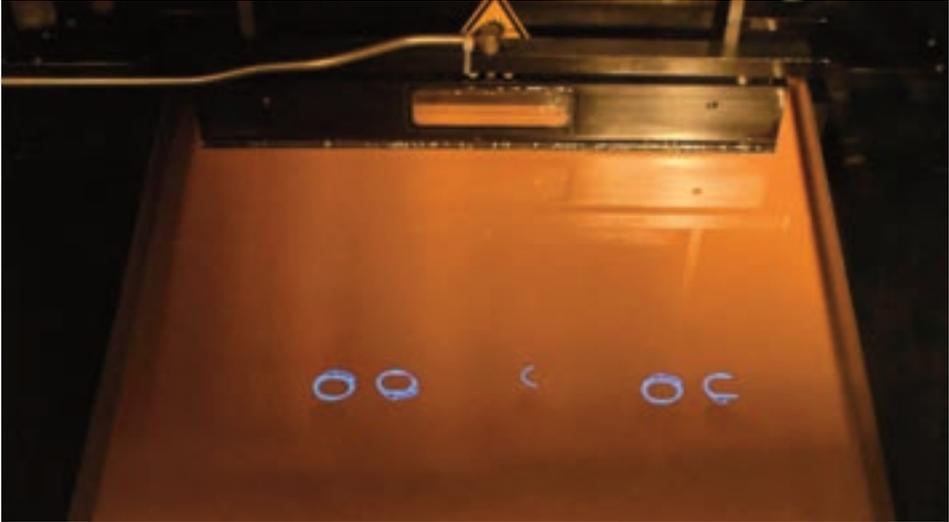
The questions to ask ourselves are: What 3D printing technologies are most suitable for architecture? Will the results of architectural experiments that we have observed in recent years be able to meet current expectations? The improvement of the chemical-

physical characteristics of the printing material, on the one hand, and the 3D technology on the other are also the subject of research and investment for many companies even in the building industry, so that in 2014 the printing of the first home began. What are the implications of this innovation? Is 3D printing technology mature enough to be applied to the building field? To what extent can 3D printing replace traditional technology in the building industry?

**Digital manufacturing for Architecture** – 3D printing was born in 1986 with the registration of Chuck Hull's patent on stereolithography (Figg. 80-82), a patent that permits the realization of objects by subsequent solidified resin layers. In practice, an ultraviolet light is concentrated on the surface of a tub filled with liquid photopolymers and, through specific software and hardware, draws every layer of the object onto the liquid surface, which is hardened and polymerized (Hull, 1986). Since its creation, 3D printing has evolved thanks to different technologies, such as: Stereolithography (SLA), Selective Laser Sintering (SLS), Digital Light Processing (DLP), PolyJET, Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Selective Laser Melting (SLM), Two-Photon Polymerization (2PP), Direct Metal Laser Sintering (DLMS), Selective Heat Sintering (SHS), Anti-Gravity Object Modelling (AOM), the recent Stress Line Additive Manufacturing (SLAM). It has also evolved by using different materials, with specific mechanical characteristics, printed alone and in combination, to be used in areas ranging from industry to crafts, from medical to food, making the prototyping of new products accessible to everyone. Some of the most used materials are: ABS (Acrylonitrile Butadiene Styrene) or PLA (Polylactic Acid) made from corn starch or sugar cane, biodegradable and able to increase its range of applications and to give to the printed material a wood, metal (Fig. 83) and sandstone appearance (ColorFabb, 2016).

Over the last decades, many low-cost 3D printers have been put on the market. The first one, produced by 3D Systems, was Actua 2100 in 1996, that deposited wax in subsequent layers using the inkjet printing mechanism. Since then, machine tool manufacturers have developed several devices that use both subtractive and additive technologies but that are also equipped with accessories to cut or mill (Zelinski, 2014). Additive manufacturing technology continues to improve in print detail accuracy, in reducing the time required to make an object, while the size of printable objects grows, and materials and equipment are increasingly affordable and more accessible. Today, there are fifty different additive manufacturing processes, based on different chemical working principles, which can be used at any stage in the design and manufacture of a component with modest limitations related to geometry, complexity, or composition of the material.

Construction activity in general, which consists mainly of the laying of different components and the overlapping of subsequent layers of material, can be considered an additive process (Naboni and Paoletti, 2015). Additive production can be applied to the construction industry essentially in two ways: to produce components to be assembled into larger structures, or to 'print' on large-scale whole architectural structures. Since the mid-1990s, several research groups and industries have attempted to apply additive production to the scale of the building, trying to overcome the main limit represented by the



*Fig. 80-82 - Stages of the stereolithographic printing process for headsets produced by the Danish Company Widex (credits: [www.disruptiveinnovation.se/?tag=stereolithography](http://www.disruptiveinnovation.se/?tag=stereolithography), 2016).*

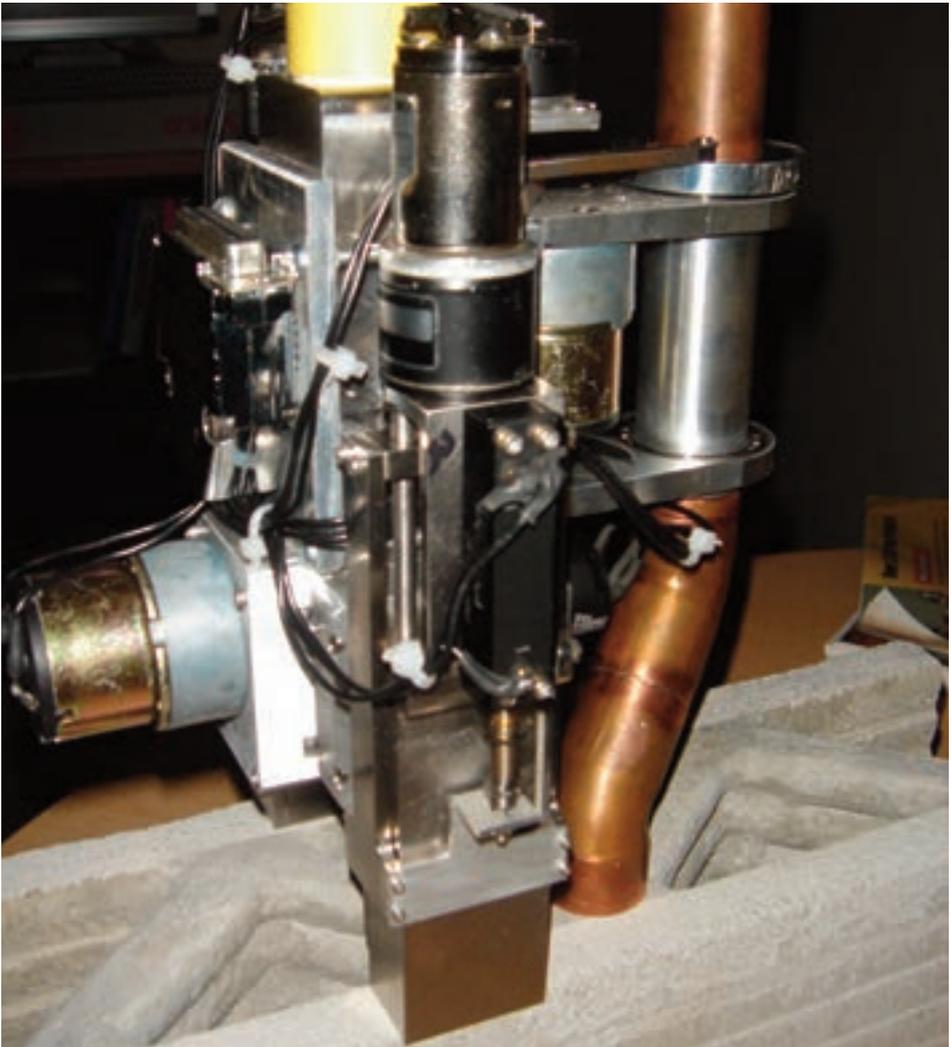
*Fig. 83 - Iron Man mask printed with PLA e PHA, bronze and copper effect (credit: ColorFabb, 2015).*

size of the machines compared to the scale of the buildings. The increase of automation in the building industry has been and is still rather slow for several reasons including: the traditional design approach is not adaptable to the new process and innovation; the technologies available are inadequate for large-scale realization; there is still a search on materials with physical and mechanical characteristics compatible with the printing process; and the machines are quite expensive. On the other hand, the building industry still faces a high fatal accidents and injuries rate in building sites, and a low efficiency and a low-quality production. 3D printing, if employed in the building industry, promises to limit the problems related to human errors, to respect deadlines, to enhance designers' creativity on geometries and complex shapes, to improve the functionality of the structures, the control on materials and on the quality of the finishes (Fischer et alii, 2013).

Among the different printing processes, the additive manufacturing stands out. It is a process of incremental formation executed by the addition of subsequent layers of materials without using supplementary instruments or moulds (Kolarevic, 2003). Physical and chemical processes led to the creation of homogeneous solid forms, composed of amorphous materials such as liquids, powders, gases and fibres. This process offers a wide range of flexibility and a great economic potential, since the components are made directly from natural materials and allow to produce unique components, which would not be economically sustainable if produced with traditional manufacturing techniques (Hauschild and Karzel, 2011). This feature, together with the possibility of freely creating complex forms, makes the additive manufacturing process particularly relevant within the perspective of advanced customization, and explains the increasing involvement of architects in the development of techniques and applications in this field.

**Contour Crafting** – The first attempt to realize an architecture entirely with Digital Manufacturing is to be attributed to additive manufacturing technology called Contour Crafting (CC), developed since 1998 by Behrokh Khoshnevis, director of the Centre for Rapid Automated Fabrication Technologies (CRAFT) of the University of Southern California. The CC employs a digital model that, through a computer, governs the material extrusion process with one or more nozzles, layer by layer, and the finishing process with a spatula (Zhang, 2013). The 'printer', which is managed by a 3D CAD software, is a portal frame that runs on two rails placed about one meter around the perimeter of the house to be printed; on the portal there is a robotic arm (with nozzles and spatula) capable of moving along the horizontal axis and along the vertical one (Figg. 84, 85). The most used material is a mixture of concrete with special hardeners and fibres to make each layer sufficiently hard, while the extruder circumnavigates the entire structure, to support the next layer. Contour Crafting is designed to build large constructions in a timely manner and can therefore, with the help of robotic arms, install structural scaffolding, water systems, electrical and air-conditioning ducts in small sections which do not hinder the movement of the extruder and spatula (Khoshnevis, 2012).

*Next page. Figg. 84, 85 - The fabrication of a traditional building using Contour Crafting and the robotic arm with nozzles and spatula (credits: Khoshnevis, [www.contourcrafting.org/high-resolution-photographs/](http://www.contourcrafting.org/high-resolution-photographs/), 2016).*

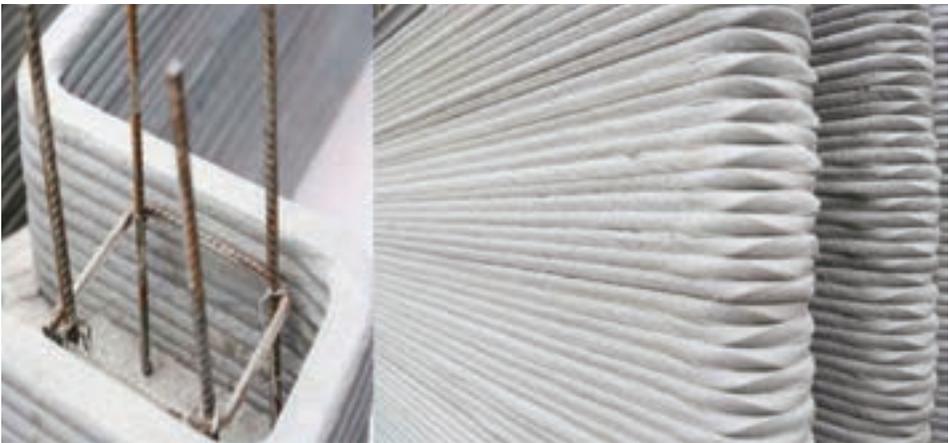


Although the CC seems very simple and intuitive, this technology has yet to mature in process management, in a complete robotic automation and in the use of eco-friendly materials before it can be applied on a large scale. Despite all this, technology provides several points of interest for the construction world for current and potential features (Kreiger et alii, 2015). First, for the guaranteeing of executive quality. The risk of execution errors that may affect the quality of the product is null, as for every procedure of a robotic system, except for design or software programming errors. Instead, when physical labour depends on men, there is the risk of errors due to insufficient skills or attention of the operators, but due also to interferences arising in complex building sites.

Second, for its significant social impact, although one of the first effects of Contour Crafting in the building site might be the reduction of the number of workers: when almost every stage of the work will be handled by a software, only a few workers will be needed, beside a couple of technicians with computer knowledge. Actually, it is possible that work will be differently classified, from mostly physical to intellectual (programmers, computer engineers, chemists, etc.), might increasingly include women, increase the average age of the operators and drastically reduce the risk of work accidents. Moreover, the speed of realization of the housing units and the reduction of building costs, makes this technology a very interesting solution to emergency housing for the most deprived and in case of natural disasters. Third, due to its reduced environmental impact, thanks to its lower energy consumption during the building construction, the drastic reduction of waste material, noise pollution and emissions of harmful dust and leachate produced on a building site (Hager et alii, 2016).

And finally, for reduced times and costs compared to a traditional building process, that in a traditional building process are mainly determined by labour, processing waste and unexpected circumstances. A research group directed by Farook Hamzeh of the Department of Civil and Environmental Engineering at the American University of Beirut has carried out some simulations, using the EZStrobe software, to compare the time needed to build a dwelling with traditional techniques and with Contour Crafting technology (Rouhana et alii, 2014). The studied dwelling was square, 3 meters clear height and 200 square meters. It was divided into four small apartments, with 4 rooms each. The simulation excluded for both cases foundations, systems and finishing. It was based on the construction of ten diaphragms in reinforced concrete, 20 cm thick and 42 square meters. In the conventional model, the roof decking was imagined made of 30 cm of clay-cement mix, while in the CC model made of steel plates and a 10 cm concrete slab. The simulation has shown that building with traditional techniques is considerably slower than building with CC. The time difference between the two simulations (92 hours the first and 29 hours the second) can be found in the placement and removal of the formworks, in the hardening time of the concrete used, in the organization of the works at the building site. With the optimization of the process, the authors of the research think that the CC may reduce to a quarter the time of realization compared to traditional building processes (Figg. 86-88).

Of course, there are still issues to be solved, such as the high cost of the machinery, its transportability and adaptability to soil morphology: the 'printer' needs a mobile



*Fig. 86-88 - The residential unit produced by WinSun and some details of the structure: the Chinese company prints the basic components separately in 3D and then assembles them in situ (credits: WinSun, Pechino 2014).*



*Fig. 89 - The largest residential building made with additive 3D printing: 1,100 square meters and has five floors (credit: WinSun, Pechino, 2014).*

*Fig. 90, 91 - The low-cost House made by the Russian company APIS COR: the fabrication stage and the final product (credits: APIS COR, 2017).*

*Next page. Fig. 92 - The first office realized in Dubai (2016) with 3D printing and additive technology: mixture of special cement reinforced, fiberglass and fiber-reinforced plastic (credit: WinSun, 2016).*



crane to transport it, because of its size and weight, although it is made with modular components. Moreover, the portal frame system on tracks cannot be used on a not perfectly levelled soil, while a viable solution, still in experimentation, could be a system with a cable-suspended extruder (Bosscher et alii, 2007). The new construction paradigm introduced by Contour Crafting will require an innovative approach also for construction logistics. In the future, this technology will be able to set up a building unit in twenty-four hours and will need a logistics support to deliver at the building site all the needed materials in a short period of time and to organize them in their right order of laying. Furthermore, a complex software to handle the storage of materials, the organization of the building site and the various operational phases should be created. That is, a detailed manufacturing plan, able to optimize execution time and the intermediary phase of inspection by the operators, at least until a sensor system for real-time automated verification is developed (Yossef et alii, 2015).

Another problem to be solved is the identification of a material (an alternative to concrete) that has a low environmental impact and that is workable, extrudable, with a good hardening speed, easy to be mixed and resistant to compression. The impact that the cement (from its extraction to its processing) has on the environment affects from 5 to 8% CO<sub>2</sub> global emissions in the atmosphere. Clay and marl, even if limestone, are quite available, but their extraction has a considerable environmental impact, that could be greatly magnified if the CC was used with concrete to solve the problem of the emergency housing in the western world and in third world countries on a large scale (Peng et alii, 2016).

**D-Shape** – The first ecological alternative to CC, although it is a ‘hybrid’ system, is the D-Shape technology by the engineer Enrico Dini that, through its large format, uses sand and an inorganic and eco-friendly binder to create a stone-like material (Fig. 93). While



*Fig. 93 - House printed with D-Shape, designed by Marco Ferreri, exhibited and commissioned by the Triennale Milano in 2010 (credit: D-Shape.com).*

the piston is moving horizontally, the printer head lays a layer of sand (from 5 to 10 mm), mixed with magnesium oxide and through a series of nozzles it deposits a chlorine-based liquid. It chemically reacts to set the mix and form an artificial sandstone. Then the piston is lifted, another layer of sand is added and the process is repeated. The desired shape is achieved thanks to the selective and programmed action by some of the 300 available nozzles and, when the D-Shape has completed its printing, once finished the 24 hours of the solidification process, the excess sand is carefully removed to reveal the solid object which presents a marble-like surface finishing, high durability and external resistance. Other components such as glass fibre and carbon fibre can be added to further increase the system's resistance (Dini, 2010). For the Dutch Universe Architecture's Landscape Architecture, Dini has devised a system that will see two D-Shape printers working side by side inside temporary structures close to the site. The D-Shape will print the prefabricated parts that will be assembled to form the looping structure. Each part will be hollow and will be filled with fibre-reinforced concrete to give it structural integrity and to allow huge potential time, labour and transportation savings.

**WASP** – A clear environmental inspiration is the WASP (World's Advanced Saving Project) project by Massimo Moretti, a project that was born in 2012 with the goal of building a 3D printer capable of making homes with locally available and low-cost materials. In general 3D printing works with the deposition of composite materials, WASP prefers



*Fig. 94 - Ait Benhaddou in Morocco: all buildings are built of mixed clay with tamarind fiber.*



*Fig. 95 - Shimban in Yemen with its skyscrapers in raw earth.*

mixes of fluid-dense, locally based materials that change state by evaporating a solvent such as water. Free from the logic of plastic materials, the team has sought research into easily obtainable, high-yielding and low-cost materials such as clay and hemp. The use of clay for the construction of houses has ancient roots, especially in the Mediterranean regions and WASP can create interesting architectures, in a short time and with reduced manpower (Figg. 94, 95). The mainly used mixture also contains discontinuous hemp fibres, but to control clay retention and to avoid excessive variations in its size, Moretti's team is also currently evaluating the use of seeds of some grass types: plant seeds absorb clay moisture until it develops and grows so that their roots become a kind of internal, totally natural armour.

The main features of WASP are its ease of transportation and its low energy demand. Some construction printers that are bigger than BigDelta exist, but they weigh hundreds of tons and consume huge amounts of energy (Figg. 96, 97). The delta approach was chosen because, with its reticular support structure, the three vertical axes allow a low energy consumption, since only the extruder moves. The BigDelta arms carry about 70 kg and reduce the consumption to less than a tenth compared to portal printers and with about 300 watts, therefore, perfectly manageable with a battery and a few square meters of solar panels. In addition, BigDelta was designed to be quickly assembled: three people take about two hours to make it operational.

The latest innovation is the rotating nozzle. Movements control is crucial in 3D



*Figg. 96, 97 - The BigDelta in Massa Lombarda (RA) in 2015 and the demonstration press of a circular volume: height m 2.70, diameter m 5.00, t 40 of material distributed on 135 layers, mc 2 of water and 200 Kwh of energy consumed (credits: WASP Team).*

printing, but it was limited with the old peristaltic pump extruder. That's why it was re-designed adopting a cochlea concept. The new extruder can even manage retraction, so it can stop working and pull extruded material back. In a few words, it moved from a continuous extrusion to a precise flow control, and to the chance of stopping and resuming the work with a micrometric precision. The new extruder can be assembled and disassembled very quickly, it mixes the material in its way out, in this way, layers properly adhere on each other, it cleans by itself, it has a constant control at all the speed levels and it needs a very low energy amount: to push the clay in the tubes it takes several kilowatts, to let clay fall in a controlled way with a screw it takes just a few tens of watts.



*Fig. 98 - Saltygloo is a room made with modular components that recall the crystalline form of salt and which are randomly rotated and aggregated; the mixture, composed of salt and glue, is resistant, waterproof, light, translucent and cheap (credit: Rael, San Fratello and Lee, 2013).*



*Fig. 99 - Wood-Block is an example of 3D printed material using a mixture based on recycled agricultural waste; it reproduces the veins of natural wood and is characterized by a slight translucency (credit: Giannini, 2016).*

**Conclusions** – Today, the potential of advanced digital design and manufacturing technologies is not limited to a small number of operators, but it is a global priority for the development of a new industrial paradigm, as demonstrated by the US government recent funding in favour of the research and the development of new technologies and to set up a network of 15 innovative production institutes in 2015. In the building industry, digital manufacturing is now a reality in the production of free-form components for the casing or for the technical elements capable of ‘materializing’ the technological complexity and the formal specificity of some architectural projects. The transition from component to large scale requires thorough research in different themes.

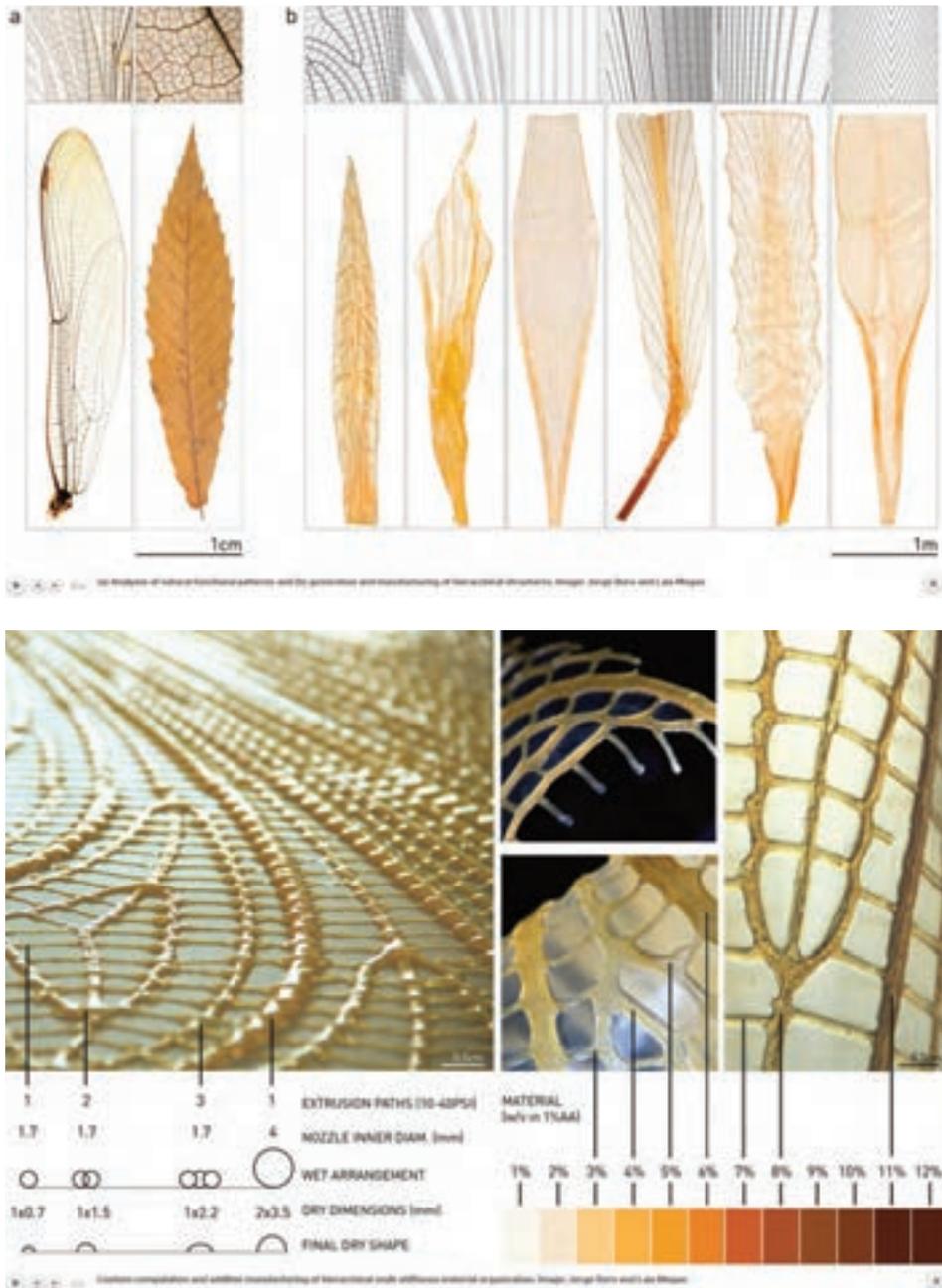


Fig. 100, 101 - Digital manufacturing platform with water-based materials, biodegradable and heterogeneous, of MIT Media Lab: analysis of natural functional models and generation-production of hierarchical structures; table for the production of additives aimed at the hierarchical organization of materials with differentiated stiffness (credits: Duro and Mogas, MIT Media Lab 2015).

First, on the materials, on their physical and mechanical properties and on their behaviour when printed. The 3D printing process works by adding material through subsequent layers and makes this technology flexible and usable with polymers, metals, composites (such as ABS with added resin and carbon fibre) and cement materials. However, thanks to the engineering of materials and synthetic biology, we need to deepen the search for more sustainable materials (more resistant, opaque, transparent and insulating) with characteristics that will allow us to create organic digitally-built buildings, in full agreement and respect with nature (Figg. 99-101). The research of Neri Oxman on chitin goes in this direction, a biodegradable material based on shrimp shells, with variable density and resistance, that could eventually start to replace plastics, or on some insect wings that are light and strong due to their geometry which concentrates the material along the lines of tension.

At the same time, it is of particular interest the research developed by the MIT Self-Assembly Laboratory, in collaboration with Stratasy Ltd. and Autodesk, on 'printable' nanostructured materials, able to change shape and functionality after their production, thus providing additional features, and applications and performance on command. This new manufacturing process, called '4D printing', may allow to change the properties of printed material (for example, flexibility, porosity, conductivity, optical properties, magnetic properties, etc.) by programming its modifications post-fabrication to fit the shape or the functionality wanted or to decompose it quickly for the benefit of the environment (Campbell et alii, 2014). Second, some research is needed on the new software that with 3D printing allows designers and builders to work seamlessly in a digital environment, but often using different applications for modelling the project, for the engineering of shapes, etc. In the rush to better controlling each and every aspect of the workflow (from creation to realization) the risk that software is processed with different languages, without the possibility of exchanging information, requires constant disciplinary research on the interoperability of platforms.

Finally, on the organization of the proceedings, Jeremy Rifkin argues that the marginal cost of man-made labour to produce goods and services will tend to be abandoned with the advancing of intelligent technologies in every sector and in every field of technical and professional applications. What is more realistic is that advanced production technologies will not completely replace traditional ones, which will remain the most appropriate solutions for some applications. It will be necessary to understand how robots and humans can work side by side and study intelligent sensors and man-machine interfaces to start the fourth Industrial Revolution.



*Vertical Forest in Nanjing designed by Stefano Boeri Architects (2018).*

## APPLICATION OF THE METHODS TO THE DESIGN

### ABSTRACT

*The creative vitality expressed by the younger generations, validly reactive towards a different methodology of production of the project oriented to Regenerative Architecture, validates the thesis that the support of Scientific Research can be extremely significant in a didactic path, where the scientific knowledge is structured to orient, qualify and substantiate the teaching, both on the level of disciplinary content and on the methodological one. The design constraints strictly aimed at Possible Quality have given rise to didactic experiments of considerable scientific interest, some of which are reported in this volume.*

### KEYWORDS

*regenerative architecture, zero energy building, eco-oriented design, BIM, bioclimatic architecture*

The cultural solicitations strongly orientated to regenerative architecture and design constraints strictly focused on Possible Quality have created educational experiments of considerable interest, testifying the creative vitality of the young generations that have shown themselves validly reactive to a different production methodology of design. Four different experiences made within the educational activities led at the Department of Architecture and Industrial Design of the University of Campania ‘Luigi Vanvitelli’ are reported below, where didactic methodologies and innovative approaches, described in the previous paragraphs, have been experimented: 1) SEED, a project for Solar Decathlon: learning by doing; 2) Zero Energy Social Housing: quality control of eco-oriented design with BIM logics; 3) Energy-environmental performances of ‘Edoardo Amaldi’ Scientific High School at Santa Maria Capua Vetere: the research-action method; 4) Water as a material for architecture in the Fitness centre at Maddaloni: the regenerative approach.

**SEED, a design for Solar Decathlon: learning by doing** – The occasion of the Ideas Competition SEED<sup>17</sup> has given the opportunity to both teachers (not only those belonging to ‘Building Technology Sector’) to work together on a common issue and students to aim their efforts and their enthusiasm for an ultimate goal, not only as the achievement of a profit examination. The result has been a stimulating teaching experience, the students of the Sustainable Technologies Laboratory for interior space<sup>18</sup> have taken part in, with great commitment and enthusiasm. As a matter of fact, participation in a national competition has created the motivation that has led the students to interact with one another with constructive competitiveness. In other words, an intrinsic motivation, which has made the work stimulating and gratifying in itself, has been added to an ex-

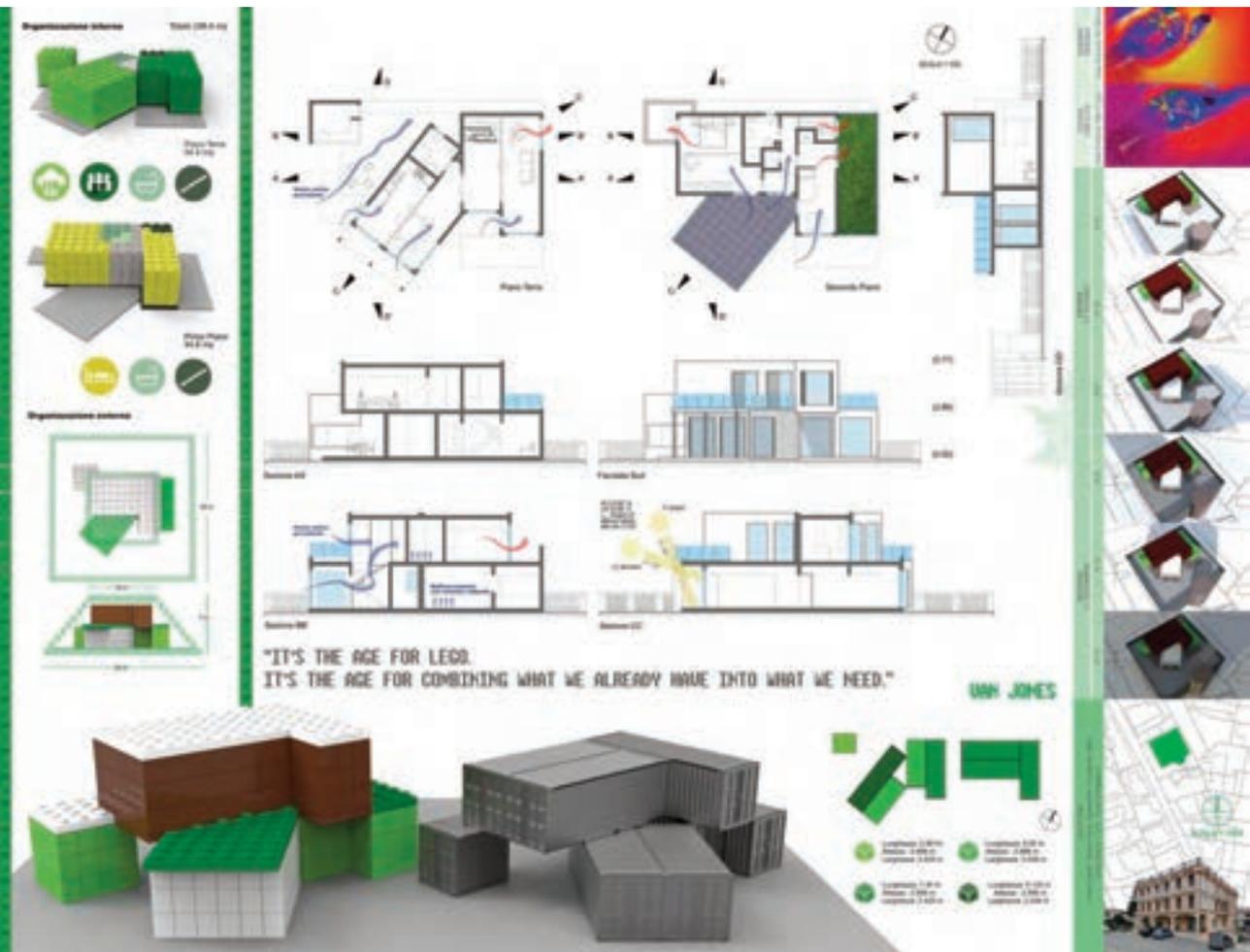
trinsic motivation, that normally leads them to be engaged for having a good result at the exam; it has generated satisfaction in feeling themselves more and more competent because, as mentioned above, learning in adults is focused on the problem rather than the content and on the steps taken to solve it. In many cases students, comparing themselves with real situations and applying their knowledge and skills to achieve an aim, learn not only from the teachers and their mistakes, but above all from the comparison with the other fellow students. The comparison of ideas among peers stimulates a constructive competition and motivates the commitment to gain knowledge. Schank teaches us that the motivational aspects of learning play an important role. The expectations of the trainee represent a decisive moment in the development of his/her skills and his/her interest represents the motivating core in activating his/her knowledge.

In the didactic experience made at the Department of Architecture and Industrial Design (DADI) of the University of Campania 'L. Vanvitelli', the theoretical principles and methodological tool of technological eco-design have been applied to the design of an architectural addition. The request has consisted in designing a roofing extension of existing buildings that could be differently interpreted as: crowning, new roofing or attack to the sky. An action of densification, therefore, destined for residence: industrialised, self-constructible and self-sufficient housing from an energy point of view, meeting the requirements of the Solar Decathlon Europe contests. Emphasizing the organicist dialectic of synergies established among the human being, the building organisation and its environmental surrounding, the key words on the base of the concepts of all the proposed design solutions have been: Adequacy/Appropriateness; Consistency/Harmony/Compliance; Coupling/Continuity; Mimesis/Reworking or Contrast/Negation.

Participating students have been asked to respond to a triple challenge concerning energy, environment and society in order to obtain a residential unit as a design result, that is efficient and comfortable at the same time, meeting the following standards: Zero Energy Building (the energy produced by renewable sources in the building must be sufficient for the primary energy needs for heating, cooling, domestic hot water production and power supply to household appliances); Zero Emission Building (in the overall environmental balance, a residence guarantees the conditions of interior comfort of temperature, relative humidity and lighting, with a limited production of CO<sub>2</sub> and VOC); Zero Waste Building (all the construction elements can be recycled at the end of their life and the ground can be returned to nature, without any residual waste or contamination hazards).

The didactic aim has consisted essentially into orientating students' choices towards a technological design, that would give new living quality to compromised settlement structures, where the design was an open system of flows of material, energy and information and eco-compatibility was the reading-key as well as the tool to suggest scenarios, not only minimally impacting, but also potentially self-regenerative. In the complex dialogic relationship between coupling and contrast, the performing approach has played a part in establishing new forms of balance between the proposed transformations and

*Next pages. Figg. 102-104 - LegoHouse (designed by E. Ciccone, C. Marino, R. Martone, J. Munteanu and D. Pigova), 3rd classified: Tab. 1 | Environmental Context; Tab. 2 | Technical Solutions; Tab. 3 | Renders.*







pre-existing consolidated urban ecosystems, on different scales. And since «there is no consolidate models to be applied to make a context ‘smart’, it will be only by design that the smart features can be effectively integrated within the urban dynamics» (Antonini and Mussinelli, 2018, p. 26). The awareness of environmental problems and the will to give the students the tools to manage both the design and construction process, in an eco-compatible and energy-efficient way, have been the strong points of the proposed didactic experimentation. Once the basic choices have been finalised, ICT tools have been used to control the choices contemporary with the design definition phase; the students have converged on technological solutions aimed at optimising the relationship between formal consistency and compliance with the law, adequacy to the context and technical appropriateness. Specific software has supported the student in the evaluation of alternative technological solutions and in verifying the appropriateness of the choices, in a continuous trade-off condition.

The performances of the opaque envelope have been measured with the J-Tempest software, which computes the values of thermal Transmittance, Attenuation and Phase shift of the thermal wave and compares them with the regulatory standards in force; those ones of the transparent envelope have been measured with the Pilkington Spektrum software, which allows simply and dynamically to check the parameters of thermal Transmittance (in  $\text{KWh/m}^2\text{K}$ ), light transmission (as a percentage of incident light), heat transmission (as a percentage of incident radiation) and solar Gain (indicating the ratio between the thermal energy transmitted globally through the glass and the incident one, variable from 0 to 1). So the students have had the opportunity to measure on-going design choices, acquiring the practical competence of the software use, but above all the control of the design. A meaningful phase of the training action has been the elaboration of the three tables of the competition. After having analysed, designed and produced one or more design solutions, it has been necessary to know how to ‘sell your design’, that is to know how to argue the choices and convince the jury of their goodness and the real benefits deriving from the implementation of those ideas.

Each group of students has prepared a graphic-descriptive paper, divided into three phases: a) Tab. 1, where the rules for inserting the design proposal in the pre-existing context have been illustrated through plans, sections and prospects on an adequate scale (in this phase, students have analysed the relationship between the existing building, the architectural addition and the external environmental components as sunshine, ventilation, etc.; Fig. 102); b) Tab. 2, where innovative technical solutions, proposals of energy functioning and constructive characteristics have been examined: spatial conformation, technological, functional, environmental and energy performances. the students have highlighted the quality of the technological design and the innovative potentialities of domotics, applicable to the management of interior space, according to the conceptual approach of ‘possible quality’ (Fig. 103); c) Tab. 3, where render and images of the model have been reported, as well as preparatory eidotypes and sketches (Fig. 104).

The didactic experimentation has produced three different and interesting types of design: 1) traditional use of space and materials; 2) traditional materials and innovative spatial distribution; 3) innovative materials and spatial distribution. The formal and material

characteristics of these drawings are very different, but the energy and environmental performances are all respectful of the same minimum standards (Transmittance below 0.38 W/m<sup>2</sup>K in type C climate; Attenuation of the thermal flow below 0.10; Phase shift of heat flow over 12 hours; architectural integration of active and passive solar systems; use of bioclimatic technologies for passive cooling, use of eco-compatible materials, recycled in the cradle and recyclable in the grave, according to the C2C approach; etc.).

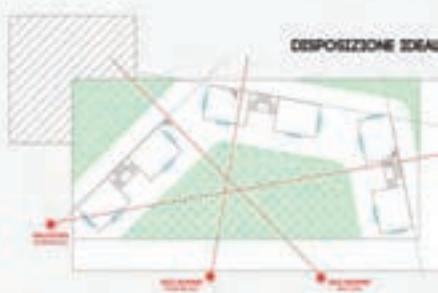
**Zero Energy Social Housing: quality control of the eco-orientated design with BIM technology** – The design experimentation led with the students of the Construction Laboratory of the architecture A/B of the DC in Architecture has concerned the use of BIM methodology to favour the collaboration process of different actors starting from the early phases of the design. The aim of the laboratory was the design of a residential unit of social housing designed for a single divorced man with children, in whose context there is the need to periodically host two children. These requirements have led the students to compare themselves with the design of flexible spaces and furnishings, whose intended use is not unique. From the construction point of view, the housing cell design has got a ‘rustic house’ as its basic element with fixed dimensions and openings, to be completed with closures and internal partitions. The basic cell of 5,3x5,3 metres has got two contiguous close sides carried out with Bioisotherm Argisol technology (disposable insulating formwork in Neopor for cast-in-place concrete walls) where it is possible to open only one access. The design proposal includes volumetric additions with energy/bioclimatic qualities linked with the housing and functional needs of the accommodation, of max 12 sqm, structurally linked with the existing structures.

The residential unit is conceived as an elementary unit of a tower or in-line building, whose composition/typological scheme is freely chosen by the design group, to be placed into a bio-climatically correct way on a lot that measures a total of 60x30 metres, with municipal roads on the S and E sides. The ground floor plan, the intermediate type floor and the crowning solution must be designed for each building, with an inclined or flat and practicable roof. The design must also include the integration of active systems for the production of energy from renewable sources (photovoltaic, solar thermal, micro-wind), to meet the requirements of the current standard (Law 90/2013 and DM 26/06/2015) for almost zero energy buildings. All the minimum requirements related to the opaque envelope, required by the standard (thematic transmittance, thermal flow attenuation, thermal phase shift, interstitial condensation, periodic thermal transmittance, equivalent solar area, average heat exchange coefficient), have been controlled with specific software during the design phase (PAN 7.0).

The design issue thus set has stimulated a more interactive and creative problem solving process. In fact, the designs had to meet a triple challenge concerning: energy, environment and society, in order to obtain a residence that had all the requirements of

*Next pages. Figg. 105-107 - Zero Energy Social Housing: EcoHousing Design (designed by A. Mattiello, F. Bove, S. Vassalluzzo); Green Housing (designed by S. Amoroso, T. Dell’Aquila, A. Iorio, R. M. Yelo Gomez); Terrazzamenti urbani (designed by A. Marino, M. Rinaldi, T. Ruocco).*

## CONCEPT



## PLANIMETRIA



## PIANTE



## SEZIONI



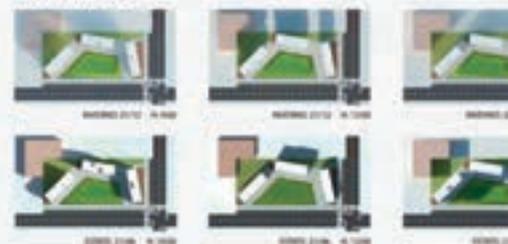
## ANALISI CLIMATICA

LA ZONA CLIMATICA DI AVERA È DI TIPO C, DI CARATTERE UMIDO, CON PRESSIONI DELL'UMIDITÀ RELATIVA CHE IN OTTOBRE, DICEMBRE, FEBBRAIO E MARZO SONO SUPERIORI AL 70% E IN GENNAIO, APRILE, MAGGIO, GIUGNO, LUGLIO, AGOSTO, SETTEMBRE, OTTOBRE, NOVEMBRE, DICEMBRE AL 70% INQUADRANDO UN CLIMA UMIDO SUBTROPICALE.

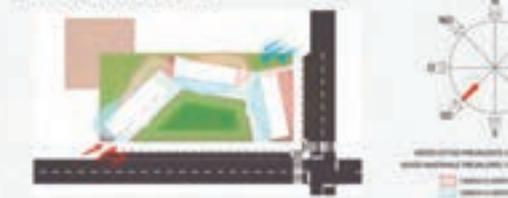
IL CLIMA DI AVERA È DI TIPO UMIDO MEDITERRANEA, CON INVERNI MOLTO FREDDI E CALDI, LE MESE INVERNALI SONO FREDDI IN OTTOBRE, NOVEMBRE, DICEMBRE, FEBBRAIO, MARZO, APRILE, MAGGIO, GIUGNO, LUGLIO, AGOSTO, SETTEMBRE, OTTOBRE, NOVEMBRE, DICEMBRE. LE MESE ESTIVE SONO CALDE IN GIUGNO, LUGLIO, AGOSTO, SETTEMBRE, OTTOBRE, NOVEMBRE, DICEMBRE. LE MESE AUTUNNALI SONO FREDDI IN OTTOBRE, NOVEMBRE, DICEMBRE, FEBBRAIO, MARZO, APRILE, MAGGIO, GIUGNO, LUGLIO, AGOSTO, SETTEMBRE, OTTOBRE, NOVEMBRE, DICEMBRE.

POSIZIONE TROPICALE 15° 30' TO LE PRECIPITAZIONI SI CONCENTRANO PRINCIPALMENTE TRA OTTOBRE E GENNAIO, SUBITO SUCCESSIVE DIMINUISCONO NEL PERIODO ESTIVO DI MAGGIO E SETTEMBRE. LA TABELLA SINTETICA DEI PRINCIPALI DATI METEOROLOGICI RIFERITI AL TERRITORIO COMUNALE.

## STUDIO DELLE OMBRE



## STUDIO DEI VENTI PREVALENTI

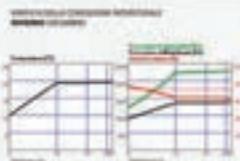


## PROSPETTI





## SOLAIO



### PARAMETRI TECNICI, di TRASMISSIONE e INERZIA TERMICA

Parametro	Valore	Unità
Spessore	210	mm
Area superficiale	10,2	m <sup>2</sup>
Resistenza termica	0,11	m <sup>2</sup> ·K/W
Conduttività termica	1,9	W/m·K
Capacità termica	120	kJ/m <sup>2</sup> ·K
Indice di massa termica	1,2	h <sup>0,5</sup> ·m <sup>2</sup> ·K <sup>0,5</sup> ·W <sup>-1</sup>

### Verifica invernale

Profilo	CASERTA
Caratteristiche	CANTILE
Gradi giorno	0
Nota	0

Verifica invernale

Trasmissione	0,102 (max)
Trasmissione di allungamento	0,14 (max)
Trasmissione di allungamento con sovraccarico	0,14 (max)

**Verifica estiva**

## PARETE



### PARAMETRI TECNICI, di TRASMISSIONE e INERZIA TERMICA

Parametro	Valore	Unità
Spessore	210	mm
Area superficiale	10,2	m <sup>2</sup>
Resistenza termica	0,11	m <sup>2</sup> ·K/W
Conduttività termica	1,9	W/m·K
Capacità termica	120	kJ/m <sup>2</sup> ·K
Indice di massa termica	1,2	h <sup>0,5</sup> ·m <sup>2</sup> ·K <sup>0,5</sup> ·W <sup>-1</sup>

### Verifica invernale

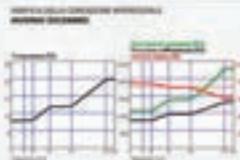
Profilo	CASERTA
Caratteristiche	CANTILE
Gradi giorno	0
Nota	0

Verifica invernale

Trasmissione	0,102 (max)
Trasmissione di allungamento	0,14 (max)
Trasmissione di allungamento con sovraccarico	0,14 (max)

**Verifica estiva**

## COPERTURA



### PARAMETRI TECNICI, di TRASMISSIONE e INERZIA TERMICA

Parametro	Valore	Unità
Spessore	210	mm
Area superficiale	10,2	m <sup>2</sup>
Resistenza termica	0,11	m <sup>2</sup> ·K/W
Conduttività termica	1,9	W/m·K
Capacità termica	120	kJ/m <sup>2</sup> ·K
Indice di massa termica	1,2	h <sup>0,5</sup> ·m <sup>2</sup> ·K <sup>0,5</sup> ·W <sup>-1</sup>

### Verifica invernale

Profilo	CASERTA
Caratteristiche	CANTILE
Gradi giorno	0
Nota	0

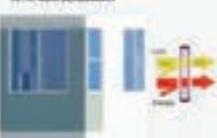
Verifica invernale

Trasmissione	0,102 (max)
Trasmissione di allungamento	0,14 (max)
Trasmissione di allungamento con sovraccarico	0,14 (max)

**Verifica estiva**

## VETRI

### VETRI NON SCHERMATI



### DESCRIZIONE

Profilo	Standard
Materiali	Aluminati
Trasmissione	Standard

### PROTEZIONE

Lastr	0%	0%
Trasmissione termica	0%	0%

Energia		
Trasmissione energetica diretta	10	20%
Afflusso energetico	10	20%
Risparmio energetico	10	20%
Costo di esercizio	0,10	0,10
Costo di esercizio di shading (max)	0,10	0,10
Costo di esercizio di shading (min)	0,10	0,10

Costo produzione  
 € 1,50/m<sup>2</sup>

### VETRI SCHERMATI



### DESCRIZIONE

Profilo	Standard
Materiali	Aluminati
Trasmissione	Standard

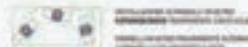
### PROTEZIONE

Lastr	0%	0%
Trasmissione termica	0%	0%

Energia		
Trasmissione energetica diretta	10	20%
Afflusso energetico	10	20%
Risparmio energetico	10	20%
Costo di esercizio	0,10	0,10
Costo di esercizio di shading (max)	0,10	0,10
Costo di esercizio di shading (min)	0,10	0,10

Costo produzione  
 € 1,50/m<sup>2</sup>

## FOTOVOLTAICO



### VERIFICA

PROFILLO	DESCRIZIONE	ATTACCO (mm)	IN INERZIA (mm)
1		15	14
2		32	4
3		203	4
4		71	3
5		159	3

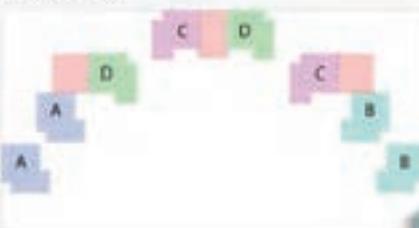
NOTA: Per informazioni sui prezzi e sulle condizioni di vendita, visitate il sito [www.onyx.it](http://www.onyx.it)



ESERCIO	INERZIA	INERZIA	INERZIA	INERZIA
A	5	1000 x 1000	1000 x 1000	1000 x 1000
B	7	1000 x 1000	1000 x 1000	1000 x 1000
C	5	1000 x 1000	1000 x 1000	1000 x 1000



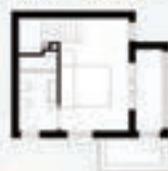
**TPOLOGIE ABITATIVE**



**Pianta Piano Terra (00)**



**Pianta Primo Piano (01)**

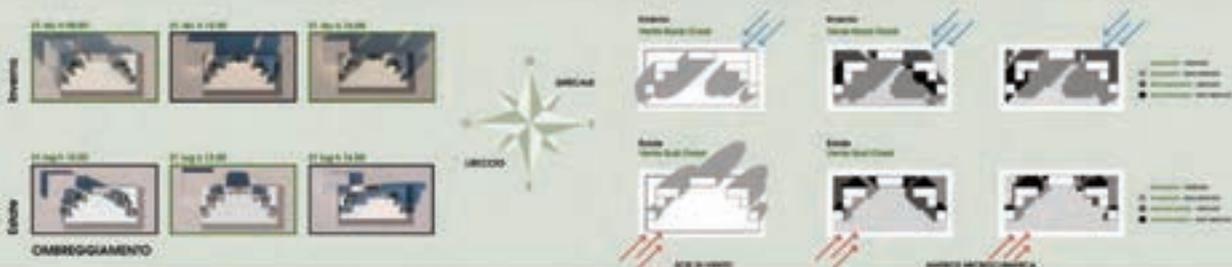


**VENTILAZIONE NATURALE INVERNO**

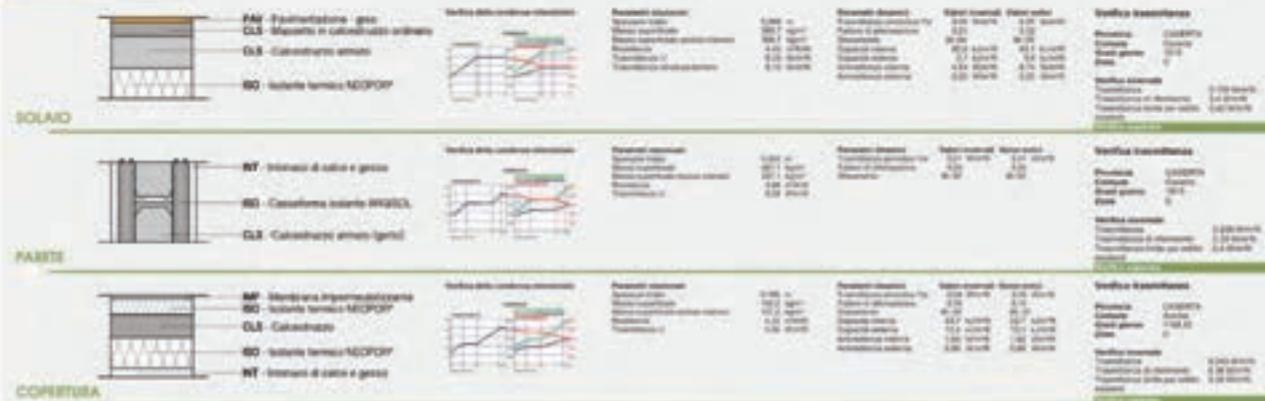


**VENTILAZIONE NATURALE ESTATE**





## STRATIFICAZIONE



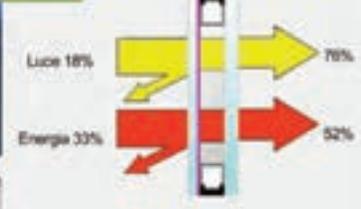
## EDIFICIO DI PROGETTO



## ZONA CLIMATICA C



## INFISSO



DESCRIZIONE	Materiali	Spessore	Conduttività	Resistenza
Vetro 1	Intercapedine	4,00 mm	0,025	0,16
Vetro 2	Intercapedine	12,00 mm	0,025	0,48
Vetro 3	Intercapedine	6,00 mm	0,025	0,24

DESCRIZIONE	Valore	Unità
LUCE	70%	%
Energia	52%	%
Trasmissione luminosa	0,70	
Trasmissione energetica diretta	0,15	
Riflessione energetica	0,36	
Assorbimento energetico	0,49	
Fattore solare	0,70	
Coefficiente di shading totale	0,80	
Coefficiente di shading onda corta	0,55	
Trasmissione termica	1,50	
Indice di abbattimento acustico	34	(2-3) dB

## CLIMATIZZAZIONE ESTIVA

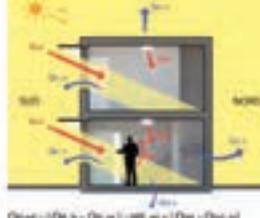


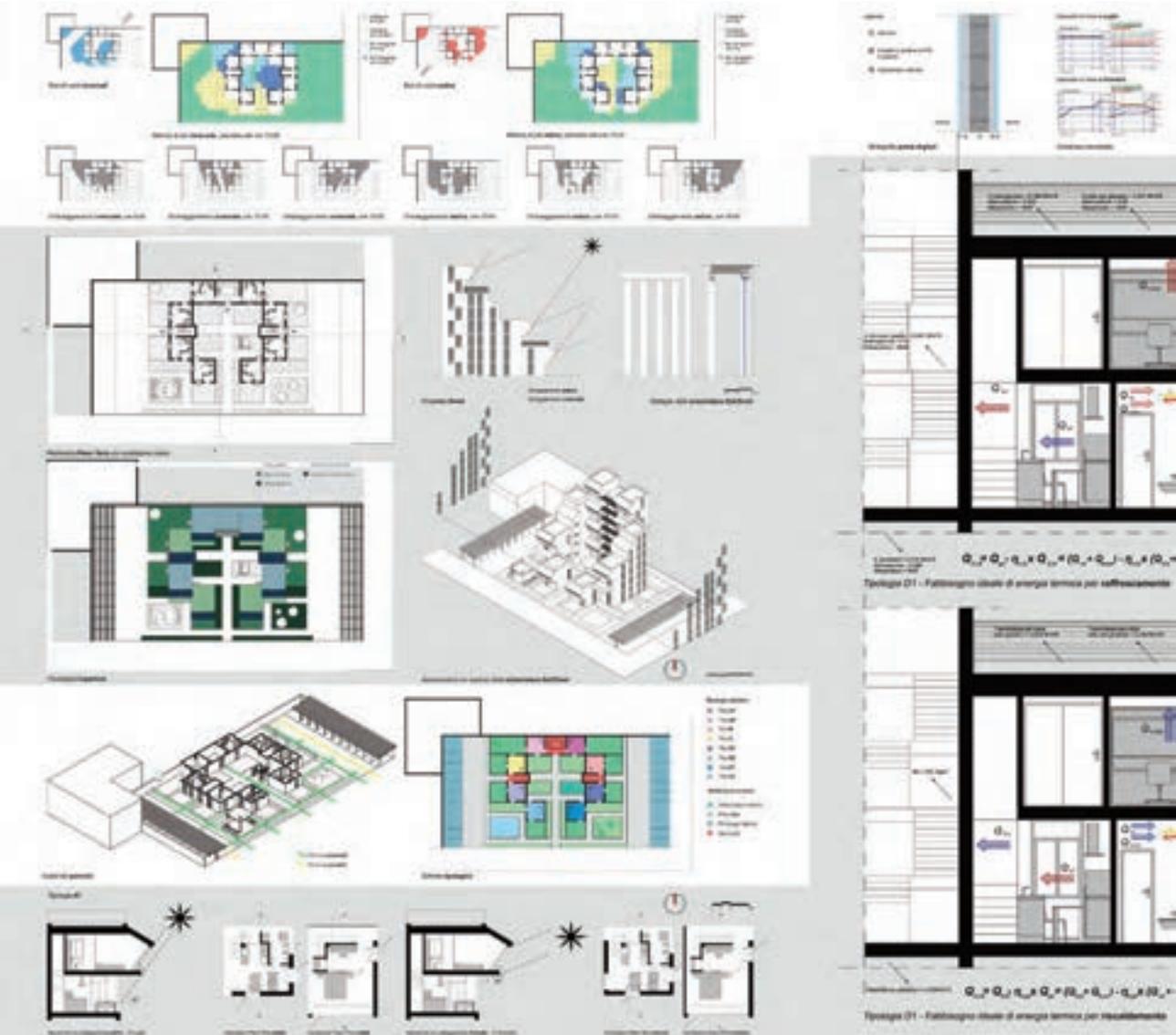
## FOTOVOLTAICO



N° PANNELLI	ESPOSIZIONE	RENDIMENTO	PORENZA	COSTO
2	30° or	75%	390 W	348 €
2	90° ad	70%	364 W	348 €
1	90° or	50%	130 W	134 €
1	90° ovst	50%	130 W	134 €
			<b>1014 W</b>	<b>1044 €</b>

## CLIMATIZZAZIONE INVERNALE







comfort and wellness, which can be translated into quality of life for those who live there (Roaf et alii, 2007). In addition, the choice of the construction system has been strongly orientated to absence of thermal bridges and condensation, anti-seismic safety, healthy environments, energy efficiency (expandable polystyrene characteristically coloured silver-gray with improved conductivity –  $\lambda = 0.031$  W/mK – which guarantees high thermal insulation. This improvement is due to encapsulated graphite particles inside able to reflect infrared and neutralise the negative effect of solar radiation). In collaboration with ALLPlan 2017, the BIM digital technological design has been proposed.

The new holistic and multidisciplinary approach that is at the base of Integrated Design, proposes a radical change in the design process based on the involvement of all the project actors, who will have to collaborate in the different phases: from the meta-project to the end of the building's life cycle. The new design paradigm requires the optimization of the entire process and at the same time allows a digital simulation of the work (BIM 3D), a temporal planning of the processes (BIM 4D) and a precise analysis in terms of technological performance and costs (BIM 5D), in order to fully satisfy the economic, environmental and social requirements. However, this type of approach requires new tools and methods of analysis, design and verification, in order to facilitate dialogue between the involved technicians, allowing everyone to access the same information in real time. The adoption of a BIM operating process offers new opportunities for the construction sector to increase efficiency and profitability.

The fifty design solutions (panels and models) were presented in an exhibition-competition at which a jury of experts evaluated and awarded the ten most interesting design solutions with respect to five indicators: technological quality, energy quality, environmental quality, architectural quality, ability to explain the theoretical and conceptual reasons put forward by the working group behind the work (Fig. 105-107). This last indicator was also intended to give value to the creative concept and the skills acquired by the members of the group to argue it. Pedagogical value of the didactic experience refers to: a) gaining experience in technological design by dealing with companies in the construction market and their production of materials, systems and components; b) understanding the value of digital simulation through appropriate software, in making predictions and eventually problem solving in alternative technological solutions; c) obtaining practical experience in BIM design. The overall experience makes the student competent to carry out with skill, new projects and/or rehabilitation design, scientifically documented, and energy effective. The strength of the learning project is the pair comparison both on the methodologies of analysis and on the different design solution, strictly connected with the minimum requirements dictated by the current regulations.

**The energy-environmental performance of the ‘Edoardo Amaldi’ Scientific High School in Santa Maria Capua Vetere** – Learning based on Scientific Research and so supported by university equipment and research laboratory is an essential and qualifying tool. It is the only one able to give a real added value to the different methods of communication and transfer of knowledge, and substantiate them of innovative, updated contents suited to the different needs of dialogue among the actors, who intervene in

learning path. The higher is the quality level obtained the more rigorous and often is the use of supports based on scientific, experimental and applied studies. The implemented didactic path carries out through methodologies aimed at developing competences based on lab didactics, problem analysis and solution and project work, with a particular reference to technological laboratorial activities and teachings. Using specialist softwares, applied to the real case study, allowed to examine the behavior of the building-plant system, on the base of different parameters (envelope performances, plant efficiency, direct end-users' real energy consumptions, exterior environmental conditions, interior comfort levels, integrability with both active and passive solar systems), up to determine energy performances of the whole system for a standard use.

From the didactic point of view, the students' direct involvement in finding out the most efficient rehabilitation interventions, on not only the base of the technical feasibility, but also of the economic parameters (costs/benefits), can produce meaningful results and interesting reflection cues. A student<sup>19</sup> from the Lab. of Building Acoustics of the Technical University of Athens visited the Department of Architecture and Industrial Design of the University of Campania 'L. Vanvitelli'. The exercise concerned the assessment of the energy-environmental performance of an existing school building. The public school building complex and more precisely the Scientific High School 'Edoardo Amaldi', located in Santa Maria Capua Vetere (Caserta) is chosen as one of cases study. The training work comprises three phases:

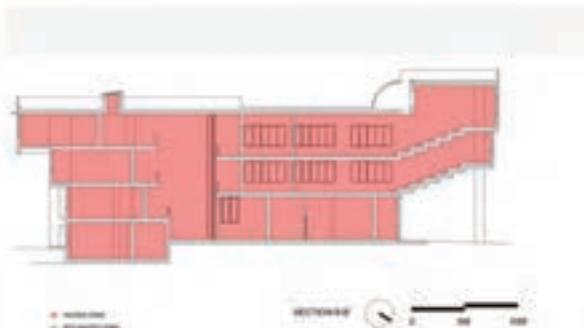
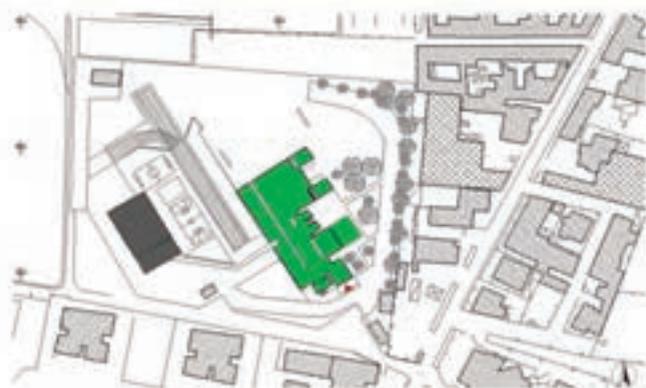
1) First phase (Fig. 108). This phase involves a review of relevant published scientific work, referring to the environmental performance of public open spaces in Mediterranean cities. Also meteorological data (environmental variables) such as temperature, relative humidity, natural ventilation (prevailing winds) etc., concerning the wider area of the environmental surround was collected. This can be done through a variety of means, such as, drawings, photos, aerial photographs, maps, in situ observations and measurements, surveys among the users, research on internet, experimental procedures etc. The expected results was a Report involving the relevant literature review, and the characteristics of the selected open space i.e. meteorological, spatial, technological and functional information.

2) Second phase (Fig. 109). In-situ measurements of energy and acoustic variables. Also digitization of measured results and architectural features of the test space, for use in appropriate software. In order to assess the thermal performance and energy efficiency of the building the used tool is the software SEAS 3.0 (Simplified Energy Auditing Software)<sup>20</sup>, based on the MS Excel Suite. The software provides simplified energy simulation models utilizing a multitude of data imported by the user through a graphical user interface consisting of worksheets with input fields for each parameter needed for the simulation. According to this a variety of data was analysed and assessed in order to be prepared to be inputted in the software. The first type of data request is about geographic characters (Degrees-day, climatic zone, latitude, wind zone, etc.); then, envelope's characteristics and

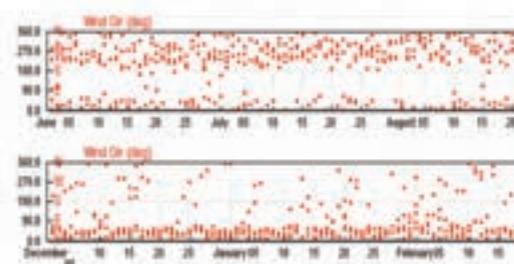
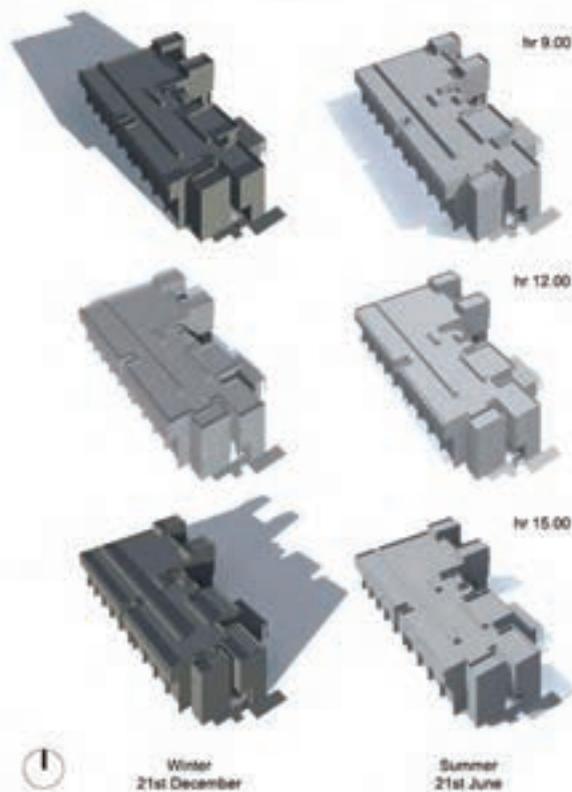
*Next pages. Figg. 108-110 - Amaldi' Scientific High School (designed by K. A. Kontonikas): Data Collection; Evaluation and Computational Data Modelling; Assessment and Results.*

# DATA COLLECTION

# EVALUATION AND COMPUTATIONAL DATA MODELING

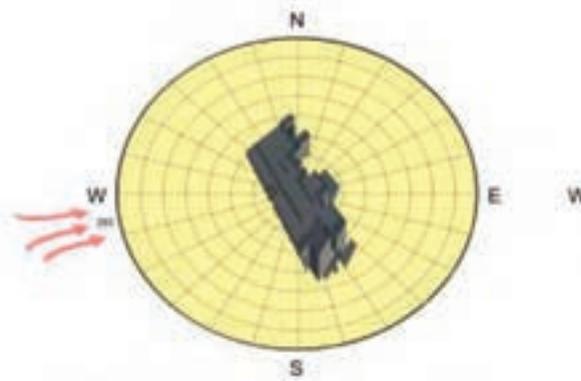


PREVAILING WINDS DURING SUMMER (2011) AND DURING WINTER (2010-2015) PERIOD



Summer

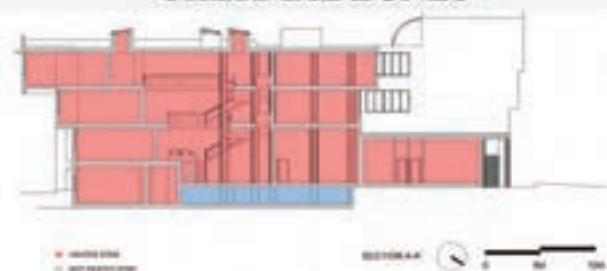
Winter



ASSESSMENT  
AND RESULTS

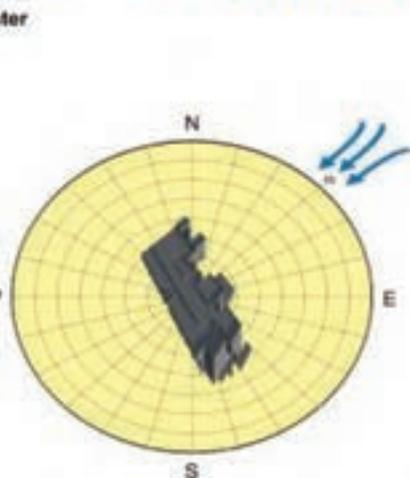
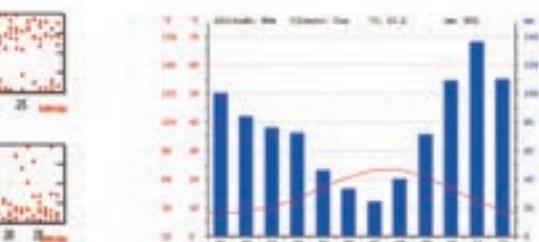
DESIGN  
PROPOSALS

### THERMAL ZONES



(2015)  
D

THE AVERAGE VALUES OF THE TEMPERATURE AND  
PRECIPITATION FOR EACH MONTH IN AN ANNUAL  
BASIS OF THE CASERTA AREA(2010-2015)

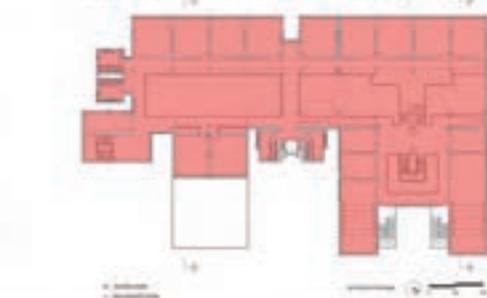
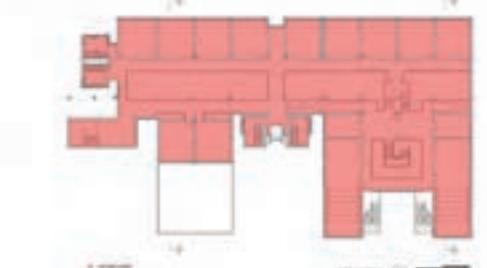
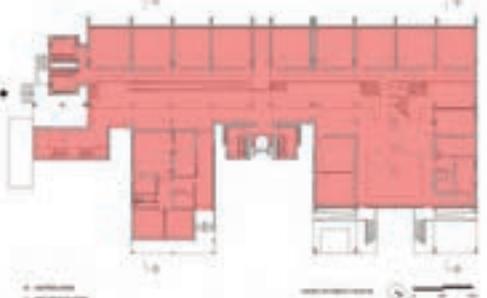
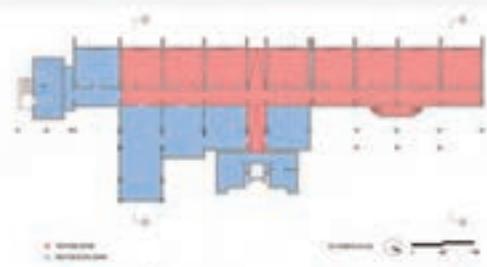


BASEMENT

GROUND FLOOR

FIRST FLOOR

SECOND FLOOR



# DATA COLLECTION

# EVALUATION AND COMPUTATIONAL DATA MODELING

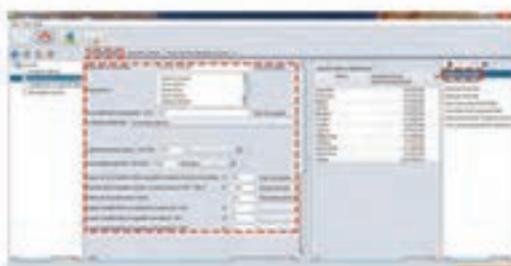
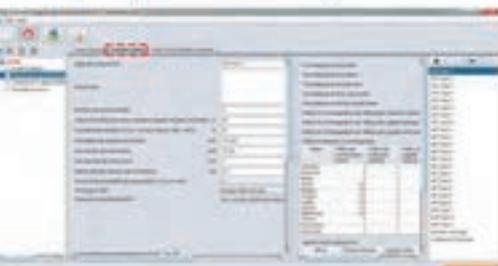
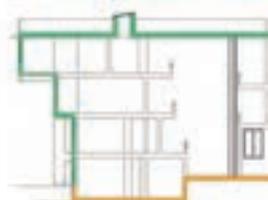
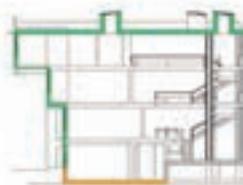
## TRANSPARENT ENVELOPE



- Dispersive surface / volume
- Dispersive surface / volume
- Dispersive surface / volume



## NATURAL INTERNAL VENTILATION



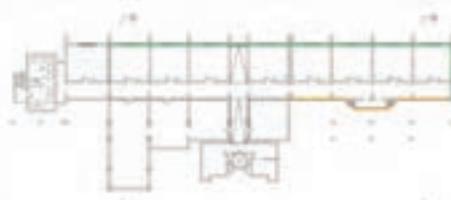
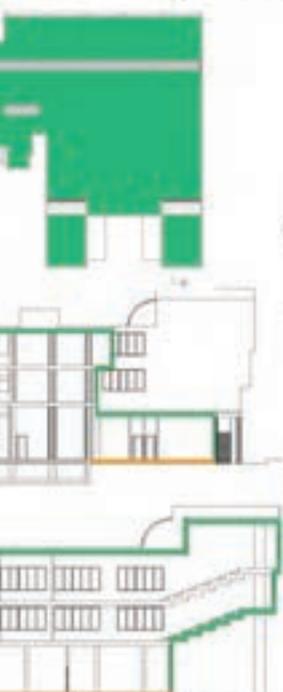
ID	Element name	Material	Volume	Area	Surface Area
1	Internal wall towards the 0th direction	Internal Environment	0.0	0.0	0.0
2	Internal wall towards the 1st direction	Internal Environment	0.0	0.0	0.0
3	Internal wall towards the 2nd direction	Internal Environment	0.0	0.0	0.0
4	Internal wall towards the 3rd direction	Internal Environment	0.0	0.0	0.0
5	Internal wall towards the 4th direction	Internal Environment	0.0	0.0	0.0
6	Internal wall towards the 5th direction	Internal Environment	0.0	0.0	0.0
7	Internal wall towards the 6th direction	Internal Environment	0.0	0.0	0.0
8	Internal wall towards the 7th direction	Internal Environment	0.0	0.0	0.0
9	Internal wall towards the 8th direction	Internal Environment	0.0	0.0	0.0
10	Internal wall towards the 9th direction	Internal Environment	0.0	0.0	0.0
11	Internal wall towards the 10th direction	Internal Environment	0.0	0.0	0.0
12	Internal wall towards the 11th direction	Internal Environment	0.0	0.0	0.0
13	Internal wall towards the 12th direction	Internal Environment	0.0	0.0	0.0
14	Internal wall towards the 13th direction	Internal Environment	0.0	0.0	0.0
15	Internal wall towards the 14th direction	Internal Environment	0.0	0.0	0.0
16	Internal wall towards the 15th direction	Internal Environment	0.0	0.0	0.0
17	Internal wall towards the 16th direction	Internal Environment	0.0	0.0	0.0
18	Internal wall towards the 17th direction	Internal Environment	0.0	0.0	0.0
19	Internal wall towards the 18th direction	Internal Environment	0.0	0.0	0.0
20	Internal wall towards the 19th direction	Internal Environment	0.0	0.0	0.0
21	Internal wall towards the 20th direction	Internal Environment	0.0	0.0	0.0
22	Internal wall towards the 21st direction	Internal Environment	0.0	0.0	0.0
23	Internal wall towards the 22nd direction	Internal Environment	0.0	0.0	0.0
24	Internal wall towards the 23rd direction	Internal Environment	0.0	0.0	0.0
25	Internal wall towards the 24th direction	Internal Environment	0.0	0.0	0.0
26	Internal wall towards the 25th direction	Internal Environment	0.0	0.0	0.0
27	Internal wall towards the 26th direction	Internal Environment	0.0	0.0	0.0
28	Internal wall towards the 27th direction	Internal Environment	0.0	0.0	0.0
29	Internal wall towards the 28th direction	Internal Environment	0.0	0.0	0.0
30	Internal wall towards the 29th direction	Internal Environment	0.0	0.0	0.0
31	Internal wall towards the 30th direction	Internal Environment	0.0	0.0	0.0
32	Internal wall towards the 31st direction	Internal Environment	0.0	0.0	0.0
33	Internal wall towards the 32nd direction	Internal Environment	0.0	0.0	0.0
34	Internal wall towards the 33rd direction	Internal Environment	0.0	0.0	0.0
35	Internal wall towards the 34th direction	Internal Environment	0.0	0.0	0.0
36	Internal wall towards the 35th direction	Internal Environment	0.0	0.0	0.0
37	Internal wall towards the 36th direction	Internal Environment	0.0	0.0	0.0
38	Internal wall towards the 37th direction	Internal Environment	0.0	0.0	0.0
39	Internal wall towards the 38th direction	Internal Environment	0.0	0.0	0.0
40	Internal wall towards the 39th direction	Internal Environment	0.0	0.0	0.0
41	Internal wall towards the 40th direction	Internal Environment	0.0	0.0	0.0
42	Internal wall towards the 41st direction	Internal Environment	0.0	0.0	0.0
43	Internal wall towards the 42nd direction	Internal Environment	0.0	0.0	0.0
44	Internal wall towards the 43rd direction	Internal Environment	0.0	0.0	0.0
45	Internal wall towards the 44th direction	Internal Environment	0.0	0.0	0.0
46	Internal wall towards the 45th direction	Internal Environment	0.0	0.0	0.0
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48	Internal wall towards the 47th direction	Internal Environment	0.0	0.0	0.0
49	Internal wall towards the 48th direction	Internal Environment	0.0	0.0	0.0
50	Internal wall towards the 49th direction	Internal Environment	0.0	0.0	0.0
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53	Internal wall towards the 52nd direction	Internal Environment	0.0	0.0	0.0
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55	Internal wall towards the 54th direction	Internal Environment	0.0	0.0	0.0
56	Internal wall towards the 55th direction	Internal Environment	0.0	0.0	0.0
57	Internal wall towards the 56th direction	Internal Environment	0.0	0.0	0.0
58	Internal wall towards the 57th direction	Internal Environment	0.0	0.0	0.0
59	Internal wall towards the 58th direction	Internal Environment	0.0	0.0	0.0
60	Internal wall towards the 59th direction	Internal Environment	0.0	0.0	0.0
61	Internal wall towards the 60th direction	Internal Environment	0.0	0.0	0.0
62	Internal wall towards the 61st direction	Internal Environment	0.0	0.0	0.0
63	Internal wall towards the 62nd direction	Internal Environment	0.0	0.0	0.0
64	Internal wall towards the 63rd direction	Internal Environment	0.0	0.0	0.0
65	Internal wall towards the 64th direction	Internal Environment	0.0	0.0	0.0
66	Internal wall towards the 65th direction	Internal Environment	0.0	0.0	0.0
67	Internal wall towards the 66th direction	Internal Environment	0.0	0.0	0.0
68	Internal wall towards the 67th direction	Internal Environment	0.0	0.0	0.0
69	Internal wall towards the 68th direction	Internal Environment	0.0	0.0	0.0
70	Internal wall towards the 69th direction	Internal Environment	0.0	0.0	0.0
71	Internal wall towards the 70th direction	Internal Environment	0.0	0.0	0.0
72	Internal wall towards the 71st direction	Internal Environment	0.0	0.0	0.0
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79	Internal wall towards the 78th direction	Internal Environment	0.0	0.0	0.0
80	Internal wall towards the 79th direction	Internal Environment	0.0	0.0	0.0
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93	Internal wall towards the 92nd direction	Internal Environment	0.0	0.0	0.0
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95	Internal wall towards the 94th direction	Internal Environment	0.0	0.0	0.0
96	Internal wall towards the 95th direction	Internal Environment	0.0	0.0	0.0
97	Internal wall towards the 96th direction	Internal Environment	0.0	0.0	0.0
98	Internal wall towards the 97th direction	Internal Environment	0.0	0.0	0.0
99	Internal wall towards the 98th direction	Internal Environment	0.0	0.0	0.0
100	Internal wall towards the 99th direction	Internal Environment	0.0	0.0	0.0

ASSESSMENT  
AND RESULTS

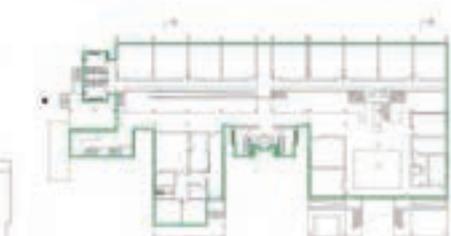
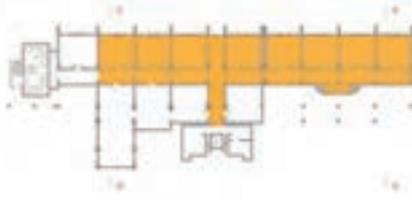
DESIGN  
PROPOSALS

### DISPERSIVE SURFACES DISCRIMINATION

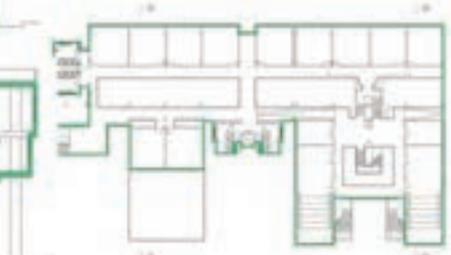
Legend:  
 - External  
 - Internal  
 - Soil



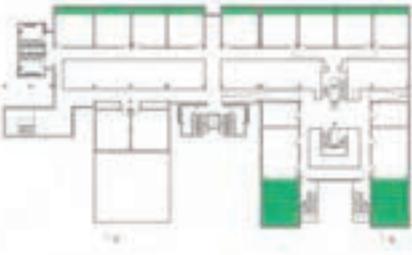
**BASEMENT**



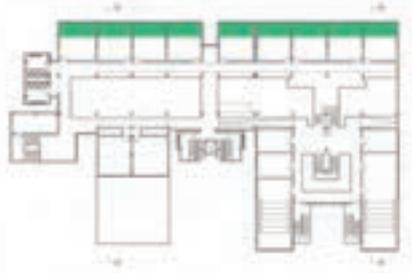
**GROUND FLOOR**



**FIRST FLOOR**



**SECOND FLOOR**



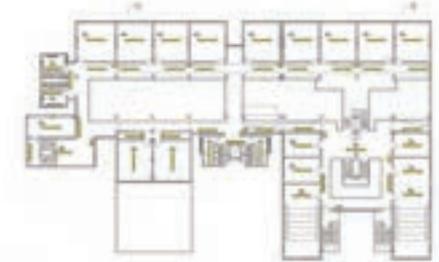
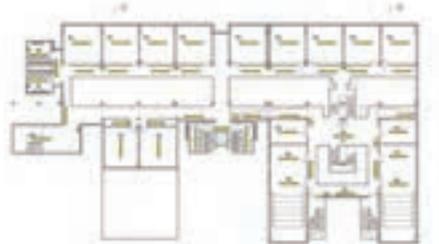
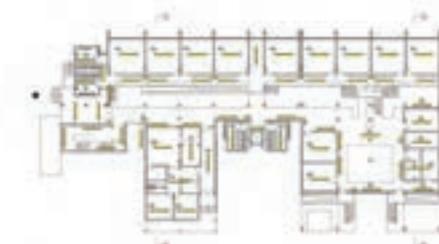
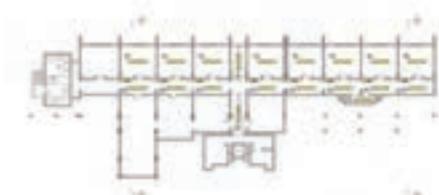
Thermal Transmittance (U-value)	Thermal Absorption Factor	Angle of surface with respect to the horizontal (deg)	Angle of surface with respect to the north (deg)	Weight of the surface (kg/m²)
0.00	0.0	90	0.0	0.0
0.00	0.0	90	0.0	0.0
0.00	0.0	90	0.0	0.0
0.00	0.0	90	0.0	0.0
0.00	0.0	0	0.0	0.0
0.00	0.0	0	0.0	0.0
0.0	0.0	0	0.0	0.0
0.0	0.0	0	0.0	0.0

**DATA  
COLLECTION**

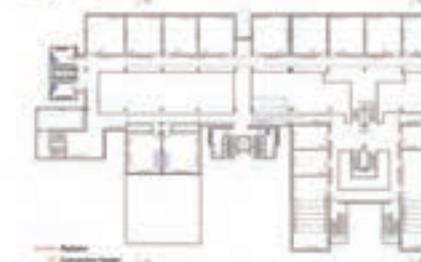
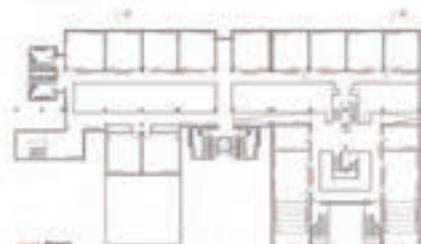
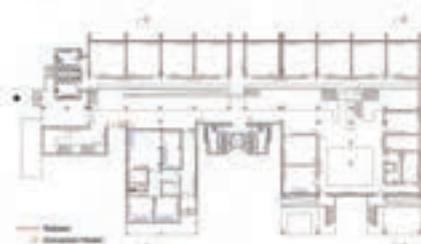
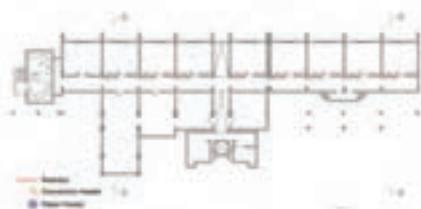
**EVALUATION AND  
COMPUTATIONAL  
DATA MODELING**

**ARTIFICIAL LIGHTS**

**HEATING / COOLING TERMINALS  
AND DHW INSTALLATIONS**



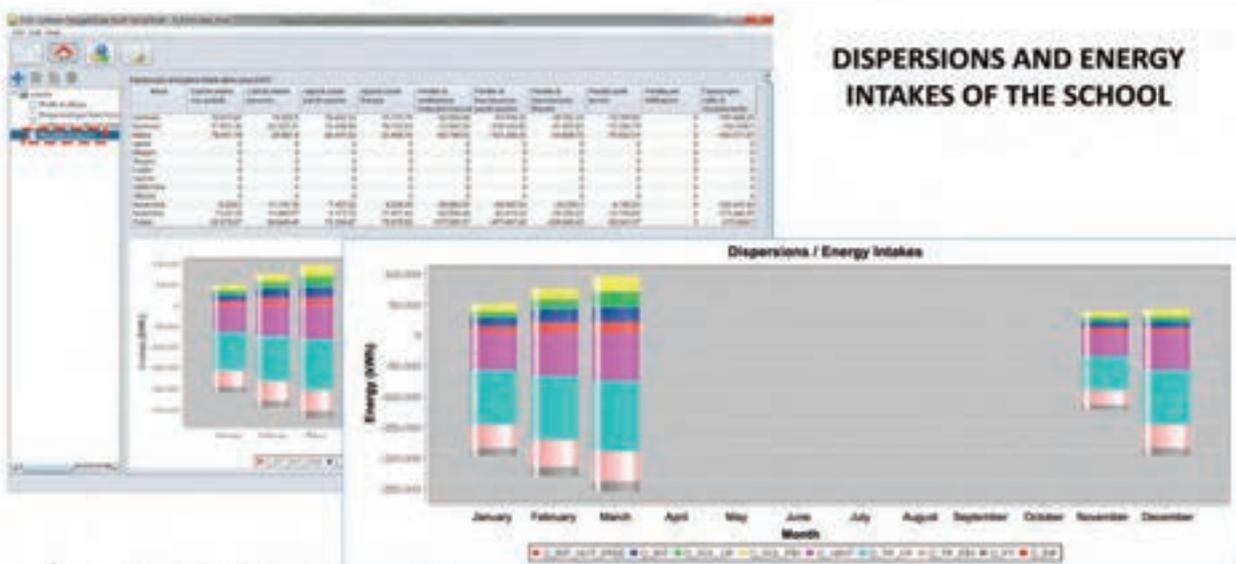
**BASEMENT**  
**GROUND FLOOR**  
**FIRST FLOOR**  
**SECOND FLOOR**



# ASSESSMENT AND RESULTS

# DESIGN PROPOSALS

## DISPERSIONS AND ENERGY INTAKES OF THE SCHOOL

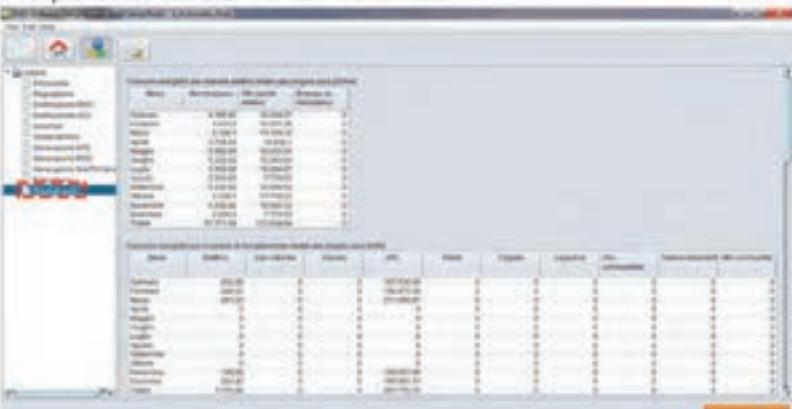


## TOTAL ENERGY NEEDS OF THE SCHOOL (kWh)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Electricity	14,644.90	19,033.04	19,740.41	13,848.98	18,584.99	17,328.09	14,235.42	10,308.11	17,328.09	19,479.18	17,463.64	50,652.53	192,627.34
Gas	187,536.08	198,475.64	211,090.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	109,531.98	195,081.13	801,715.76
<b>Total</b>	<b>202,181.00</b>	<b>217,508.68</b>	<b>230,831.38</b>	<b>13,848.98</b>	<b>18,584.99</b>	<b>17,328.09</b>	<b>14,235.42</b>	<b>10,308.11</b>	<b>17,328.09</b>	<b>19,479.18</b>	<b>127,000.00</b>	<b>245,733.66</b>	<b>994,343.10</b>

## TOTAL ENERGY CONSUMPTION OF PLANT SYSTEMS

Month	Electrical consumption	GPL
January	14,644.90	187,536.08
February	19,033.04	198,475.64
March	19,740.41	211,090.97
April	13,848.98	0.00
May	18,584.99	0.00
June	17,328.09	0.00
July	14,235.42	0.00
August	10,308.11	0.00
September	17,328.09	0.00
October	19,479.18	0.00
November	17,463.64	109,531.98
December	50,652.53	195,081.13
<b>Total</b>	<b>192,627.34</b>	<b>801,715.76</b>



profile of use are fully documented. The software requires all the measurable data related to the thermal zones and every possible parameter that may affect the transmission of thermal loads within the building as much as incoming and outgoing thermal loads.

3) Third phase. Assessment of the environmental and architectural data collected and suggestions of innovative technological interventions for the improvement of the energy quality of the opaque and transparent envelope of the scholar building. In order to plan the design actions of retrofit and address the objectives of this project successfully, there is an imperative: it needs to have a full and thorough understanding of the current condition, so as to make a proper assessment and thus, through a scientifically accepted process, to reach to the appropriate results which will guide the technicians throughout appropriate proposals (Abbi and Jain, 2009).

The traditional paradigm of education, based on the standardized approach with classroom lessons and final test on the acquired knowledge to be passed or a proficiency exam during which graphic-descriptive elaborations are debated, has been changed into a more efficient educational model. The didactic path carries out through methodologies aimed at developing competences based on lab didactics, problem analysis and solution and project work, with a particular reference to laboratorial activities and teachings. Using specialist software applied to the real case study allowed to examine the behavior of the building-plant system, on the base of different parameters (envelope performances, plant efficiency, direct end-users' real energy consumptions, exterior environmental conditions, interior comfort levels, integrability with both active and passive solar systems), up to determine energy performances of the whole system for a standard use. In particular, acquired skills and competences are been: a) Knowledge and use of specific bioclimatic software; b) Knowledge of innovative technological design solutions in order to improve energy-environmental performances of an existing building.

**Water as a material for architecture in the Fitness centre at Maddaloni: the regenerative approach** – The performative method and the regenerative approach are the basis of the work<sup>21</sup> by Antonio Bizzarro, who uses water as a central element of a wellness centre design that is proposed as a compositional experimentation of a systematic study of innovative technologies, in which water-built integration is the main concept. The design solutions systematised identify this resource with the double quality of a useful goodness for life, for which it is necessary to manage it without any waste, and resource able to provide an ecosystem service which, therefore, must be valued in its natal cycles, also involving the aesthetic sphere and that psycho-somatic wellness one. The wise use of the element of water, in fact, contributes to create a hygrometrically controlled environment, but also relaxing sound effects, pleasant lights, stimulating sensory interactions, very pertinent to the characteristics of a wellness centre.

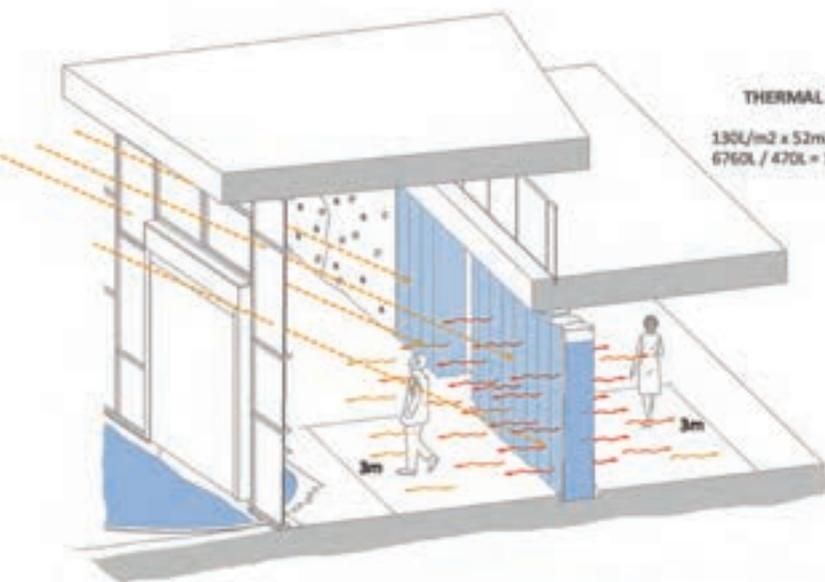
The evaluation of the technological footprint has been made in a multi-scale manner according to the C2C approach. The whole design is thought to be in total and ecosystem harmony with the natural water cycle: the materials chosen are those ones that do not require an excessive use of water in the production; the construction system provides for the installation of technical elements and dry components; on a building scale, the

plant system is designed to reduce consumption (through the rational development of the adduction network), recover and reuse rainwater and, also from a bioclimatic point of view, water walls and roof pond contribute to adjust the hermos-hygrometric performances of the system (Francese and Balestra, 2009).

Close to the design of systems for reducing consumptions, uses have been evaluated and identified where non-drinkable water could be used, which is environmentally less impactful and economically less expensive. Geothermal pumps with very low enthalpy, combined with solar collectors or photo-bioreactors, Solar Pond and Roof Pond are some of the technologies that strategically direct design towards the new paradigm of regenerative architecture. From the analysis of the biophysical system, on an urban scale, green areas and draining asphalts filter and dispose of rainwater. The largest covers in the market area have got the function of rainwater accumulation surfaces, conveyed and collected in tanks put below. The building used as a fitness centre, located in a trapezoidal lot, is generated, from a morphological point of view, by bioclimatic matrices that have dictated spatial organisation, openings, inclination of the roofs and its structure, coherently with what emerged from the study of sunshine and natural ventilation of open spaces. The building is closed in the north, to protect itself from the cold winter winds, and open in the south, embracing a bio-pond that connects the external environment with the interior spaces.

The Fitness Centre covers about 1300 sqm and has several rooms internally accessible from two entrances, a main one in the north leading to the hall, where there is also a wall for outdoor climbing and a secondary one in the south, accessible to people coming from the parking areas. The combination created between the external landscape and the architectural interior is not only guaranteed by the body of water and the modular glass walls that surround the building, but also by the vegetation that uninterruptedly climbs the roof, integrating it into the context. The remaining part of the roof and the wall on the whole north side is covered with a second layer of recycled aluminium sheet wrapping the building. From the spatial point of view, the south entrance leads to a double-height environment that acts as a thermal buffer, used as a functional training room, where there is also a wall for indoor climbing that surrounds the main staircase and rooms for about 6,5 metres. On the ground floor there is also an area equipped for body building training, one dedicated to physical rehabilitation and a room for specialist visits, while in the west you can access the 220 sqm SPA consisting of swimming pool, hydro-massage, Kneipp path, relax area with salt wall, sauna, Turkish bath and changing rooms. In the east, slightly underground and accessible through a ramp, there are the changing rooms of the centre and a restaurant area, where it is accessible the first level through a second staircase. On the first floor there is the equipment room characterised by a large area (330 sqm) that overlooks the double height, the room dedicated to spinning and a large room (150 sqm) completely full of glass walls, where you can do all

*Next pages. Figg. 111-115 - The Fitness Centre (designed by A. Bizzarro): Natural ventilation and heating system; Summer and winter bioclimatic behaviour; Construction details; Internal and external pool details; Thermo-hygrometric performance of the water wall.*

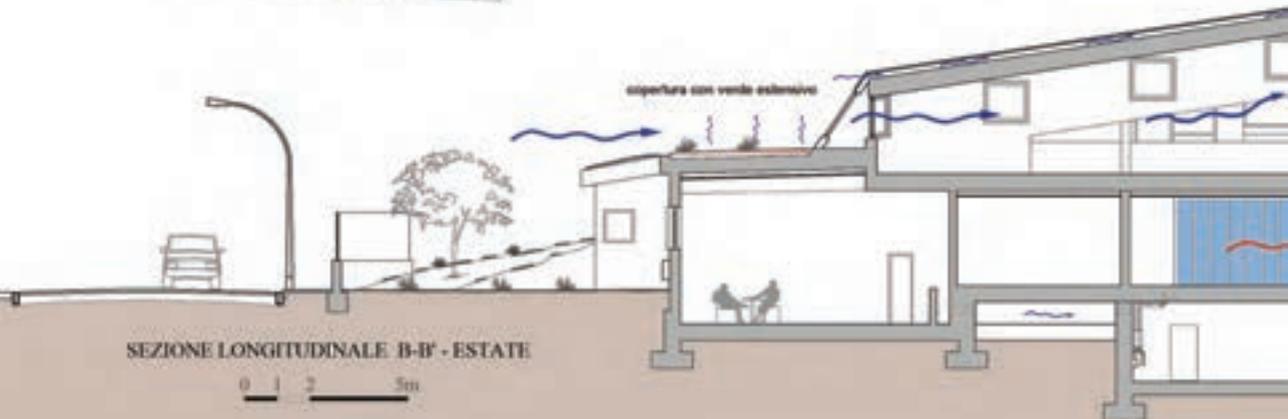


**THERMAL STORAGE**

130L/m<sup>2</sup> x 52m<sup>2</sup> (facciata) =  
6760L / 470L = 15



**PIANTA PIANO PRIMO**

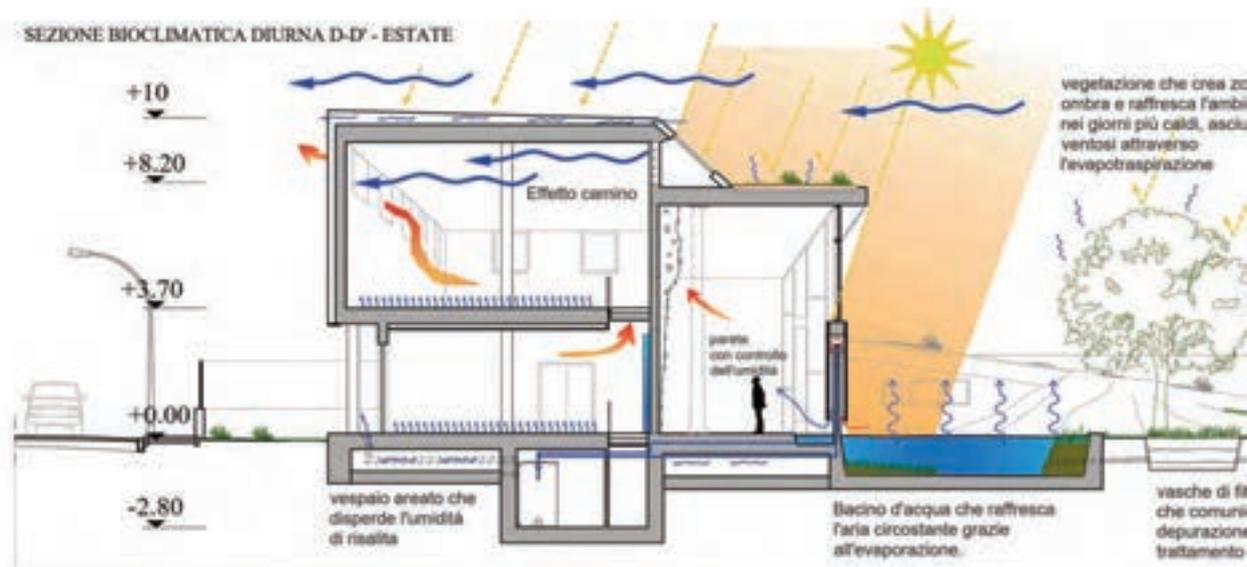


**SEZIONE LONGITUDINALE B-B' - ESTATE**

0 1 2 5m



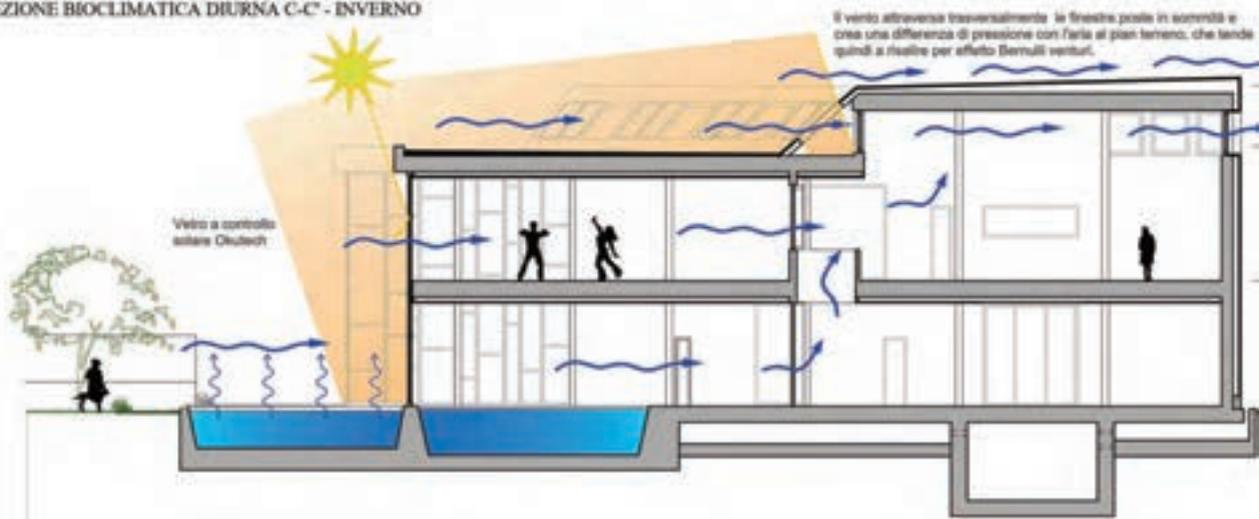
SEZIONE BIOCLIMATICA DIURNA D-D' - ESTATE



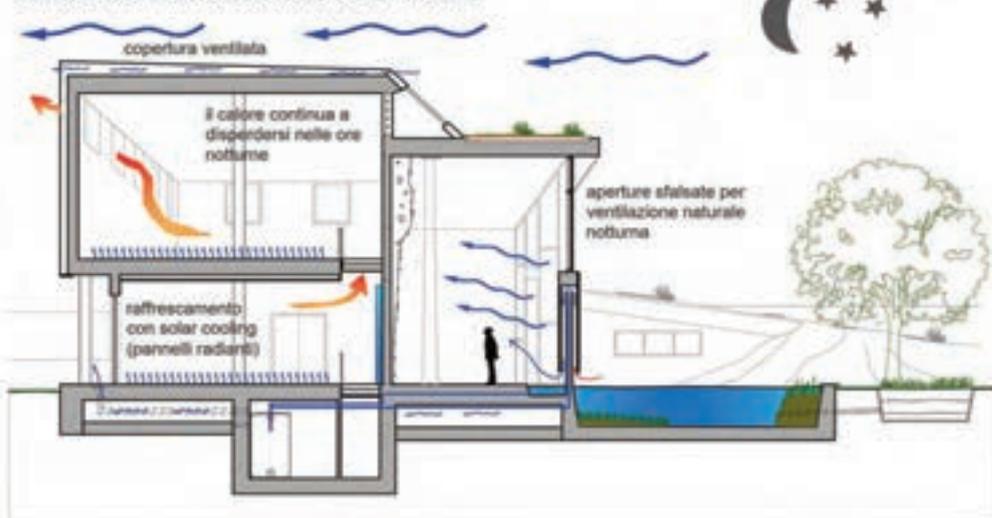
SEZIONE BIOCLIMATICA DIURNA D-D' - INVERNO



SEZIONE BIOCLIMATICA DIURNA C-C' - INVERNO



### SEZIONE BIOCLIMATICA NOTTURNA D-D' - ESTATE



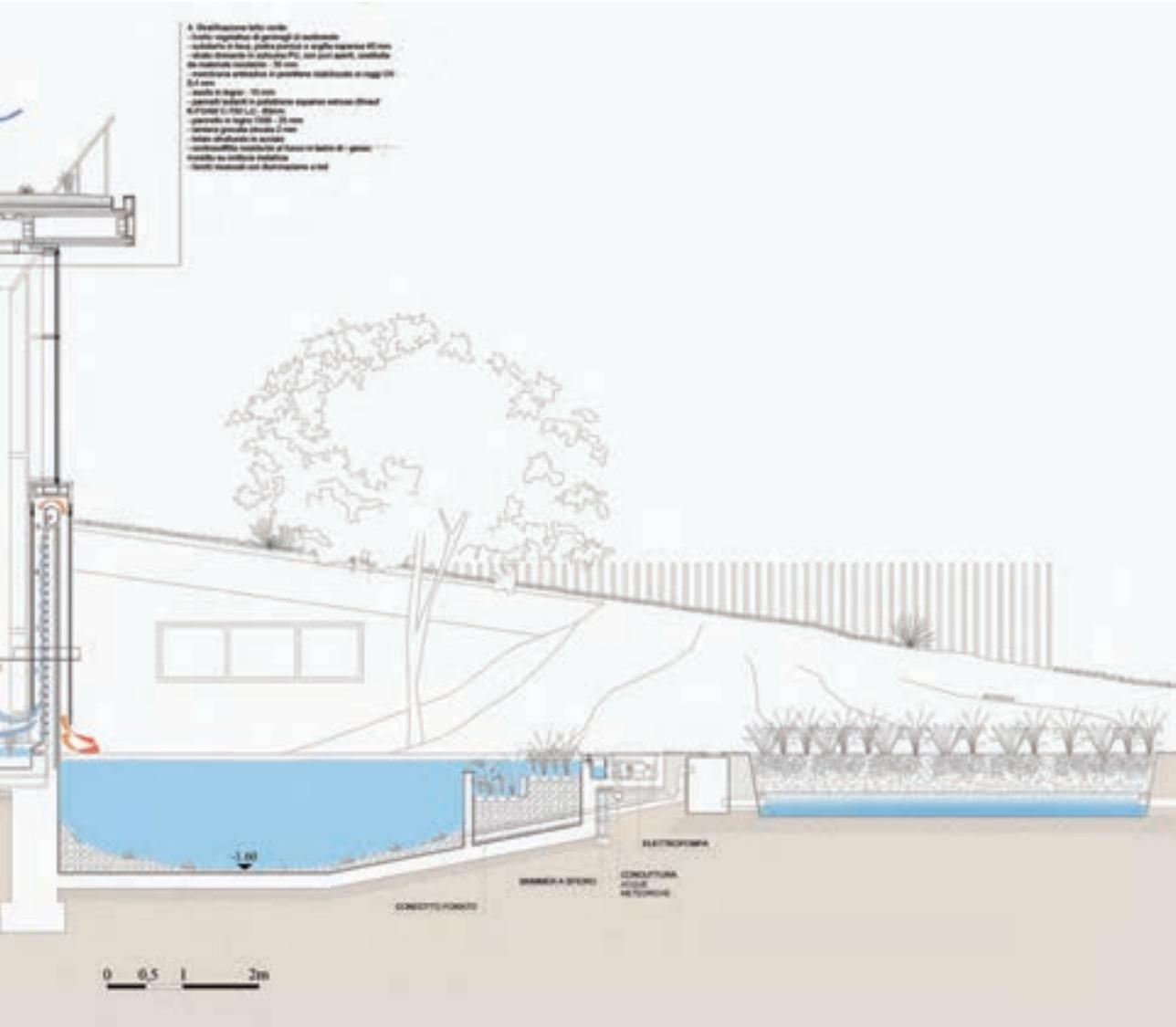
### SEZIONE BIOCLIMATICA NOTTURNA D-D' - INVERNO



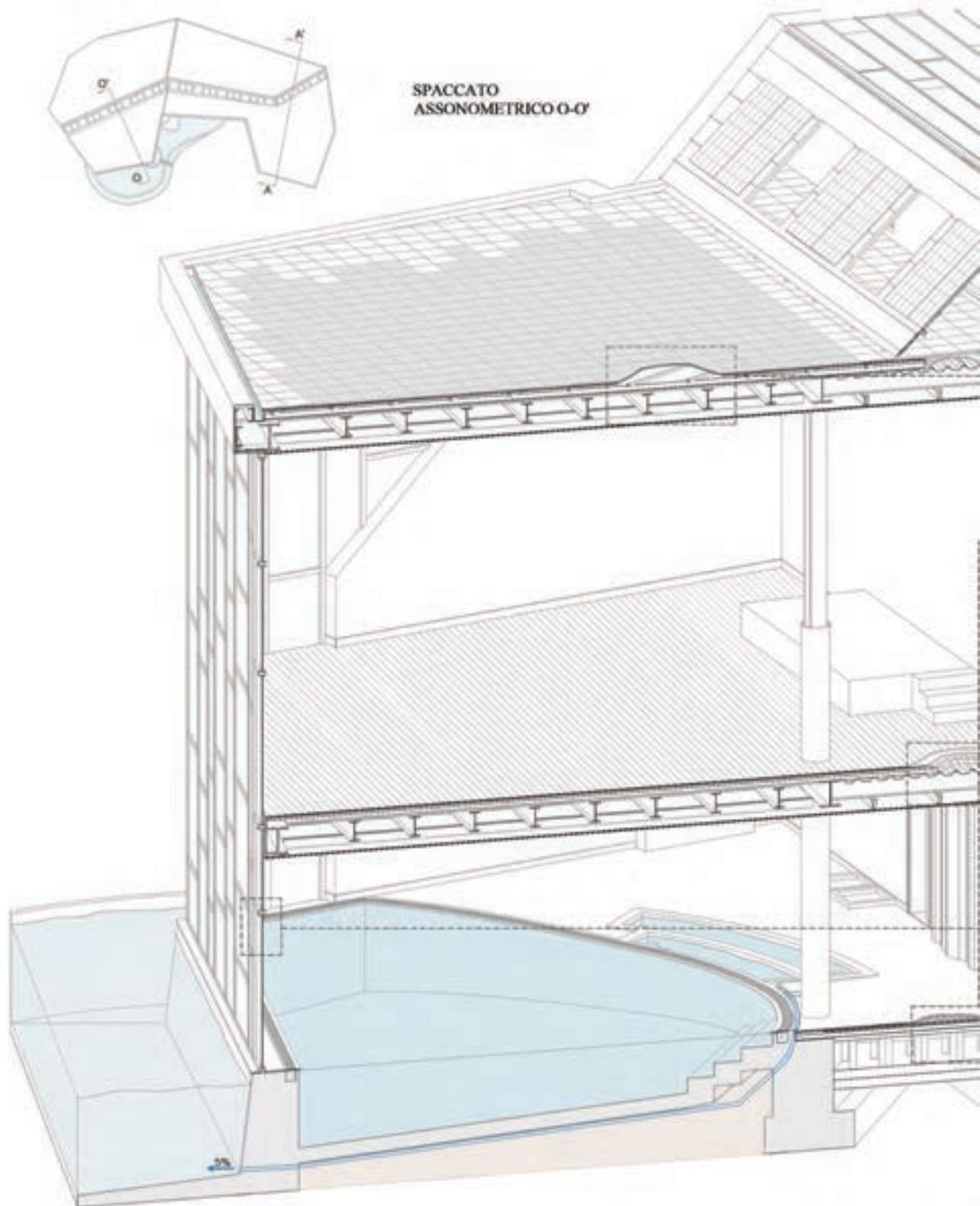
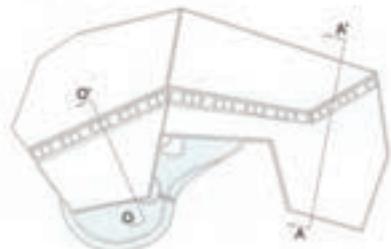
### SEZIONE BIOCLIMATICA DIURNA C-C' - ESTATE







SPACCATO  
ASSONOMETRICO O-O'

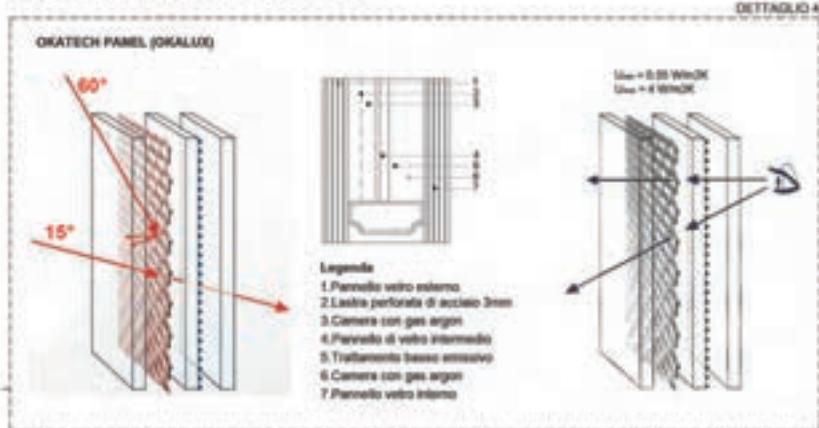
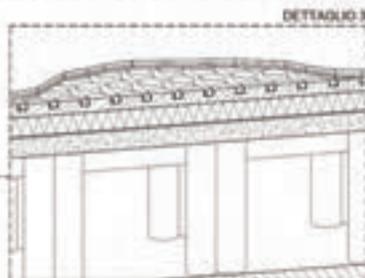
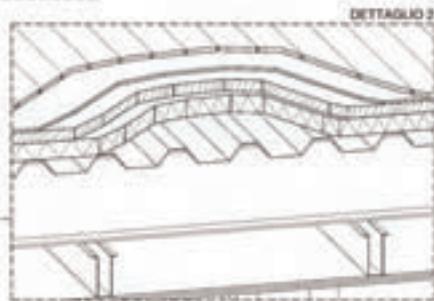
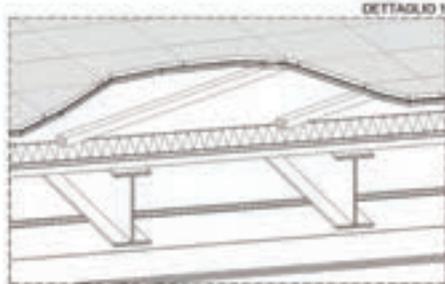


SEZIONE BIOCLIMATICA  
A-A' - ESTATE

0 1 2 5m



Manto d'erba che purifica l'aria che lo lambisce  
Il microclima dell'ambiente sottostante resta  
asciutto e ventilato attraverso l'evapotraspirazione



...e migliora  
giorni più caldi,  
azione

+3.70

+0.00

-1.00

serbatoio interno  
di 5 mc

+10.2

Pannelli solari termici inclinati  
da 40° a 60°



Parete ventilata 7cm con  
rivestimento in lamiera aggraffata.



PIANO IN GRANITO ROSSO  
 PIANO IN LEGNO ABETE  
 PROFILO COLD FORMED  
 POLISTIRENE ESTRUSO  
 PROFILO SCATOLARE IN ACCIAIO  
 CORNICI IN ALLUMINIO  
 VETRO TEMPERATO E STRATIFICATO  
 PIANO IN GRANITO ROSSO  
 STRATO DI GHIAIA, SABBIA E TORBA CON PANTACQUATICHE

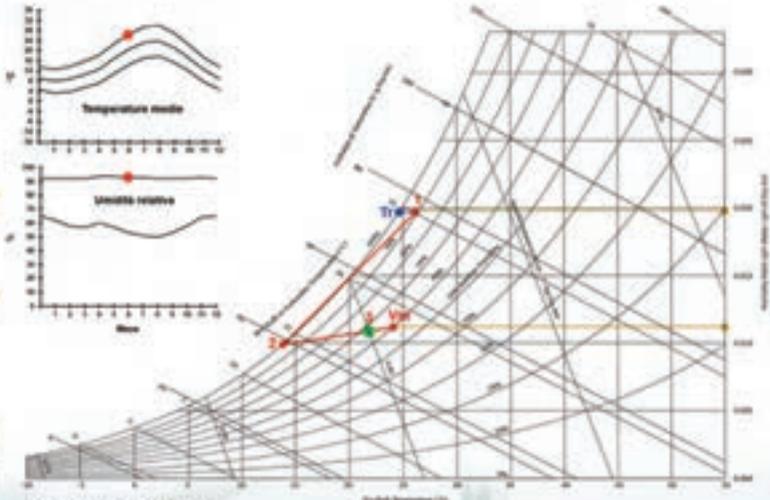
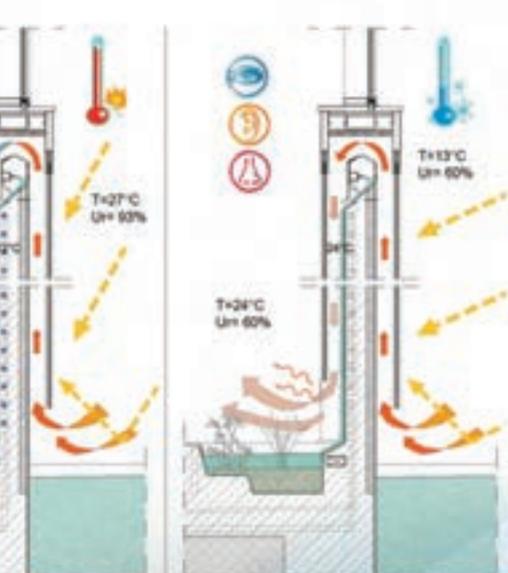
**WATER WALL**  
 - DEUMIDIFICAZIONE  
 - RAFFRESCAMENTO  
 - PURIFICAZIONE

VETROCAMERA CON GAS ARGON  
 PROFILATI IN ALLUMINIO  
 VETRO SATINATO NERO  
 MONTANTE IN ACCIAIO  
 SCOSSALINA IN ALLUMINIO  
 VANO CON UGELLI  
 ISOLANTE IN POLISTIRENE ESTRUSO 50mm  
 CONDOTTO DI MANDATA DELL'ACQUA 20mm  
 SERPENTINA PER L'ACQUA REFRIGERATA  
 PARETE IN CLS  
 LAMIERA IN ACCIAIO  
 POLISTIRENE ESTRUSO  
 TERMOSTATO/GRIGIATO  
 GUANA IMPERMEABILE  
 GRIGLIA DI MANDATA V.M.C.  
 VANO ISPEZIONE POMPA  
 DOPPIA GUANA IMPERMEABILE  
 CANALINE PER V.M.C. 60X120mm  
 PARQUET FLOTTANTE  
 CONDOTTO DI MANDATA DELL'ACQUA BIOLOGICO



T=22°C  
 Um=65%





### Psychrometric Chart

Fenomeno di raffreddamento e deumidificazione e successivo miscelamento con aria trattata proveniente da V.M.C. con scambiatore di calore.



types of musical fitness and martial arts. The main technical room of the centre is completely underground and is accessible from the main staircase set in the middle of the structure.

The study of climatic data, through the Brown diagram, suggests feasible passive effective bioclimatic solutions. The different types of use destinations determine the level of comfort that will be based on the adaptive principle (Nicol et alii, 2012). From the Brown diagram, specifically, it emerges that for 8 months a year there has been being a situation of comfort, for 2 months, during the summertime, a good natural ventilation and evaporative cooling is required, as well as a suitable shielding from the radiation. Only for a few days with extreme temperatures it may be required the active technological contribution of the plants. For 2 winter months, heat is required with plant systems. From the various bioclimatic sections that analyse the relationship of the building with environmental factors, it is possible to notice all the contributions of passive and active technologies during the various seasons and the night/day cycle. The heat deriving from the solar radiation, from the radiant panels (Fig. 111) and controlled by the checked mechanical ventilation system that recovers the heat coming from the changing rooms, makes the environment comfortable especially during daylight hours, also thanks to the protection from cold winds that do not hit the north wall, well insulated and with crossed ventilation of the crawl space that prevents the rising of humidity from the sub-soil. During the summer season the behaviour of the building is inverted: the overhang of the façade and the solar control windows, as well as the presence of deciduous trees, massively reduce the solar radiation especially in the central hours of the day. In order to disperse the heat from radiation, both a ventilated roof and a garden roof have been installed that mitigate the heat of the rooms below on the hottest days, through evapotranspiration. At sunset, the indoor climate comfort will be guaranteed by the heat exchange ventilation system supported by the solar cooling system and radiant panels, or we will dispose of the excessive heat using night ventilation (Fig. 112).

The design of the rainwater recovery system involves the installation of 3 underground tanks of 5 cubic metres each and 12 polyethylene tanks of 2 cubic metres, which fully satisfy the need for undrinkable water. As regards the use of renewable energy sources, after estimating the energy consumption of the building and the need for domestic hot water (DHW) for the changing rooms, the SPA and the radiant panel system, the installation of 3 different types of plants has been considered. The ventilated roof wrapping the building will be scanned from south-west to south-east thanks to windows and thermo-photovoltaic panels that are inclined at different degrees (from 40° to 60°), so that they mediate the performance of the plant, which there is in the various seasons of the year. The cold-storage panels that consist of 60 cells made of 60 mono-crystalline silicon cells are the latest generation hybrids able to produce 1.32kW of overall power, thanks to the optimisation of the heat exchanger. Integrated into the sheet of the ventilated roof, amorphous silicon thin-filmed photovoltaic modules have been fixed over the whole area. On the flat roof in the south, instead, walk-on thermal solar panels of polycarbonate have been installed for an extension of almost 150 sqm, which contribute to satisfy the needs of DHW. Generally an estimated 70% electricity requirement was met, while about DHW

production, it was considered appropriate to support a plant to contribute to DHW peak demands and to low temperature heating of the rooms and swimming pool (Fig. 113).

The gray waters are treated and fed to phyto-purification tanks, where thanks to the action of the suitable tree species, it is deprived of any pollutant and with the support of a level regulator it is introduced into the bio-lake, where it also spills 5% of daily water change from the SPA pool. In this way the water undergoes a further treatment and with an annual total of just over 3 million litres, the irrigation needs of the whole equipped area are met. The bio-lake represents, even from the design point of view, the fulcrum of the design and communicates visually with the pool present in the SPA, giving the sensation of continuity between external and interior environment of the structure (Fig. 114).

In the design, an essential role is played by the water resource, which is used as a technological element to control the comfort parameters in the fitness centre environments (Faroldi, 2009). Particularly, two innovative plants are planned in the design: Thermal Storage Tubes and Water Wall. Thermal Storage Tubes are cylindrical fiber-glass containers containing water inside and at the same time they remain transparent enough to allow natural light to pass through. They help to regulate the temperature during the day and at night, in fact in wintertime, when the solar rays penetrate inside the structure, water absorbs and retains part of the heat (nearly 50% of the power), thanks to its high thermal inertia. When the sun goes down and the temperatures drop, the heat contained in the thermal tubes starts dissipating, heating the room with a heat transmission range of about 3 metres. The following morning the cycle is repeated, as the cool water can begin to absorb the heat from the sun. In water, however, copper sulphate has been diluted to eliminate the unwanted growth of algae, whose blue colour gives a pleasant atmosphere to the interior environment (Fig. 115).

Water Wall has an essential bioclimatic role for indoor comfort. The three walls that mark the south glass façade provide for dehumidification, cooling and air purification according to the interior thermo-hygrometric conditions revealed by a thermostat and a hygostat. Water wall therefore behaves differently with the changing seasons: in summertime when both the temperature and the relative humidity percentage are high, the external hot air will tend by its nature to rise inside the part, also stimulated by the heating caused by solar radiation hitting external black glass. After that, the air will be dragged downwards by the sheet of water that touches a steel plate, which will be cooled by water coils inside the concrete wall and fed by the absorption chiller. As the psychometric diagram shows, you will have a water temperature lower than the dew temperature, as much as necessary so that the right amount of water is condensed and the specific humidity is brought back to an acceptable level.

While water and condense produced will flow into a basin of water, where there are also aquatic plants suitable for low temperatures (*Phragmites australis* and *Lemna* sp.) performing a phyto-purifying action, the cold air expelled from the bottom will be simultaneously propagated and mixed with the treated air, introduced by the mechanical ventilation openings on the sides of the wall. The water from the basin will instead be directed inside the rainwater storage tanks, present in the technical room and from there it will be taken again to do the same cycle. In wintertime, considering the low temperatures,

having no need for dehumidification, the wall will expel air at room temperature, which will be mixed with the preheated ventilation air. The waterfall and the essences present in the basin will also produce other psycho-sensor benefits to the user. From the construction point of view the building has got all prerequisites that characterise a regenerative architectural design. Also the use of a steeled structure and the use of materials dried assembled are part of a choice aiming at reducing the huge waste of water during the construction site phase, besides respecting Cradle to Cradle aims. With the support of Thermus-Acca software all minimum prerequisites imposed by standards in force have been occurred and thermal bridges have been solved applying an envelope insulation and installing a wall/ventilated roof made of recycled aluminium sheet. Referring to the criteria used by the Building Research Establishment Environmental Assessment Method (BREEAM), one of the first tools to be used as a tool for voluntary certification of buildings, the design has tried to manage, through appropriate choices, the seven categories of energy, water, pollution, materials, transport, ecology and land use, health and wellness.

Law 90/2013 and DM 26/06/2015, combining the general aims of a rational use of climate and energy resources with the control of the characteristics of building materials and innovative components, propose a series of requirements that overcome the traditional contrast between innovation/development and rehabilitation/conservation and they structure the reference base for a performing apparatus that goes from the evaluation of the energy performance of the building system, to the systems that guarantee wellness and comfort, from the rational use of natural resources to the correct maintenance and management of the building and plant system. These qualities rehabilitate the existing building heritage from the condition of physical and functional obsolescence, to transform it into an architectural place of inspiration where you can experience languages, technologies and functionality: an opportunity! So the envelope will be the first technological system to be affected by this type of design attention. All the information collected can be useful at design level, both to define adequate technological solutions and to favour a 'systematised design' of the components to be used, which is possible only if the transformability of the building organism, specific requirement, efficiency and integrability of the chosen technologies have been previously analysed.

The elements that condition the degree of quality are linked with both the characteristics of the architectural organism (construction type, morphology, materials, exposure, degree of finishes, plant equipment) and the relationships that it establishes with its surrounding environment. Each element has its own degree of significance to be analysed and controlled by design, through a clever balance between compositional knowledge and constructive knowledge. Water, energy and green areas become immaterial materials of the design, with the aim of limiting the ecological footprint of the building system and maximising the social wellness of its direct users. Above all, in this design proposal the formalisation of needs in terms of requirements is thought again. The use of appropriate technologies is promoted which lead us to reflect on the need for design solutions with minimal impact and maximum environmental integration; waste is drastically reduced; compatibility and integration between appropriate building systems and innovative technological solutions are optimised.

## NOTES

- 1) Cfr. MIUR Ministerial Decree n. 270, article 3, paragraph 5 and article 11, paragraph 4 of 22 October 2004. [Online] Available at: <https://www.gazzettaufficiale.it/eli/id/2004/11/12/004G0303/sg> [Accessed on 05 December 2018].
- 2) The National Council of Architects, Planners, Landscapers and Conservators (CNAP-PC) with the Space Orientation for Architecture (SOA) project, promotes the creation of the National Observatory and the SOA Network by 2020, with the purpose of increasing the value of architecture, enhance the matching of skills demand and supply, favouring training success and employability, support professionals through a continuous support to face the complexity and the innovations connected with the exponential changes in progress. Cfr. web site: <http://www.awn.it/component/attachments/download/2158> [Accessed 20 December 2018].
- 3) Cfr. *Conferences, Seminars, Appointments*. [Online] Available at: <http://www.architettura.unicampania.it/> [Accessed on 20 December 2018].
- 4) An example is the educational experience carried out by students of the Course: Project of Building Rehabilitation, together with Erasmus students of Polytechnic University of Madrid and Polytechnic University din Timisoara, as part of the project actions for preservation of Campi Flegrei, conducted by the Department DICEA of the University of Naples 'Federico II'.
- 5) Cfr. Grundtvig Project, Leading Elderly and Adult Development – LABoratory, Modello europeo integrato per la personalizzazione dell'apprendimento nell'educazione degli adulti, p. 20. [Online] Available at: [http://www.afolsudmilano.it/attachments/588\\_LEADLAB-MODEL\\_IT.pdf](http://www.afolsudmilano.it/attachments/588_LEADLAB-MODEL_IT.pdf) [Accessed on 5 December 2018].
- 6) Cfr. *Ibidem*, p. 22.
- 7) Cfr. Structure of evaluation requirements AVA System.
- 8) Better knowledge for society becomes available when the methodologies of management studies, law and humanities are deployed in the research activities. Cfr. the web site: <https://www.eur.nl/en/research/erasmus-initiatives/dynamics-inclusive-prosperity/conference-dynamics-inclusive-prosperity> [Accessed on 05 December 2018].
- 9) Cfr. New Code of Public Contracts – Legislative Decree 18 April 2016, n. 50, coordinated with Legislative Decree 56/2017 (corrective tenders), with modifications foreseen by Law 145/2018. [Online] Available at: [https://www.codiceappalti.it/documenti/CodiceAppalti.it\\_Ultimo\\_aggiornamento.pdf](https://www.codiceappalti.it/documenti/CodiceAppalti.it_Ultimo_aggiornamento.pdf) [Accessed on 05 December 2018].
- 10) Cfr. art. 23 of Legislative Decree 18 April 2016, n. 50. [Online] Available at: [https://www.codiceappalti.it/documenti/CodiceAppalti.it\\_Ultimo\\_aggiornamento.pdf](https://www.codiceappalti.it/documenti/CodiceAppalti.it_Ultimo_aggiornamento.pdf) [Accessed on 05 December 2018].
- 11) On 12 January 2018, the so-called BIM Decree (Ministerial Decree n. 560/2017) was published on the MIT website, which indicates how to progressively introduce electronic methods and tools specific of BIM to the contracting stations, granting administrators and economic operators. [Online] Available at: <http://www.mit.gov.it/normativa/decreto-ministeriale-numero-560-del-01122017> [Accessed on 05 December 2018].
- 12) Satellite images, digital photography, photogrammetry, infrared images, 3D laser scanning, unmanned aerial vehicles, drones and BIM software, give new possibilities of

quickly and carefully document the consistency and the state of conservation of an archaeological site, being an important platform for decision-making and monitoring activities, while the rendering software gives a virtual or augmented reality useful for the interpretation of Cultural Assets.

13) Some examples of good practices on Management Plans can be found in the UNESCO archaeological sites of Joya de Cerén in El Salvador and Monte Albán in Mexico and Hoi An in Vietnam. Cfr. the web sites: <https://whc.unesco.org/en/list/675/> and <https://whc.unesco.org/en/list/415> [Accessed 17 October 2018].

14) For the sheltering system types in Archaeological Assets, cfr.: Schmidt, H. (1988), *Schutzbauten*, Theiss, Stuttgart; Stubbs, J. H. (1995), “Protection and presentation of excavated structures”, in Stanley-Price, N. (ed.), *Conservation on archaeological excavations: with particular reference to the Mediterranean area*, ICCROM, Roma, pp. 73-90; Mertens, D. (1995), “Planning and executing anastylosis of stone buildings”, in Stanley-Price, N. (ed.), *op. cit.*, pp. 113-134; Ranellucci, S. (2009), *Coperture archeologiche. Allestimenti protettivi sui siti archeologici*, Dei, Roma; Teller, J. and Lefert, S. (2004), *L’intégration architecturale et urbaine des vestiges archéologiques*, Actes du Colloque International APPEAR. [Online] Available at: <https://orbi.uliege.be/bitstream/2268/28974/1/Teller-10.pdf> [Accessed 6 May 2018]; Tricoli, A. (2011), *La Città Nascosta. Esperienze e metodi per la valorizzazione del Patrimonio archeologico urbano*, Monografie di Agathón, Offset Studio, Palermo; Ruggieri Tricoli and Sposito, 2012.

15) For the value typologies, cfr.: Appelbaum, 2007; Orbaşlı, A. (2008), *Architectural Conservation: Principles and Practice*, Blackwell Science, Oxford; Stubbs, J. H. (2009), *Time Honored: A Global View of Architectural Conservation*, Wiley, Hoboken; Gomez Robles, L. (2010), “A Methodological Approach towards Conservation”, in *Conservation and Management of Archaeological Sites*, vol. 12, issue 2, pp. 146-169; Szmelter, I. (2010), “A New Conceptual Framework for the Preservation of the Heritage of Modern Art”, in Schädler-Saub, U. and Weyer, A. (eds), *Theory and Practice in the Conservation of Modern and Contemporary Art: Reflections on the Roots and the Perspectives*, Archetype, London.

16) In this respect, it is important the careful analysis made by Randall Mason (2002) on the variability which makes a specific stakeholder or a group of people an ‘insider’ or ‘outsider’ in a particular decision-making process, their fluctuating status depends on whether they belong to the circle of people to whom the final decision is entrusted or not.

17) Headquarters participating to the SEED Competition – the Polytechnic University of Milan: A. Rogora (Coordinator); University of Geova: A. Magliocco; Università della Campania ‘L. Vanvitelli’: A. Violano; University of Pescara: D. Radogna; University of Florence: P. Gallo; University of Reggio Calabria: M. Milardi; University of Catania: L. Alini.

18) Aggregate Italian/English Course of Studies in Architecture-Interior design and for Autonomy of DADI at Università della Campania ‘L. Vanvitelli’.

19) Mr. Konstantinos Kontonikas, a final year student in the School of Civil Engineering of National Technical University of Athens, Greece.

20) The SEAS software has been developed by the Department of Energy, Systems, Territory and Construction Engineering of the University of Pisa in collaboration with the Energy Efficiency Energy Unit of the Italian National Agency for New Technologies, Energy and Sustainable Economic Development. The version of the software used for this analysis is v. 3.0 (September 2014).

21) Degree thesis in Architecture at DADI of Università della Campania ‘L. Vanvitelli’.

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The book presents reflections on the centrality of Design in the discipline of Technology of Architecture and on the need to adapt the design method to the innovation of thought implemented by the research world. The theme of the Innovation in the Method of Technological Design is an interesting challenge that in this volume has been addressed considering the complexity of the levels of thematic depth, opening up to critical reflections, proposals for tools and illustration of case studies that show the breadth, relevance and multidimensionality of this issue.

The era of digital and information technology have significantly influenced the way of doing and thinking in architecture and this evolution of design thinking takes on different connotations in training or professional practice. In the volume, it is transversally observable as the degree of innovation is to be found in the contents (ideas, techniques and procedures), as well as in the tools. The need to adapt the design method to the innovation of thought, carried out and encouraged by the world of research, obliges us to rethink the existing contents and training paths that must generate it and to privilege the didactic experiences in which the traditional procedure (frontal teaching, individual study, profit examination) is passed.

Since the labour market rewards those who demonstrate their ability to control the design process with creativity and predictability, concreteness and feasibility, sensitivity and respect for the transforming environment, the book proposes the centrality of the technological project, based on a technical culture, since it is able to guarantee the correct use of resources and an appropriate management of the transformation process. New paradigms of regenerative architecture, 'cradle to cradle' approach, methodological approach to the design of shelters in archaeological sites, building with water, materials for digital production in architecture are interesting design experiments wisely described: the development of such a debate can also lead to useful contributions to the development of technological thinking.

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